RÉPUBLIQUE
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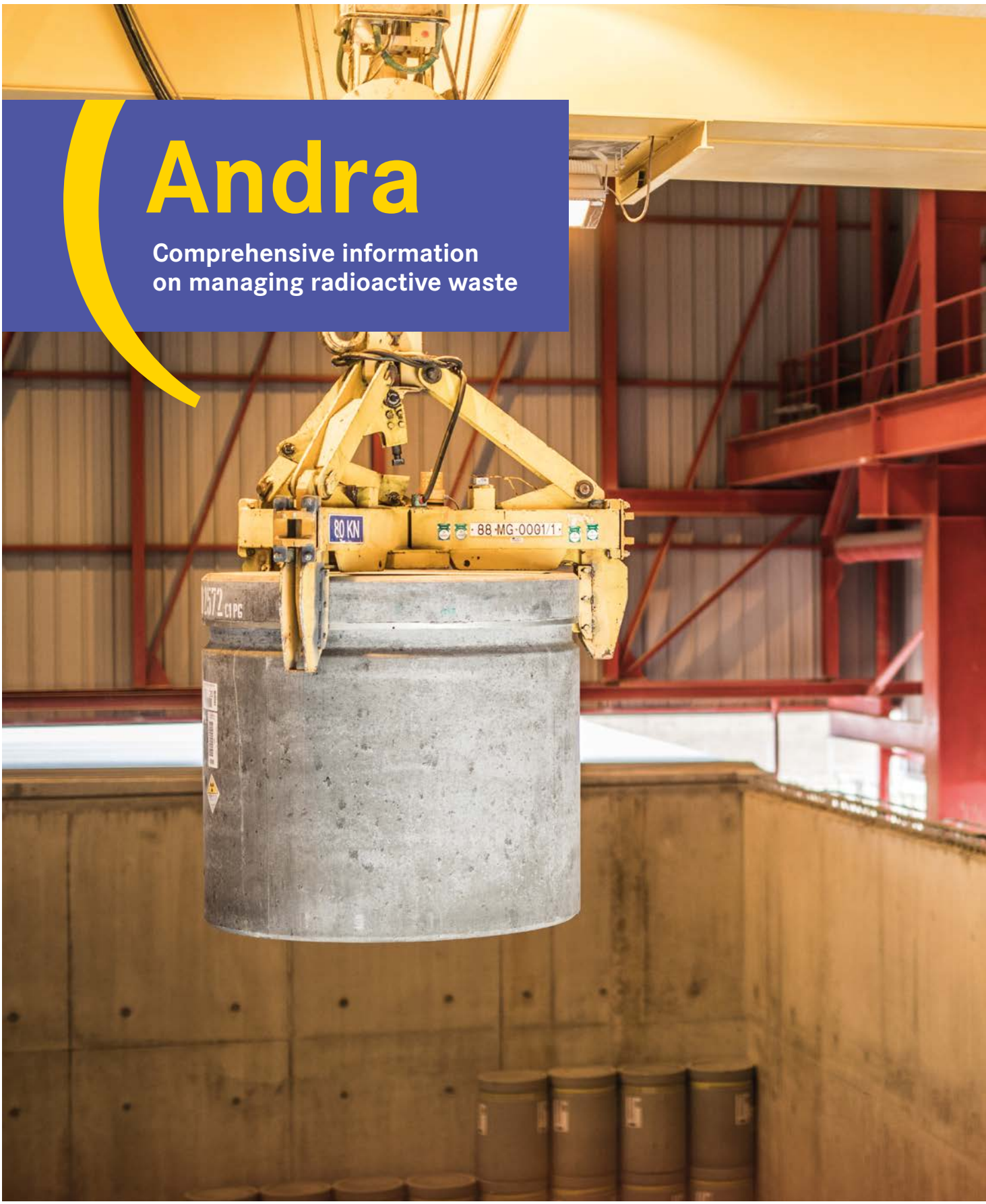
ANDRA
Agence nationale pour la gestion des déchets radioactifs

Andra

Comprehensive information on managing radioactive waste



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CONTENTS

Disposing of radioactive waste packages at the Aube disposal facility

ANDRA

French National Agency for Radioactive Waste Management

Andra is a state-owned undertaking of an industrial and commercial nature created by the law of December 30, 1991. Its mission was extended by the framework act of June 28, 2006 governing the sustainable management of radioactive materials and waste, then clarified by the 2016 law on reversibility and the terms of creation of Cigéo.

Whilst operating independently to radioactive waste producers, Andra is supervised by the French ministers for the Ecololgy and Research.

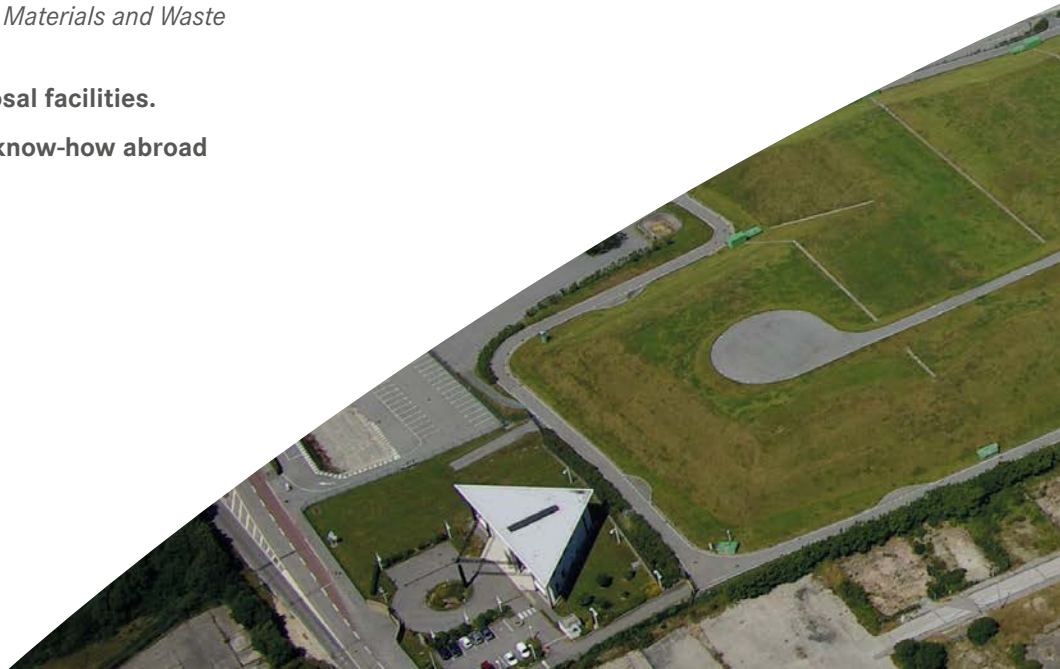
Its mission

Andra is commissioned by the French state to assiduously and responsibly fulfil a public interest mission on behalf of the French people: manage radioactive waste and make it safe for future generations.

Its activities

To fulfil its mission, Andra accomplishes several activities:

- **Operating the two existing surface disposal facilities** in Aube: the Aube disposal facility (CSA), dedicated to low- and intermediate-level waste, mainly short-lived (LILW-SL); and the Cires for Industrial Facility for Nuclear Waste Collection, Storage and Disposal of very low-level waste (VLLW).
- **Monitoring, in particular, the Manche disposal facility (CSM),** the first French facility for surface disposal of low- and intermediate-level radioactive waste, currently in a closure phase.
- **Informing and encouraging dialogue with all members of the public and providing a basis for public decisions** (prepare every five years for the *National Inventory of Radioactive Materials and Waste* present on French soil).
- **Recording the history of disposal facilities.**
- **Sharing and utilising Andra's know-how abroad**
- **Studying and designing long-term disposal solutions** for waste still requiring a solution:
  - Long-Lived Low-Level Waste (LLW-LL),
  - High-Level Waste (HLW) and Intermediate-Level Waste - Long Lived (ILW-LL) through the Cigeo project;
- **Fulfiling a public service mission** for collecting old radioactive objects held by private individuals and for cleaning up old sites with radioactive pollution.



Funding

Andra's funding is sourced from:

- **commercial contracts with radioactive waste producers** (EDF, Orano, CEA, hospitals, research centres, etc.) for the disposal of their radioactive waste;
- **a "research" tax** collected by the Nuclear Safety Authority (ASN) from the radioactive waste producers for research and studies on the interim storage and disposal of high-level and long-lived intermediate-level waste.
  This tax is credited to a "research" fund;
- **a special contribution credited to a "design" fund** by the radioactive waste producers to finance the design studies of the Cigéo installations and the pre-startup works for the construction phase for these facilities;
- **a subsidy** granted by the French State for its public interest missions (generation of the national Inventory, collection of radioactive objects from private individuals, clean-up of radioactively polluted sites where the responsible party has defaulted).

Key figures

Over 700 employees
5 sites, including:

- **the headquarters** at Châtenay-Malabry (92);
- **2** operational industrial facilities in the Aube: le **Cires** and **CSA**;
- **1** storage facility in the closure phase in the Manche department: **CSM**;
- **1** facility in the Meuse/Haute-Marne area (CMHM) composed of:
  - **an underground Laboratory,**
  - **a Technological Exhibition Facility,**
  - **an Environmental Specimen Bank.**

Aerial view of the Manche Disposal Facility (CSM)

RADIOACTIVITY
and radioactive waste

Radioactivity

Radioactivity is a natural phenomenon, where certain unstable atoms, called radionuclides, spontaneously change (decay) into another atom, while emitting radiation.

The radioactivity of an element decreases naturally with time, more or less rapidly depending on the nature of the radionuclides.

Since the discovery of radioactivity, its properties have been used in many applications: power generation, chemistry, biology (study of cells), geology, archaeology (dating), agriculture, medicine (diagnostic and treatment of cancers), etc. It also has many uses in industry, for food preservation (ionization), weld inspection in metallurgy, the sterilisation of medical equipment or fire detection, for example. All these activities produce waste, some of which is radioactive.

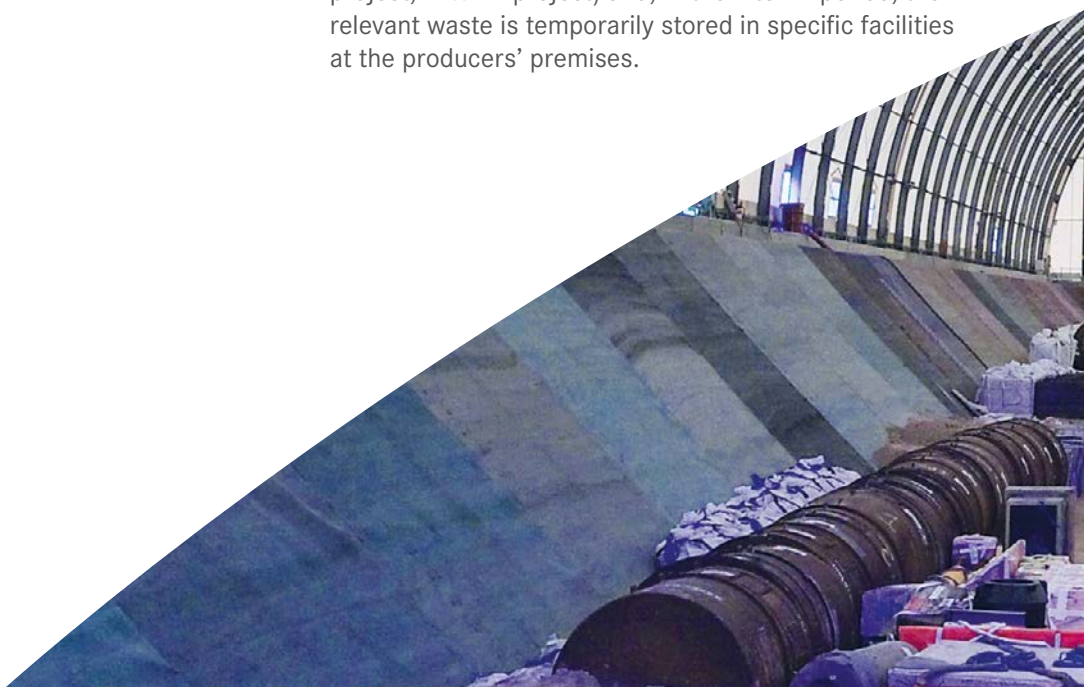
Radioactive waste and disposal

“Radioactive waste” means radioactive substances which cannot be re-used or reprocessed and must be managed in a specific manner. Radioactive waste comes from a wide range of origins: rubble, scrap metal, gloves, filters, resins, gowns, pipettes, flasks, needles or other objects in daily use such as alarm clocks, fountains or lightning conductor heads.

Radioactive waste may be generated by the maintenance, operation or decommissioning of nuclear facilities, the reprocessing of spent fuel from nuclear power plants, cleaning up legacy sites contaminated by radioactivity, research activities, industrial processes, medical examinations and healthcare, or by private individuals in possession of legacy objects from the inter-war period.

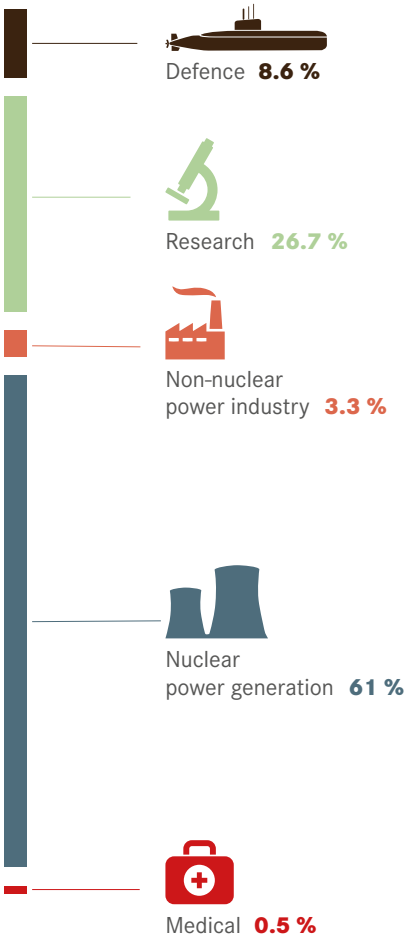
To protect people and the environment from the risks incurred by radioactive waste, France, like most countries, has opted for disposal in industrial installations tailored to each type of waste. The objective is to isolate the waste until the radioactivity has sufficiently decreased, owing to natural decay, and no longer raises risks. In France, disposal facilities managed by Andra already exist and accommodate more than 90% of the radioactive waste produced each year nationwide.

Solutions are under review for other waste (Cigéo project, LLW-LL project) and, in the interim period, the relevant waste is temporarily stored in specific facilities at the producers’ premises.



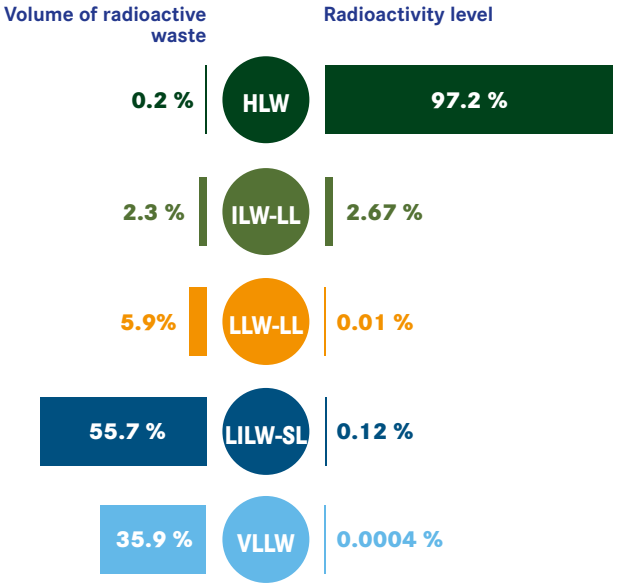
Breakdown of existing radioactive waste per economic sector *(Source: National Inventory of Radioactive Materials and Waste, end-2022 figures)*

Percentages were calculated based on the exact figures, then rounded.



Breakdown of volume and level per type of radioactive waste

(Source: National Inventory of Radioactive Materials and Waste, end-2021 figures)

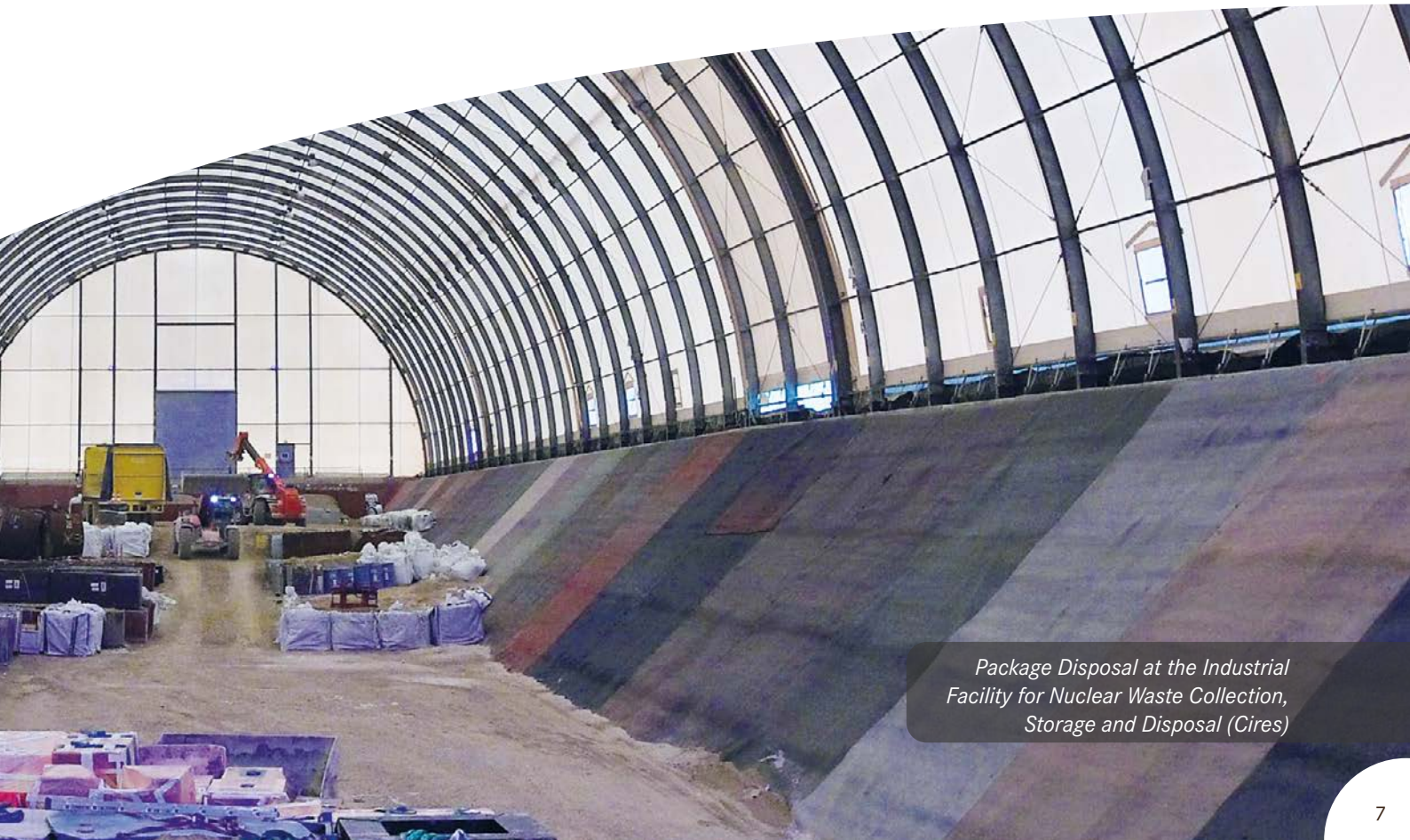


1,790,000 m³

in radioactive waste produced at end 2022.

Source: National Inventory of Radioactive Materials and Waste

These figures are for the radioactive waste handled or earmarked for handling by Andra. Other waste streams, managed via specific solutions, are listed under the *National Inventory of Radioactive Materials and Waste*.



Package Disposal at the Industrial Facility for Nuclear Waste Collection, Storage and Disposal (Cires)

CLASSIFICATION OF RADIOACTIVE WASTE

and its storage concept

Five waste categories exist in France, classified according to the disposal solution, which primarily depends on two criteria: level of radioactivity and lifetime.

Very low-level radioactive waste (VLLW)

Very low-level radioactive waste is primarily produced in the operation and decommissioning of nuclear facilities.
Some waste is also produced by the clean-up and remediation of legacy sites polluted by radioactivity.

VLLW takes the form of inert (concrete, rubble, earth), etc. or metallic waste. It is disposed of at the surface of the Industrial Facility for Nuclear Waste Collection, Storage and Disposal (Cires), opened in 2003.

Upon arrival at the site, 30% of the received waste is specifically treated before disposal:
- plastic waste or scrap metal is compacted to reduce its volume;
- liquid waste (polluted water, sludge) is solidified and made chemically inert. The waste is then placed in drums or *big bags*.

Once conditioned, these waste packages are identified and stacked in disposal cells dug several meters deep in a clay layer. When filled, the cells are covered by a capping system primarily consisting of sand, a geomembrane lining for water-tightness, and clay.

Short-lived low- and intermediate-level waste (LILW-SL)

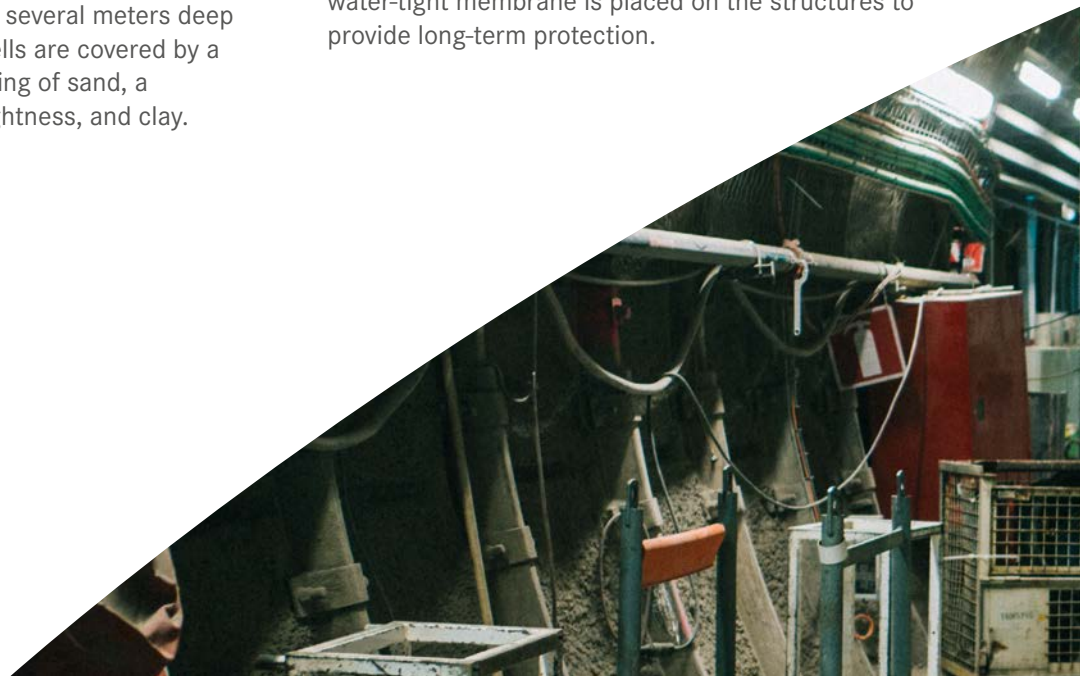
This waste is produced in either the maintenance (clothing, tools, filters, etc.) and operation of nuclear installations, or in the research or healthcare activities of laboratories and hospitals.

This waste primarily contains short-lived radioactive atoms, and since 1992 has been disposed of at the surface of the Aube Disposal Facility (CSA), which took over from the Manche Disposal Facility (CSM), in operation from 1969 to 1994.

Some waste is compacted or solidified before disposal, and then mixed with concrete before being placed in a concrete or metal container.

The waste packages are composed of 15-20 % waste and 80-85 % concrete encapsulation. They are disposed of at the surface in reinforced concrete structures with 25-meter sides and a height of 8 meters.

Once filled, these structures are closed by a concrete slab sealed and coated by a layer of water-tight resin. Lastly, a final clay layer several meters thick with a water-tight membrane is placed on the structures to provide long-term protection.



Long-Lived Low Level Waste (LLW-LL)

This waste basically covers two types of waste referred to as “radium-bearing” and “graphite”

> **Radium-bearing waste** owes its name to the radium it contains. It mainly originates in the use of ore (extraction of rare earths) or uranium and the clean-up of legacy industrial sites which used radium or thorium from 1900 to 1960.

> **Graphite waste**, as its name indicates, contains graphite, a mineral corresponding to a very pure variety of carbon. It was produced during the operation and decommissioning of first-generation nuclear reactors (UNGG or natural uranium graphite-gas reactors), now discontinued.

> **Other types of waste** also belong to this category: radioactive lightning conductor heads, luminescent paint (formerly used in the clock-making industry for example). Certain legacy radioactive objects, no longer in production, (radium watches, radium-bearing needles) have been found at the homes of private individuals.

Andra investigates the range of possible scenarios for managing this waste, in order to propose safe and appropriate disposal solutions.

High-Level Waste (HLW) and Intermediate-Level Waste - Long Lived (ILW-LL)

High-level waste (HLW) and long-lived intermediate-level waste (ILW-LL) is mainly produced by the nuclear power industry and the associated research activities and also, to a lesser extent, national Defense-related activities.

> **HLW** mainly corresponds to the highly radioactive residues produced when processing spent fuel (mainly in power generation and, to a lesser extent, in national Defense-related activities).

> **ILW-LL** varies in origin. This waste includes the metal structures enclosing the fuel (hulls and end-fittings) or the residues from the operation and maintenance of nuclear facilities.

Cigeo, the deep geological disposal project for HLW and ILW-LL

Cigéo is an Andra-engineered French project for the disposal of high-level and long-lived intermediate-level waste (HLW and ILW-LL) produced by all the current nuclear facilities up to decommissioning, in a deep geological layer.

Cigéo’s basic objective is to protect people and the environment from the danger represented by this waste, while limiting the burden placed on future generations. This project is the outcome of more than a quarter of a century of research, three laws and two public debates.

If construction is authorised, Cigéo will be sited in the Meuse/Haute-Marne area within a clay layer at a depth of 500 meters and engineered for almost 30 years by Andra, particularly thanks to its underground research Laboratory.

Pending the commissioning of Cigéo, the HLW and ILW-LL packages already produced are temporarily stored under dry conditions in buildings on their production site, mainly at La Hague (50), Marcoule (30) or Cadarache (13).

Andra’s underground Laboratory in the Meuse/Haute-Marne area

THE RADIOACTIVE WASTE
pathway

Transportation of radioactive waste to Andra's industrial facilities in the Aube department

Handling and conditioning*
of most radioactive waste by the producers

Using the properties of radioactivity
in five main economic sectors: nuclear power industry, national defense, non-nuclear power industry, medicine

Reception of the waste
by Andra at its dedicated disposal facilities

Sorting
of waste by the producers on their production site

Production of radioactive waste

- **LILW-SL and VLL waste**
- **Short-lived waste** a short half-life - less than 100 jours
- **HLW, ILW-LL and LLW-LL waste**

In situ radioactive decay *prior to subsequent management as conventional waste*

Storage at the production site for waste generated by the nuclear power industry and storage at the dedicated facility at Cires for waste generated by the non-nuclear power industry *pending the commissioning of dedicated disposal facilities*

** In order for their packages to be accepted at the disposal sites, the producers are required to meet the requirements set by Andra: weight, radioactive atoms in the waste, radiological activity and inherent risks. These data are saved under a barcode identification number, which acts as a package ID card ensuring the traceability of the waste and determining its precise position in the repository. Inspections are regularly conducted by Andra on the producers' premises to ensure conditioning quality and compliance with these rules.*

Recording site history
and passing it on to future generations

Radiological inspections
of the packages, their contents and their compliance with Andra's requirements

Closure of the storage facilities

Handling of some packages prior to disposal
to reduce volume (e.g. compacting and solidification)

Package disposal

Monitoring of disposal facilities and the immediate environment
during operations and post-closure

In-depth inspections
of randomly sampled packages at delivery

Radiological inspection of a truck upon arrival at the Aube Disposal Facility (CSA)

Andra's SITES

Manche disposal facility (CSM)

With a surface area of about 15 hectares, the first French disposal facility received, between 1969 and 1994, 527,225 m³ of low-and intermediate-level waste. It is currently in its closure phase.

MANCHE DISPOSAL FACILITY
BP 807 Digulleville • 50440 La Hague

To visit the facility: call 0033 (0)810 120 172
(price of a local call)
To find out more, go to:
https://manche.andra.fr/

Key figures for Andra's industrial facilities in the Aube department

at end 2022

> **451,259 m³ of waste** disposed of at Cires since 2003, which accounts for **69.4 %** of the Facility's total authorised disposal capacity.

> **371,305 m³ of waste** disposed of att the CSA since 1992, which accounts for **37.1 %** of the Facility's total authorised disposal capacity.

Andra's industrial facilities in the Aube department

> Industrial Facility for Nuclear Waste Collection, Storage and Disposal (Cires)

With a surface area of 45 hectares and an authorised disposal capacity of 650,000 m³, this facility has been used for the reception and disposal of very low-level waste since 2003. It has also been used for the collection and storage of waste from non-nuclear power activities since autumn 2012 and for waste and treatment since 2016.

The current configuration of Cires is not large enough to dispose of the VLLW volumes to be produced in decommissioning operations in the coming years. Additional management solutions are therefore currently being studied. The medium-term solution involves increasing the licensed disposal capacity of Cires, without changing the area of the existing disposal zone and while maintaining its safety level (Acaci project). This increase in capacity would allow Cires to operate for an extra ten years or so.

> Aube Disposal Facility (CSA)

With a surface area of 95 hectares and an authorized disposal capacity of 1,000,000 m³, this facility, dedicated to the disposal of short-lived low-and intermediate-level waste, has been in use since 1992. It took over from the Manche Disposal Facility, building on the 25 years of existing experience.

ANDRA'S INDUSTRIAL FACILITIES IN THE AUBE DEPARTMENT
BP 7 • 10200 Soulaines-Dhuys

To visit the facilities: 0033 (0)800 31 41 51
(Free call from a landline)

To find out more, go to:
https://aube.andra.fr/

Water quality monitoring station as part of the OPE

Andra's Meuse/Haute-Marne facility (CMHM)

> Underground Laboratory

Built in 2000 and located at a depth of 490 m, the Underground Laboratory is a unique research tool in the deep storage project called Cigéo, for high-level (HLW) and long-lived intermediate-level (IL-LLW) waste. Its underground tunnels can be used for the *in-situ* analysis of a 160 million year old clay formation, as well as a range of concepts and techniques compatible with Cigéo. If the Cigéo project is given the go-ahead, it will be sited close to the Laboratory.

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

Key figures for the laboratory

More than ***2 km of experimental drifts***.
80 experiments set up in the underground drifts.
40 scientific partners (public institutions, universities, etc.).
7 laboratory consortia including more than ***80 laboratories and research bodies.***

MEUSE/HAUTE-MARNE FACILITY
(Underground Laboratory, Technological Exhibition Facility, Environmental Specimen Bank)
Department road 960 • BP 9 • 55290 Bure

To visit the facility: 0033 (0)3 29 75 53 73
(Free call from a landline)

To find out more, go to:
https://meusehautemarne.andra.fr/

> The Technological Exhibition Facility

The Technological Exhibition Facility presents Cigéo with mock-ups and various robots and industrial prototypes built by Andra.
The objective is to test and validate the technological concepts underlying this repository: concrete package container, handling system, etc.

> The Environmental Specimen Bank

Andra is home to a 1400 m² Environmental Specimen Bank built in 2013 in the municipality of Bure.
It will preserve all of the environmental samples taken for one century as part of the Permanent Environment Observatory (OPE), which covers a surface area of 900 km² between the Meuse and Haute-Marne departments. This Environmental Specimen Bank is a unique infrastructure in France, following on from the most sophisticated environmental specimen banks worldwide, and part of an international network of such banks.

Facility environment monitoring

Before commissioning its sites, Andra generated an initial status report describing their main features and their environment. This status report serves as a baseline for the analyses conducted during operation and during the site closure and monitoring phases, enabling Andra to verify that the environmental impact of its activities is very slight based on multiple water, air, soil, fauna and flora quality analyses and samples.

In 2022, 977 samples were taken in the Cires environment for 5,772 radiological and physico-chemical analyses; 2,735 samples were taken in the CSA environment for 16,960 radiological and physical-chemical analyses and 2,087 samples were taken in the CSA environment for 12,024 radiological and physico-chemical analyses.

If it is given the go-ahead, a monitoring plan will also be set up around Cigéo under the control of the French Nuclear Safety Authority. This regulatory monitoring will be reinforced by the observations carried out as part of the Permanent Environment Observatory, which groups together a range of environment observation, testing and conservation resources. This certified observatory is registered in a large number of national and international scientific networks.

GLOSSARY

A

Activity: level of radioactivity. Measured in becquerels.

Atom: the basic building block of matter (composing air, water, earth, living beings, etc.). Each atom comprises a nucleus (the protons and neutrons) and electrons which gravitate around it.

B

Becquerel (Bq) : radioactivity measurement unit, for Henri Becquerel who discovered radioactivity at the end of the XIXth century.

D

Disposal: a long-term industrial management solution for radioactive waste.
Disposal safety relies upon three components: **the packages** containing the waste, **the disposal structures** hosting the packages and the site **geology**, which forms a natural barrier.

Disposal structure: host structure for the disposal of the waste packages.

I

Interim storage: temporary solution for managing radioactive waste before disposal.

P

Package: a container for radioactive waste generally set in a “matrix” (concrete or glass).

R

Radiation: radioactive atoms emit radiation at a wide range of energies.
There exist three main types of radiation, which differ in their penetrating power. **Alpha** radiation, with a range of a few centimetres in air, can be stopped by a simple sheet of paper. **Beta** radiation can travel several meters through air. It can be stopped by a sheet of aluminium or a glass window. **Gamma** radiation is similar to X rays but with higher energy, and can be stopped by several centimetres of lead or several decimetres of concrete.

Radioactive period or half-life: mean time after which a radioactive atom naturally loses half of its activity. The activity of a radioactive product is divided by four after two periods and by eight after three periods. Activity is divided by 1,000 after ten periods. A distinction is made between the waste whose main radioactive atoms have a short half-life (no longer than 31 years) and those with a long half-life (no shorter than 31 years). The 31-year limit was determined by the radioactive half-life of caesium 137. The former are generally considered to no longer represent a radiological hazard after 300 years.

Radioactive waste: radioactive substances for which no further use is foreseen or planned.

Radioactivity: most atoms (e.g. hydrogen) are stable and not radioactive. Other atoms, like plutonium, are unstable and spontaneously decay to other atoms (stable or not). Upon decay, they release surplus energy in the form of radiation, until they reach a stable condition: this is known as radioactivity.

Reversibility: according to the law of June 28, 2006, the deep disposal of high-level and long-lived intermediate-level waste must be reversible during at least 100 years. And, according to the law of July 25, 2016, reversibility is the capacity for successive generations to either continue with the construction and the operation of the successive disposal phases, or to re-assess the previously defined choices and upgrade the management solutions.

S

Sievert (Sv): the measurement unit for the biological effects of exposure to radioactivity on people. According to regulations, the annual dose caused by the activities of the nuclear industry must be as low as possible and may not exceed 1 mSv for the population. BY way of comparison, in France, mean annual exposure to naturally occurring radioactivity is 2.4 mSv and 1,1 mSv for artificial radioactivity (medical exposure).

A dose of 1 mSv is equivalent to: 17 months in the Paris region, 7 Paris-San Francisco return plane trips and the mean annual number of medical radiological procedures in France per inhabitant.

THE KEY DATES

for radioactive waste management in France

1969
Manche Disposal Facility (CSM) opened under the CEA's responsibility.

1979
Andra created within the CEA.

1991
Law of December 30th, the first in France on the receiving and management of radioactive waste. It conferred on Andra its status as a state-owned undertaking of an industrial and commercial nature, independent of the radioactive waste producers.

1992
Facility for the disposal of short-lived low-and intermediate-level waste (CSA) opened in the Aube department.

1994
Last package disposed of at the Manche Disposal Facility.

1998
Authorization to install and operate the Meuse/Haute-Marne underground laboratory, which analyzes the feasibility of deep disposal for long-lived high-level and intermediate-level waste.

2000
Start of construction of the Meuse/Haute-Marne underground laboratory.

2001
First four-year contract
The French State/Andra which defines Andra's missions.

2003
> Commissioning of the Disposal Facility for Very Low-level Waste (Cires).
> French government decree authorising the transition to the monitoring phase of the Manche Disposal Facility.

2005
Submission of a summary report (File 2005) to the public authorities, on the feasibility and safety of deep reversible disposal for high level and long-lived intermediate level radioactive waste.

2005/2006
Public debate on the management of HLW and ILW-LL radioactive waste.

2006
Debate in Parliament and then vote on the June 28 2006 law extending Andra's missions and establishing deep reversible disposal as the reference solution for long-term management of HLW and ILW-LL.

2007
Setting up the Perennial Observatory of the Environment.

2008
Call for applications from local authorities for the siting of a disposal facility for long-lived low-level waste (forty or so applications received within the year).
Two localities were to be selected, but were to withdraw their application under pressure from opponents in 2009.

2010
The French Government validated an area of around 30 km^2 proposed by Andra for studying the potential Cigéo site, the Deep disposal facility for high level and long-lived intermediate-level waste.

2011
Launch of the Cigéo industrial design.

2012
Commissioning of the interim storage and grouping installations for the non-nuclear power waste at Cires in the Aube department.

2013
Public debates on the Cigeo project organised by the National Public Debate Commission.

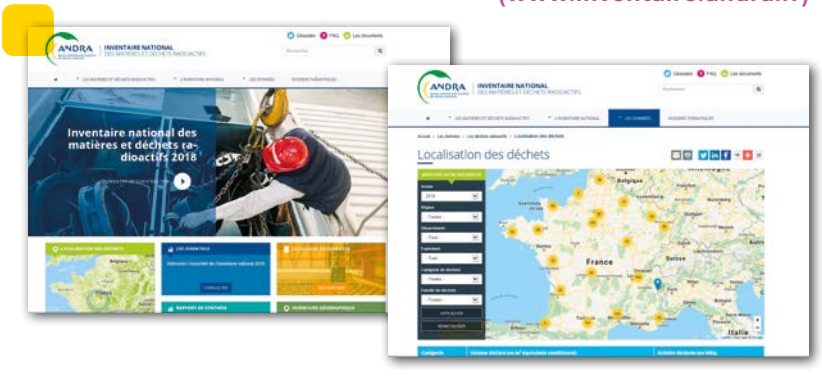
2015
Submittal to the Government of a status report on the LA-LLW project.

2016
> July 25 law stating the terms of creation of a reversible disposal installation in a deep geological layer of long-lived high-and intermediate-level radioactive waste.
> Andra submits the Cigéo safety option files to the French Safety Authority.
> Sorting, treatment commissioned at Cires.

2018
Package inspection installation (ICC) commissioned at CSA.

2022
Decree declaring the public utility of the Cigéo project.

2023
> Construction licence application submitted for Cigéo.
> New edition of the*National Inventory of Radioactive Materials and Waste published.* **(www.inventaire.andra.fr)**



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