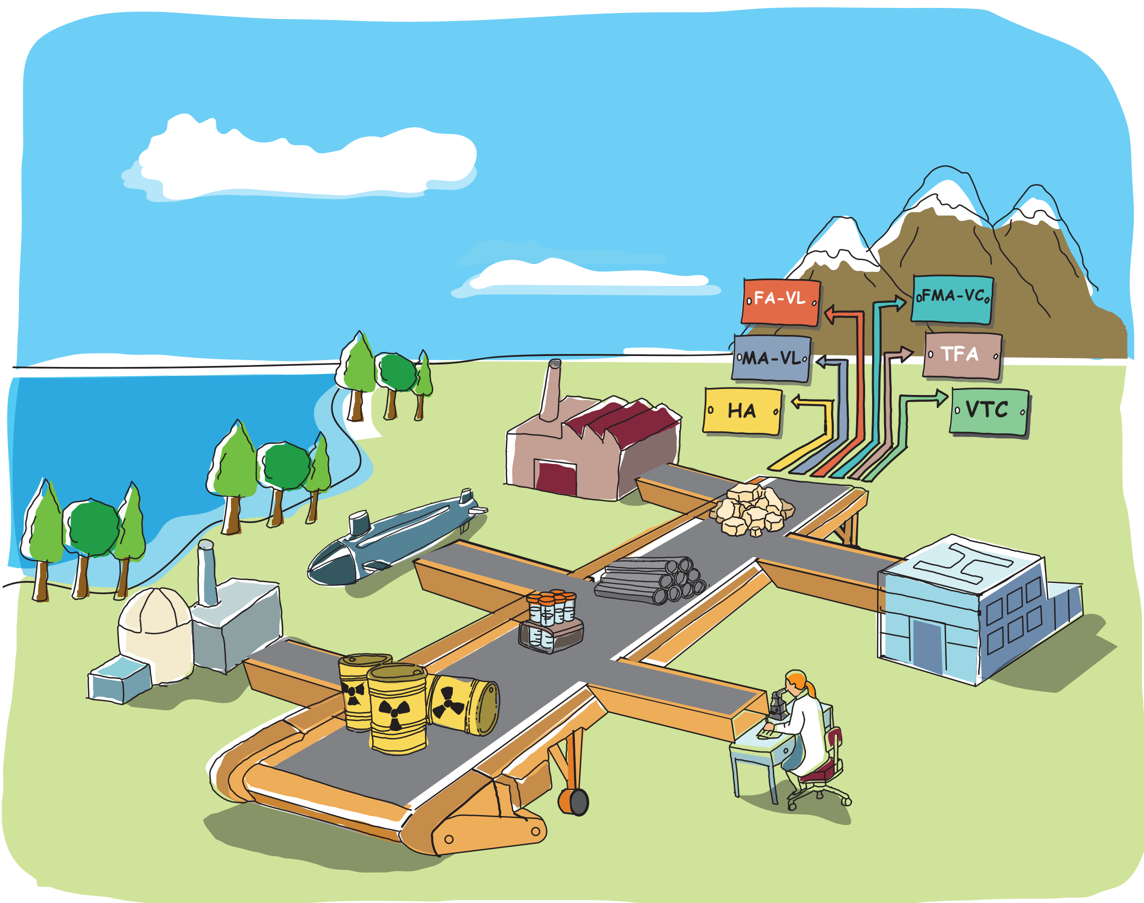
AUTORITÉ DE SÛRETÉ NUCLÉAIRE #06 · MAY 2024

LES CAHIERS DE L'ASN #06

RADIOACTIVE WASTE

How to implement lasting solutions to protect human health and the environment?



Radioactive waste under surveillance

What waste are we talking about?

The challenges for tomorrow

Informing the public

Contents

Nuclear power is a major source of energy in a large number of countries. In France, it accounts for more than 70% of all the electricity produced. Although nuclear production of electricity emits very little in terms of greenhouse gases, it does have other environmental implications, such as radioactive waste.

Some waste from the reprocessing of spent fuels from the nuclear power plants remains a danger for hundreds of thousands of years.
The French population is well aware of this issue and their primary concern is radioactive waste management, ahead of the risk of an accident. A vast majority of them wishes to see waste management solutions identified and implemented, **without placing this burden on future generations.**

Although there is still no operational management solution for certain waste, France does have a consistent overall framework for the management of all the waste, regardless of producer or type, providing a long-term guarantee of its safe management, with ring-fencing of the necessary financing.
It is the role of ASN to oversee the correct management of radioactive waste, in order to protect human health and the environment.

A strict **legal framework**

Radioactive waste is subject to strict regulations. The 28 June 2006 Act sets the broad principles governing its management and the National Radioactive Materials and Waste Management Plan (PNGMDR*) is the primary tool for implementing these principles.

WHAT THE LAW SAYS

The Order of 7 February 2012 states that all waste produced in a basic nuclear installation (BNI*) is, as a precaution, considered to be radioactive and must be sent to appropriate management routes*.

The producers of radioactive waste must sort it and carry out conditioning*, employing strict quality assurance procedures and the best available technologies, with the aim of reducing both the quantity and harmfulness of the waste.

They are responsible for storage* of the waste and its transport to the repositories* for disposal.

The producers are therefore responsible for the correct management of their waste, up until removal to a final disposal solution.

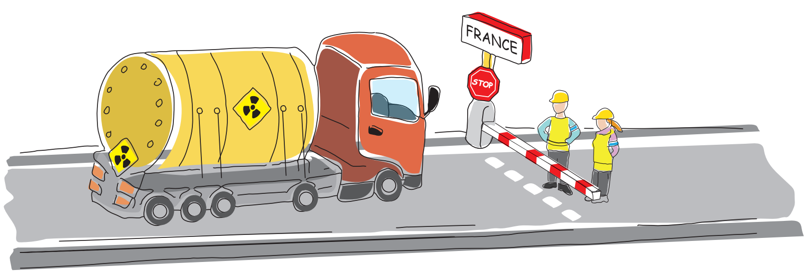
The legislative framework: setting principles and planning ahead

The main principles underpinning the sustainable management of radioactive materials and waste in France are set out in the 28 June 2006 Act:

• **Protection of human health, security and the environment** in the sustainable management of radioactive materials and waste of all types, must be guaranteed.

• **A National Radioactive Materials and Waste Management Plan** (PNGMDR) is created to ensure the long-term implementation of the principles of the Act *(see opposite)*.

• **The availability of funds** devoted to the long-term management of radioactive waste must be guaranteed. In this respect, the nuclear licensees must make a prudent assessment of the cost of decommissioning their installations and the cost of managing their radioactive waste.



• **The ban on the disposal in France of foreign radioactive waste** is reaffirmed and the conditions for the reprocessing* in France of spent fuels* or radioactive waste from other countries, along with the publicity related to these operations, are defined precisely.

• **Reversible disposal** (for a certain period of time, the possibility of removing the waste) in a deep geological formation is the reference solution for the management of high-level and intermediate-level long-lived radioactive waste (HLW-ILW/LL).

See glossary page 34

The drafting of the 5th edition of the PNGMDR (2022-2026) was for the first time preceded by a public debate in 2019. On 21 February 2020, the Ministry in charge of energy and ASN published a joint decision further to this public debate, which set out the broad guidelines of the Plan. It in particular emphasised the continued creation of management routes for waste for which these were not yet available (LLW-LL and HLW-ILW/LL waste), as well as optimisation of the existing routes, in particular that for very low-level waste (VLL), which will be required to manage waste from the decommissioning of the nuclear installations.

The National Radioactive Materials and Waste Management Plan (PNGMDR)

The main objectives of the PNGMDR are:

- to draw up the inventory of the existing radioactive waste management methods and the chosen technical solutions;
- to identify the foreseeable need for storage or disposal facilities and to clarify the capacity required for these facilities, as well as the storage durations;
- to set the general objectives to be attained, the main deadlines and the schedules enabling these deadlines to be met;
- to set the objectives to be attained for radioactive waste for which a final management solution has not yet been determined;
- to organise research and studies into the management of radioactive waste, by setting deadlines for the implementation of new management solutions, the creation of facilities or the modification of existing facilities.

AT THE EUROPEAN LEVEL

The European Euratom Directive on the management of radioactive waste (2011) contributes to reinforcing safety within the European Union, by making the Member States more accountable for the management of their radioactive waste.

AT THE INTERNATIONAL LEVEL

The International Atomic Agency's (IAEA*) Joint Convention on the Safety of radioactive waste management is a legally binding international instrument, which entered into force on 18 June 2001, and which addresses the global safety of radioactive waste management. The contracting countries (including France) undertake to apply strict safety provisions, and to periodically draw up a national report on these provisions.

Radioactive waste: **who acts, who oversees?**

The Ministry responsible for the environment draws up policy and implements the Government's decisions concerning the civil nuclear sector. In operational terms, radioactive waste management is the responsibility of various actors.

THE LONG-TERM MANAGER

The French national radioactive waste management agency (Andra) is a public institution **responsible for the long-term management of the radioactive waste produced in France**. It reports to the Ministries responsible for research, industry and the environment.

Its duties are:

- to devise and implement lasting management solutions for all categories of radioactive waste, notably high-level waste (HLW), intermediate level long-lived waste (ILW-LL) and low level long-lived waste (LLW-LL), which is currently stored;
- take charge of radioactive waste from the nuclear power sector, research, national defence, industry other than nuclear power generation and the medical sector;
- operate radioactive waste repositories* while ensuring protection of human health and the environment.

ANDRA
Agence nationale pour la gestion des déchets radioactifs

THE REGULATOR AND ITS TECHNICAL SUPPORT ORGANISATION

ASN oversees the waste producers and Andra; **it examines the BNI* authorisation procedures as related to waste management**. It regularly assesses the waste management strategy of each of the major licensees. This approach must take into account all the safety, radiation protection*, waste volume and harmfulness minimisation issues.

As part of its general role of technical support for the safety regulators, the Institute for Radiation Protection and Nuclear Safety (IRSN) **assesses the safety of all the operations associated with management of the waste from the BNIs**.

Its role notably consists in analysing all the risks which could arise from the short to the very long term, on current or future disposal facilities.

asn AUTORITÉ DE SÛRETÉ NUCLÉAIRE

IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

See glossary page 34

THE NUCLEAR LICENSEES

The producers of waste **are responsible for it from the technical and financial standpoints**, and in the environmental impact assessment of their installation must indicate whether or not it is radioactive, along with its volume, type, harmfulness and the envisaged disposal solutions.

PARLIAMENT

The Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST) **organises hearings of the radioactive materials and waste stakeholders** and publishes assessment reports and recommendations.

The National review board (CNE2) **conducts an annual assessment of the state of progress** and the quality of research concerning the management of radioactive materials and waste.

The General Directorate for the treasury and that for energy and the climate are responsible for **monitoring the financing of the long-term costs related to radioactive waste**.

THE PARTIES IN THE DEBATE

The High Committee for Transparency and Information on Nuclear Safety (HCTISN) **is an information, discussion and debating body** dealing with the risks inherent in nuclear activities and the impact of these activities on human health, the environment and nuclear safety.

The National Commission for Public Debate (CNDP) is the independent authority responsible for **guaranteeing the right of any individual living in France to obtain information about and take part in projects or policies which have an impact on the environment**.
This “debating right” for the public also helps improve the decisions made by those in charge of projects or policies. It helps inform them of the values, expectations or concerns of the public.

The Local Information Committees (CLIs) **are information and consultation structures set up for each BNI**.
Their general role is monitoring and consultation regarding nuclear safety*, radiation protection and the impact of nuclear activities on humans and the environment, and promoting information of the public about safety.

The different types of radioactive waste

Radioactive wastes are radioactive substances for which no subsequent use is planned or envisaged. They must thus be managed in a disposal route* compatible with their harmfulness.

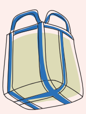
Radioactivity is a natural phenomenon to which all humans are permanently exposed. Artificial radioactivity is produced by human activities (medicine, industry, research, regulated discharges from nuclear facilities, etc.).

Radioactive wastes are also as diverse as the activities that produce them. Depending on their origin, their harmfulness varies, as does the time for which they are dangerous. In France, there are six categories of radioactive waste, based on two criteria:

- **the radioactive activity** (the number of radioactive nucleus decays occurring each second and which therefore emit radiation);
- **the lifetime** (the period of time during which this radiation is emitted).

The six categories of radioactive waste

VSL VERY SHORT-LIVED



Radioactive waste with a half-life* of less than 100 days. A large proportion of this comes from medical applications of radioactivity (diagnostic or therapeutic).

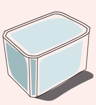
Up to about 3 years

VLL VERY LOW-LEVEL

This comes from the nuclear industry, in particular installation decommissioning operations. It is primary parts obtained by cutting up equipment, and rubble with very low levels of contamination.

Non-determinant [1]

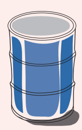
LLW-LL LOW-LEVEL LONG-LIVED WASTE



This primarily concerns:
- waste contaminated by radium for example used in the past by the watchmaking industry;
- graphite waste from the decommissioning of first-generation nuclear reactors;
- waste from the processing of minerals such as rare earths used in electronics.

Up to several hundred thousand years

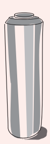
LLW/ILW-SL LOW- AND INTERMEDIATE-LEVEL SHORT-LIVED WASTE



This is primarily waste from the maintenance and operation of nuclear installations (clothing, tools, gloves, filters, etc.). This waste also comes from research laboratories, hospitals, universities, etc. It can be incinerated, melted, encapsulated in a matrix (cement for example), or compacted.

Up to about 300 years

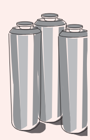
ILW-LL INTERMEDIATE-LEVEL LONG-LIVED WASTE



This primarily consists of hulls and end-pieces from the reprocessing* of nuclear fuels, and waste from the operation and maintenance of nuclear power plants.

Up to several hundred thousand years

HLW HIGH-LEVEL WASTE



This is produced by the reprocessing of nuclear fuels. It gives off heat. It must be left to cool in pools for years before final disposal. In France, high level waste is calcined and then incorporated into a molten glass paste. It is then poured into a stainless-steel package.

Up to several hundred thousand years

Time needed for the radioactivity to decay to a threshold with no further risk for human health and the environment. It depends on the radioactive half-life.

1. Given the very low activity level, the time criterion is not a factor in the classification of this waste category.

* See glossary page 34

GIVING THE MATTER SOME THOUGHT

A radioactive substance contains natural or artificial radionuclides, the activity or concentration of which justifies monitoring to prevent risks. Substance is a general term which covers both radioactive materials and radioactive waste.

A radioactive material is a radioactive substance for which subsequent use is planned or envisaged, if necessary, after processing. This is the case of the uranium and plutonium obtained from spent nuclear fuel* reprocessing, or the technetium used in medicine. France made the decision to reprocess the spent fuel from its nuclear power plants, with up to 96% of the materials being reusable as a raw material in the fabrication of various fuels, while the rest (about 4%) is waste.

The categories[2] of radioactive waste and their management routes

CATEGORY	**Very short-lived waste** containing radionuclides* with a half-life < 100 days	**Short-lived waste** in which the radioactivity comes mainly from radionuclides with a half-life ≤ 31 years	**Long-lived waste** mainly containing radionuclides with a half-life > 31 years
Very low-level (VLL)	VSL **Management by radioactive decay on the production site** then disposal through routes dedicated to conventional waste	VLL **Recycling or dedicated surface disposal*** (repository at the Industrial centre for collection, storage and disposal in the Aube *département* – Cires)	
Low-level (LL)		LL/ ILW-SL **Surface disposal** (Aube waste disposal repository – CSA)	LLW-LL **Near-surface disposal** (being studied pursuant to the Act of 28 June 2006)
Intermediate-level (IL)			
High-level (HL)	Not applicable[3]	ILW-LL HLW **Deep geological disposal** (*Cigéo*, planned pursuant to the 28 June 2006 Act)	

2. These are the categories in use in France. They may be different in other countries.
3. There is no such thing as high level, very short-lived waste.

Radioactive waste in France: **key figures**

The radioactive waste present in France is precisely inventoried by Andra. As at the end of 2021, it amounted to about 1,760,000 m³. 10% of this volume accounts for 99% of the radioactivity.

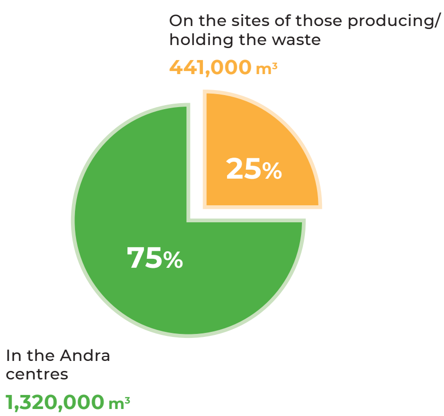
All of the radioactive waste produced in France is monitored and inventoried. Volume, type, location: every year, the waste producers declare their respective production and their forecasts.

All these data are collected and made available to everyone.

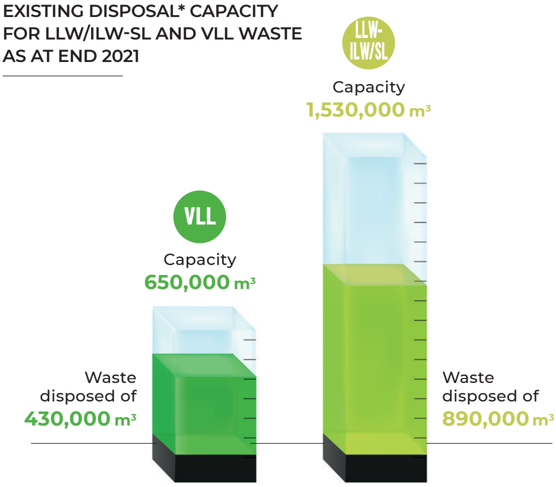
Volumes of waste present on the sites of those producing/holding it or disposed of in the Andra centres as at the end of 2021

VSL 2,170 m³ · VLL 633,000 m³ · LLW/ILW-SL 981,000 m³ · LLW-LL 103,000 m³ · ILW-LL 39,500 m³ · HLW 4,320 m³

LOCATION OF WASTE AS AT END 2021

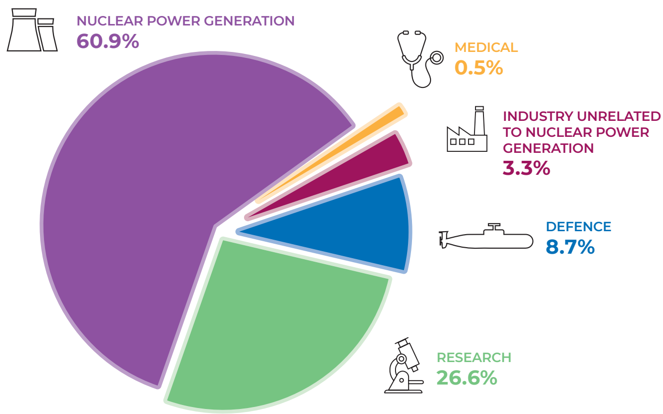


EXISTING DISPOSAL* CAPACITY FOR LLW/ILW-SL AND VLL WASTE AS AT END 2021



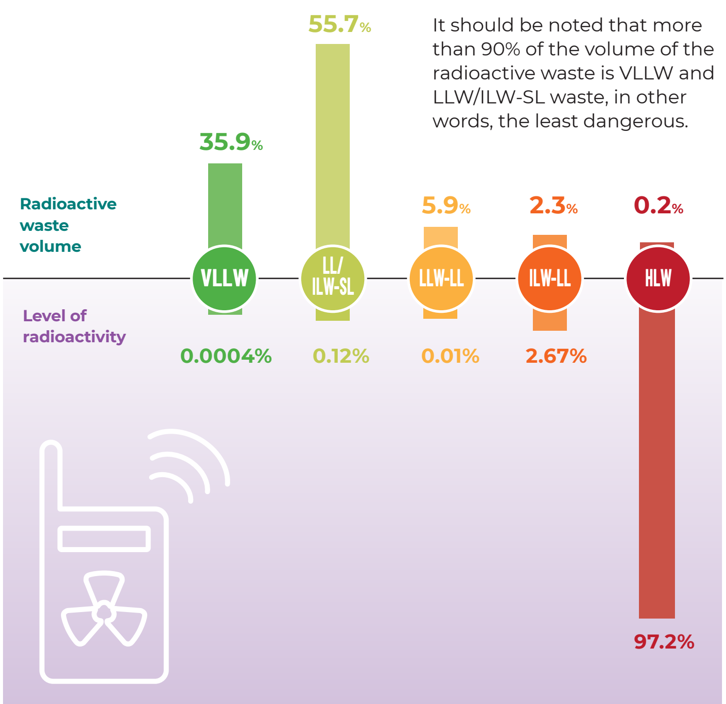
* *See glossary page 34*

Breakdown of waste volume by economic sector (in conditioned equivalent) already disposed of or to be entrusted to Andra, as at end 2021



Breakdown of volumes and levels of radioactivity as at end 2021

It should be noted that more than 90% of the volume of the radioactive waste is VLLW and LLW/ILW-SL waste, in other words, the least dangerous.



Source: National inventory of radioactive waste, Andra, 2023.

35%

of the total volume of radioactive waste is very low-level (VLL)

It comes primarily from the dismantling of nuclear installations and consists of rubble, earth, scrap with very little contamination.

It is disposed of in surface repositories.

55%

of the total volume of radioactive waste is short-lived

It loses half of its radioactivity in periods of 30 years or less. After 300 years, its residual radioactivity is close to natural radioactivity levels. It contains about 0.1% of the total radioactivity. It comes primarily from the operation and maintenance of the nuclear power plants.

It is disposed of in surface repositories.

8%

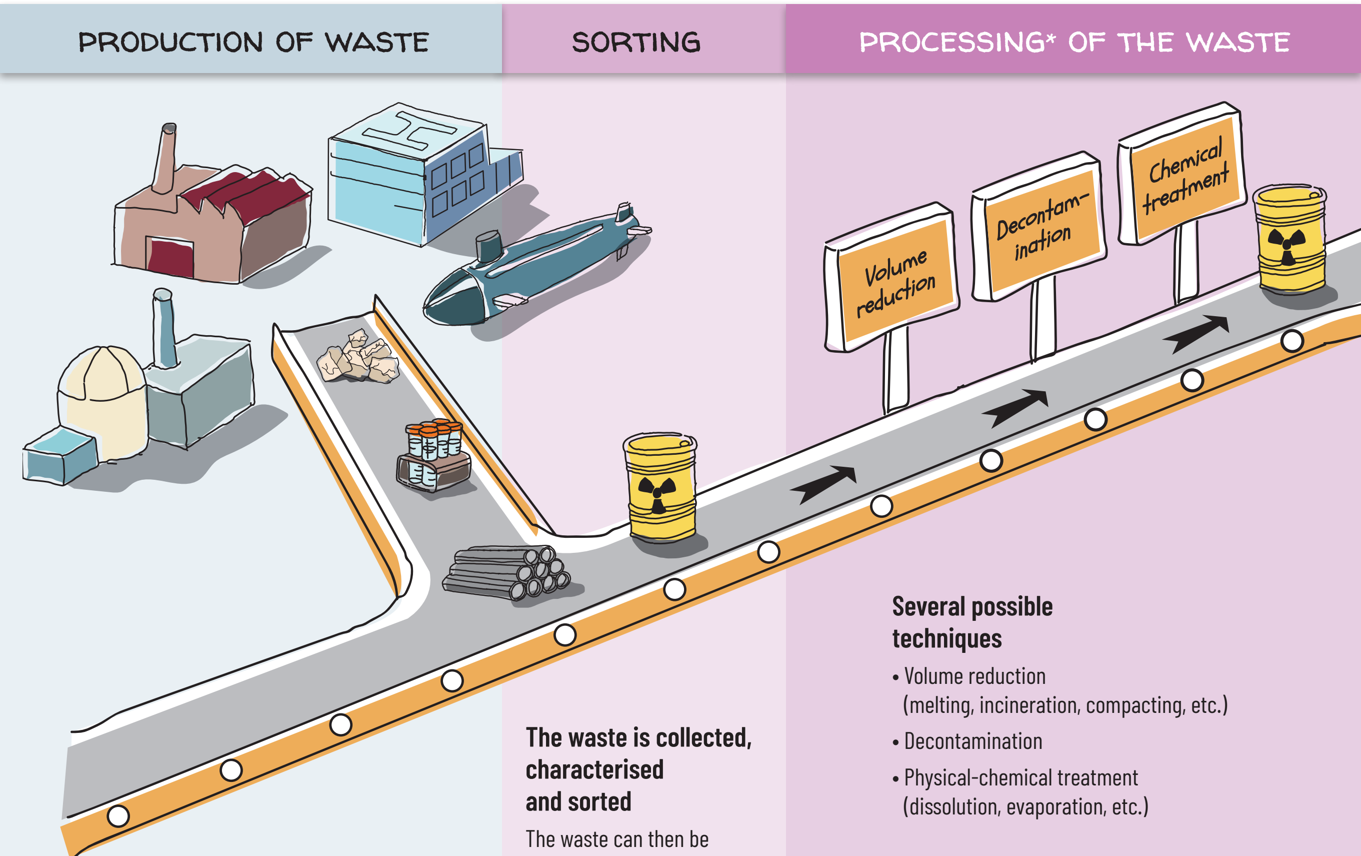
of the total volume of radioactive waste is long-lived

It can remain radioactive for hundreds of thousands of years. 2.5% of it contains 99.8% of the total radioactivity. It comes primarily from the reprocessing* of spent nuclear fuel*. It is conditioned (vitrified) and stored at La Hague, and is intended for disposal at depth. 6% is low-level waste. It comes from various activities, most of which date from far in the past.

It is stored, pending the definition of a management solution. A dedicated repository is currently being studied.

The steps in radioactive waste management

After being used for its energy-producing, medical or industrial properties, and after possibly being reused further to reprocessing, the radioactive material becomes a waste which must be managed in a manner appropriate to the danger it represents.



Preventing and reducing the production and harmfulness of the waste

This fundamental principle is enshrined in the regulations. The waste producers must present and justify their actions in this respect.

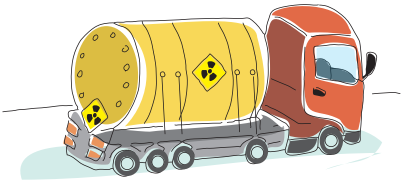
The waste is collected, characterised and sorted

The waste can then be conditioned as an interim (non-systematic) or final solution, having first been reprocessed if necessary.

Several possible techniques

- Volume reduction (melting, incineration, compacting, etc.)
- Decontamination
- Physical-chemical treatment (dissolution, evaporation, etc.)

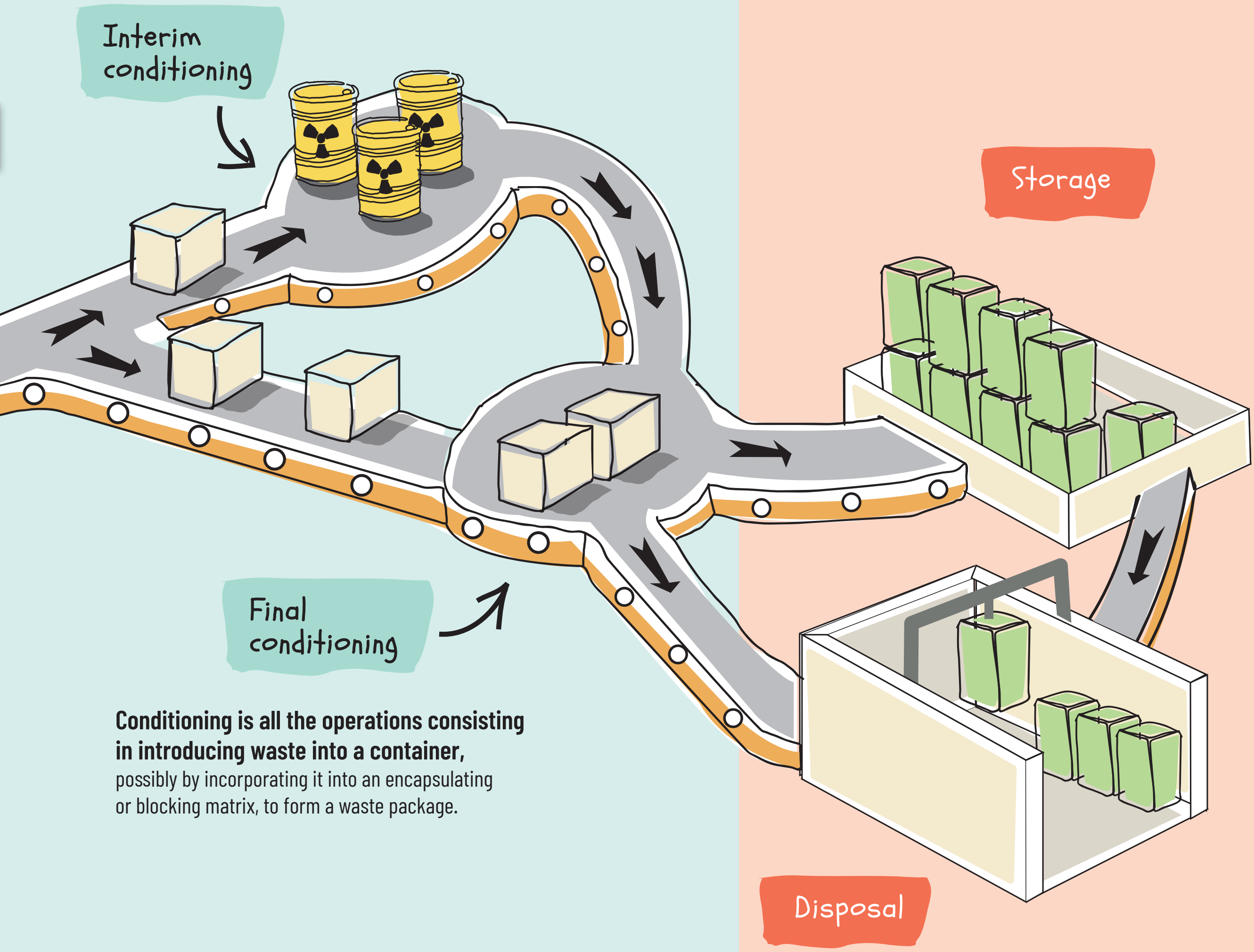
* See glossary page 34



There are significant safety issues in the transport operations involved in waste management (in particular for spent fuel shipments). The packages must be approved by ASN, after a technical examination by IRSN.*

This handbook does not aim to cover all the issues and regulations in force in the transport of radioactive waste.

CONDITIONING*	STORAGE* AND DISPOSAL*

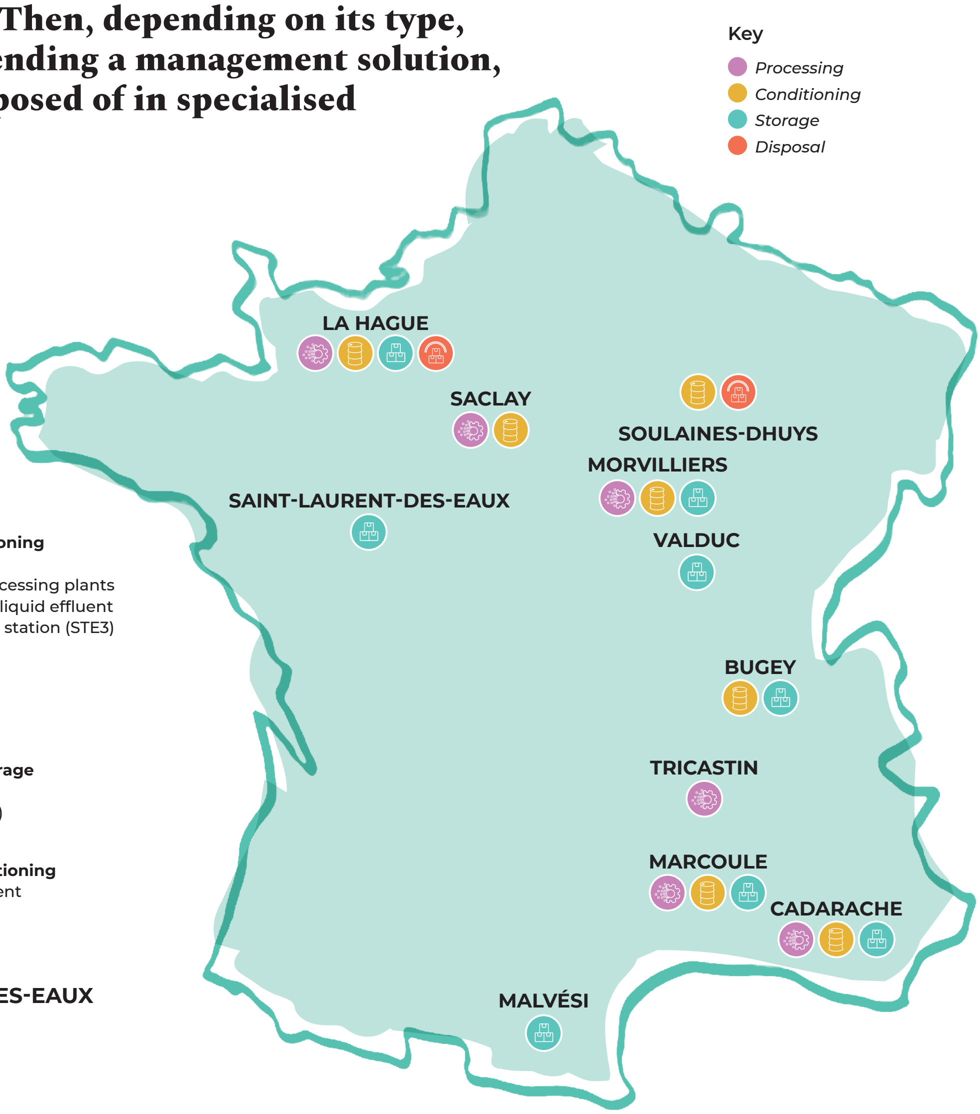


Conditioning is all the operations consisting in introducing waste into a container, possibly by incorporating it into an encapsulating or blocking matrix, to form a waste package.

The protection of human health and the environment (article L. 593-1 of the Environment Code) is monitored by ASN at each step in the management process.

Where is the radioactive waste in France?

Radioactive waste is processed and then conditioned. Then, depending on its type, it is stored pending a management solution, or finally disposed of in specialised repositories.



LA HAGUE

BNI 66
● **Disposal**
Manche repository (CSM)

BNI 116, 117, 118
● ● ● **Processing, conditioning and storage**
Spent fuel elements reprocessing plants (UP3-A and UP2-800) and liquid effluent and solid waste treatment station (STE3)

SACLAY

BNI 72
● ● **Conditioning and storage**
Solid radioactive waste management zone (ZGDS)

BNI 35
● ● **Treatment and conditioning**
Liquid Effluent Management Zone (ZGEL)

SAINT-LAURENT-DES-EAUX

BNI 74
● **Storage**
Storage of irradiated graphite sleeves

MALVÉSI

BNI 175
● **Storage**
Contained storage of conversion residues (Écrin)

MORVILLIERS

ICPE [4]
● ● ● **Conditioning, storage and disposal**
Industrial centre for grouping, storage and disposal (Cires)

SOULAINES-DHUYS

BNI 149
● ● **Conditioning and disposal**
Aube repository (CSA)

*See glossary page 34

VALDUC

● **Storage**
Military tritiated waste storage building

BUGEY

BNI 173
●● **Conditioning and storage**
Activated waste conditioning and storage facility (Iceda)

TRICASTIN

BNI 138
● **Processing**
Clean-out and uranium recovery facility (IARU – formerly Socatri)

MARCOULE

BNI 177
● **Storage**
Irradiating or alpha waste from decommissioning (Diadem)

DBNI [5]
●● **Processing and conditioning**
CDS

DBNI [5]
●● **Processing and conditioning**
STEMA

BNI 160
●● **Processing and conditioning**
Low-level waste processing and packaging centre (Centraco)

CADARACHE

BNI 171
● **Processing**
Advanced effluent management and treatment facility (Agate)

BNI 164
● **Storage**
Radioactive waste conditioning and storage facility (Cedra)

BNI 37-A
●● **Treatment and conditioning**
Solid Waste Treatment Station (STD)

ICPE [4]
●● **Conditioning and storage**
Rotonde

PROCESSING

Radioactive waste must be processed prior to safe final disposal. This processing comprises the collection and sorting of the waste, reduction of its volume and modification of its chemical composition and physical properties, for example by concentrating liquid waste, and finally conditioning to immobilise it in a packaging before storage and final disposal.

CONDITIONING

Conditioning is the operation which consists in placing the waste in a container suited to its level of radioactivity and lifetime and if necessary, immobilising it in a blocking or encapsulating material. The most widely used of these processes are cementation, encapsulation with bitumen or polymer resins, and vitrification.

STORAGE

The storage of radioactive materials or waste consists in placing these substances for a temporary period in a surface or near-surface storage facility specially fitted out for the purpose, with the aim of subsequently retrieving them. Waste is stored on the sites in specific facilities before being sent to disposal routes*.

DISPOSAL

Disposal in a deep geological formation enables the high level, long-lived (HLW-LL) waste to be definitively placed in a site guaranteeing its containment*, while keeping the option of recovering it should it prove necessary or opportune (this is the concept of "reversibility*"). The other waste categories, which are less dangerous, can be disposed of in surface repositories (CSA) or near-surface repositories (disposal facility planned for LLW-LL waste).

4. Installation Classified for Protection of the Environment.
5. Defence Basic Nuclear Installation.

Images of waste surveillance

Processing*, conditioning*, transport, storage*, disposal*, etc., strict surveillance is carried out on the waste at each step. ASN's oversight aims on the one hand to verify correct application of the regulations regarding waste management on the production sites (for example with respect to zoning, conditioning or checks carried out by the licensee); and on the other to verify the safety of the specific facilities for radioactive waste management (waste processing, conditioning, storage and disposal facilities).
This oversight is exercised in a manner proportionate to the nuclear safety issues associated with each waste management step and each facility.

PRODUCTION OF GLASS FOR THE HIGH-LEVEL WASTE VITRIFICATION PROCESS

Credits: CEA/Y. Audic and PF. Grosjean

INSPECTION AT CEDRA IN CEA'S CADARACHE CENTRE

Package handling tool with on board camera.

Credits: ASN/W. Guidarini

* See glossary page 34

INSPECTION AT CEDRA IN CEA'S CADARACHE CENTRE

Intermediate level package storage pit.

Credits: ASN/W. Guidarini

BURE UNDERGROUND LABORATORY

Excavation of a drift.

Credits: ASN

LA HAGUE

T7 vitrification unit.

Credits: Orano/C. Crespeau

TRANSPORT INSPECTION IN VALOGNES

Loading a waste package onto a truck.

Credits: ASN/D. Sohier

Close-up on some of the facilities devoted to processing, conditioning or storage of radioactive waste

Each site specialises in specific activities, ranging from processing* to disposal*, including conditioning* and storage*.

Centraco

Activities: processing and conditioning
Types of waste: very low level (VLL), low- or intermediate-level short-lived (LLW/ILW-SL)
Licensee: Cyclife France, subsidiary of EDF
Location: Codolet (Gard *département*)
Commissioned: 1996

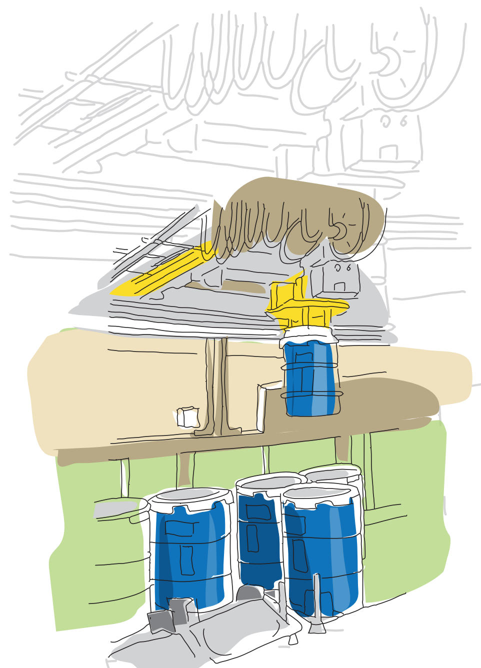
This facility is unique in France. The low-level waste processing and conditioning centre (Centraco – BNI* 160) houses:

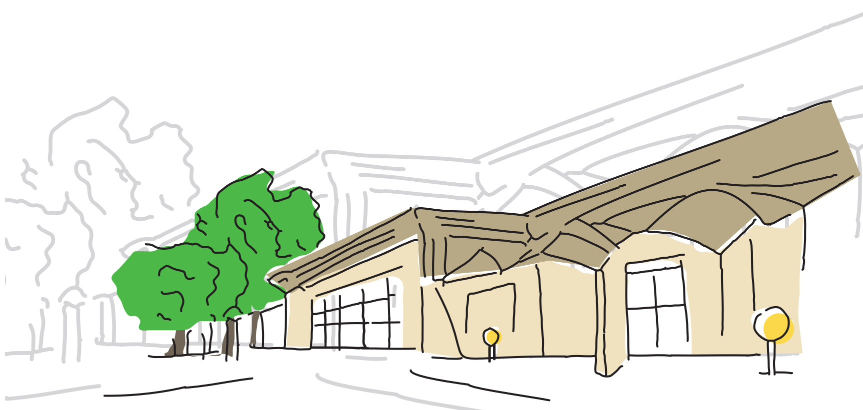
- a **fusion unit**, where metal waste is melted. Authorisation to incinerate 3,500 tonnes of waste per year;
- an **incineration unit**, where solid and liquid fuel waste is processed (LLW/ILW-SL waste). Authorisation to incinerate 3,000 tonnes of solid waste and 3,000 tonnes of liquid waste per year;
- a **storage area**.

Apart from waste processing, the purpose of the industrial site is also to:

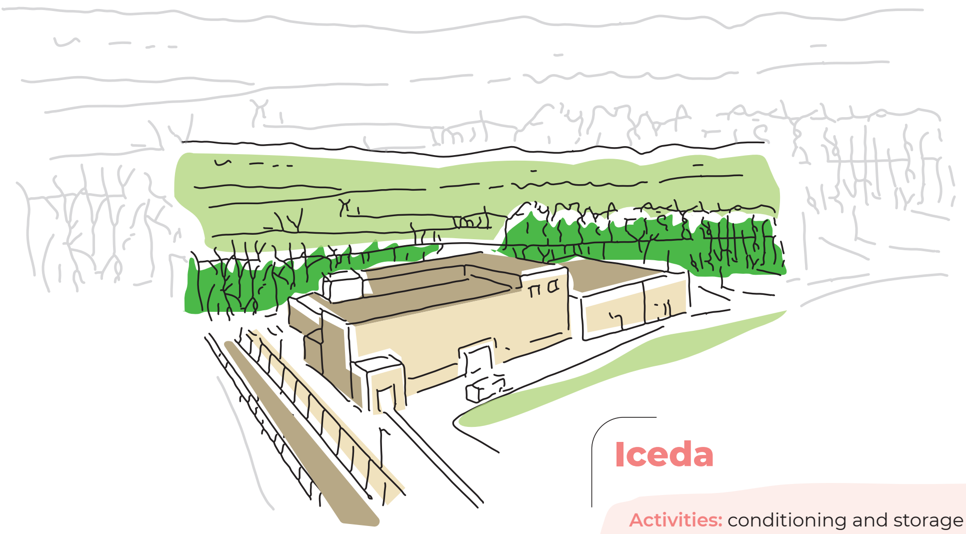
- characterise the waste;
- reduce its volume to optimise storage capacity (this is referred to as "volume reduction" of the waste);
- condition the residues, after processing (melting or incineration), in the form of packages intended for disposal.

The packages are then entrusted to Andra for final disposal.





* *See glossary page 34*



Iceda

Activities: conditioning and storage
Types of waste: low- or intermediate-level short-lived (LLW/ILW-SL), low-level long-lived (LLW-LL), intermediate- level long-lived (ILW-LL)
Licensee: EDF
Location: Saint-Vulbas (Ain *département*)
Commissioned: 2020

The activated waste conditioning and storage facility (Iceda – BNI 173) was commissioned in 2020 and is operated by EDF. It was designed to **accept, condition and store several categories of radioactive waste**, including:

- LLW-LL graphite waste from the decommissioning of the Bugey 1 Gas-Cooled Reactor (GCR) and intended for near surface final disposal;
- ILW-LL activated metal waste from the operation of the EDF nuclear power plants in service and the decommissioning of the 1st generation NPPs and Creys-Malville;
- certain ILW-SL waste, referred to as "deferred transfer". This waste, which is intended for surface disposal, requires radioactive decay of several years to several decades, before final disposal in the Aube repository (CSA).

The site received a first package of waste from the decommissioning of the Chooz A NPP (Ardennes *département*), in September 2020.

Cires

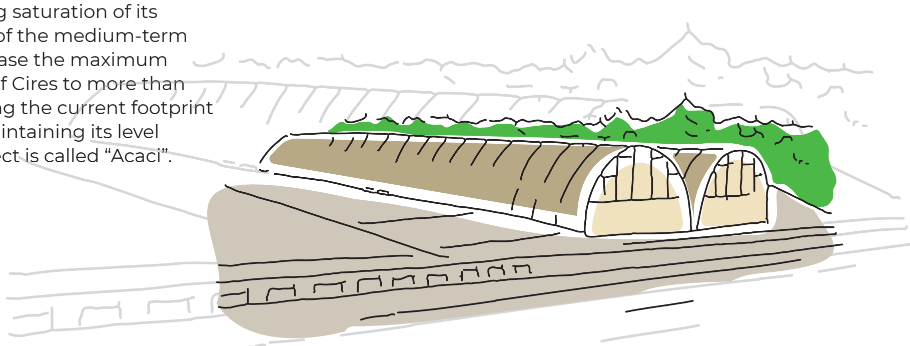
Activities: conditioning, storage and disposal
Type of waste: very low-level (VLL)
Licensee: Andra
Location: Morvilliers (Aube *département*)
Commissioned: 2003

Industrial centre for collection, storage and disposal (Cires, Installation Classified for Protection of the Environment (ICPE), is devoted to:

- **disposal of VLL waste**, since it was commissioned in 2003;
- **grouping of radioactive waste**, from activities other than nuclear power generation, and the storage of some of the waste for which there is no final management solution, since 2012;
- **sorting and processing of radioactive waste**, from activities other than nuclear power generation, since 2016.

This centre covers a total area of 46 hectares, 18 of which are set aside for the disposal of VLL waste. It is authorised to accept 650,000 m³ of waste.

The site runs the risk of seeing saturation of its capacity by about 2030. One of the medium-term solutions proposed is to increase the maximum authorised storage capacity of Cires to more than 900,000 m³, without modifying the current footprint of the disposal zone while maintaining its level of safety. This expansion project is called "Acaci".



Aube repository (CSA)

Activities: conditioning and disposal
Types of waste: low- and intermediate-level short-lived (LLW/ILW-SL)
Licensee: Andra
Location: Soulaines-Dhuys (Aube *département*)
Commissioned: 1992

The Aube repository (CSA) covers 95 hectares, 30 of which are set aside for disposal*. The centre has an authorised disposal capacity of one million cubic metres of LLW/ILW-SL waste.

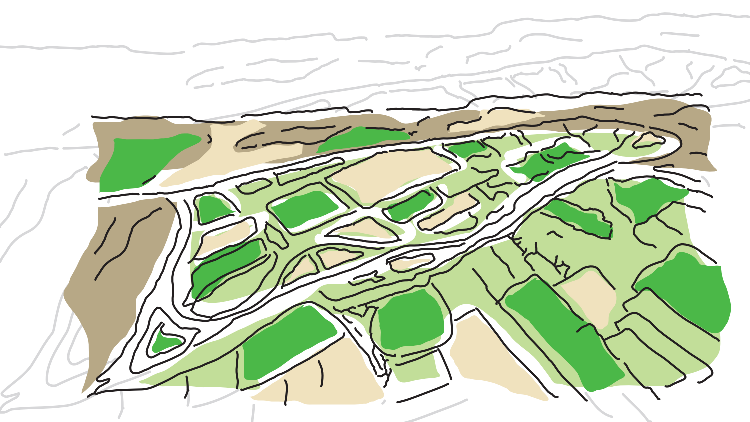
The LLW/ILW-SL waste emplaced in the CSA is conditioned in concrete or metal packages. These packages are placed in reinforced concrete structures 25 metres on a side and 8 metres high, which have been built in stages. Once filled, these structures are closed by a concrete slab, which is made leaktight by an impermeable cover.

At the end of operation, a cover consisting notably of clay will be placed over the structures to ensure the long-term containment* of the waste. Once the maximum capacity has been reached, the CSA will continue to be monitored for at least 300 years.

At the end of 2022, the volume of waste disposed of in the CSA was about 371,500 m^3, or 37% of the authorised maximum capacity.

La Hague

Activities: reprocessing, conditioning and storage
Types of waste: all types
Licensee: Orano
Location: La Hague (Manche *département*)
Commissioned: 1986 à 2002



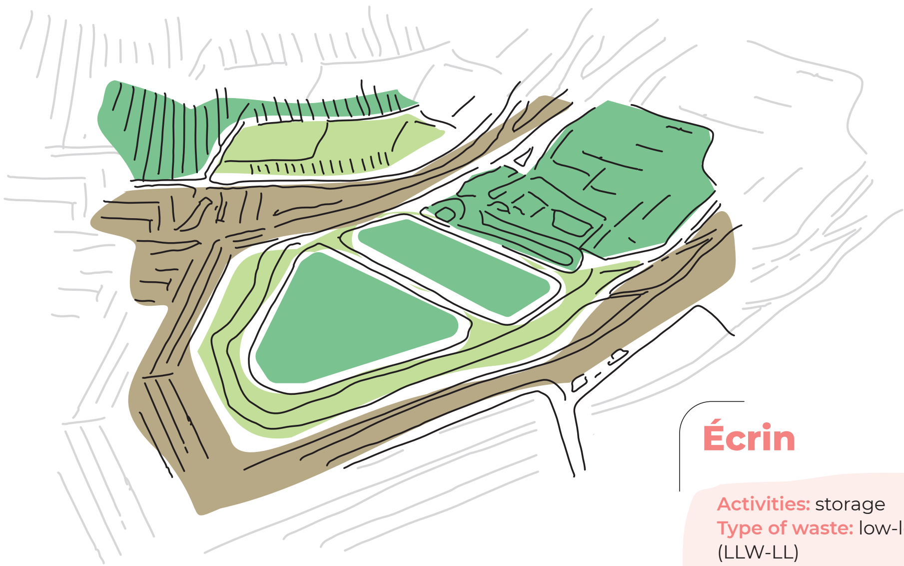
The site houses several units (UP3-A and UP2-800) performing a variety of operations: storage* of spent fuel* assemblies; shearing and dissolution of these assemblies; chemical separation of fission products*, of uranium and plutonium making up the fuels; purification of the uranium and plutonium; treatment of effluents; conditioning* of the waste.

Orano is promoting two projects to increase the spent fuel storage capacity at La Hague: one concerning the densification of the existing pools, while the other longer-term project aims to create a dry storage facility.

The fission products resulting from reprocessing of spent fuels are concentrated, vitrified and conditioned in Standard Vitrified Waste Packages (CSD-V). The pieces of fuel assembly metal cladding are conditioned in Standard Compacted Waste Packages (CSD-C). This solid waste is stored on the La Hague site pending a final disposal solution (see *Cigéo* project p. 22 and 23).

The site is also concerned by legacy radioactive Waste Retrieval and Conditioning (WRC*) operations. In 2022, technical difficulties delayed the retrieval of waste from silos 115 and 130 and the processing* of the sludges produced during effluent treatment.

See glossary page 34



Écrin

Activities: storage
Type of waste: low-level long-lived (LLW-LL)
Licensee: Orano Chimie-Enrichissement
Location: Narbonne (Aude *département*)
Commissioned: 2018

The "Contained storage of conversion residues" facility (Écrin – BNI 175) is located on a base of mining waste rock and treatment residues from a former sulphur mine. **It consists of two storage ponds for the used sludges** (ponds B1 and B2) from the Orano Chimie-Enrichissement plant (formerly Orano Cycle) at Malvési.

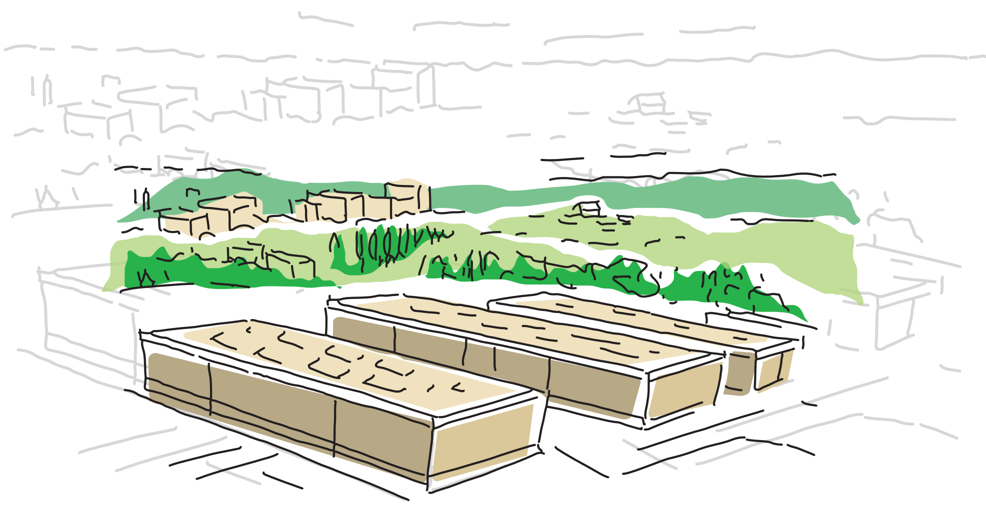
The site is authorised to store radioactive waste for a period of 30 years, with a waste volume limited to 400,000 m^3, and contains radioactive waste produced during the refining and conversion of uranium concentrates in the Orano Chimie-Enrichissement plant at Malvési, already contained in ponds B1 and B2, along with the solid residues from the drainage of ponds B5 and B6.

Cedra

Activities: storage
Type of waste: intermediate-level long-lived (ILW-LL)
Licensee: Alternative Energies and Atomic Energy Commission (CEA)
Location: Saint-Paul-lez-Durance (Bouches-du-Rhône *département*)
Commissioned: 2006

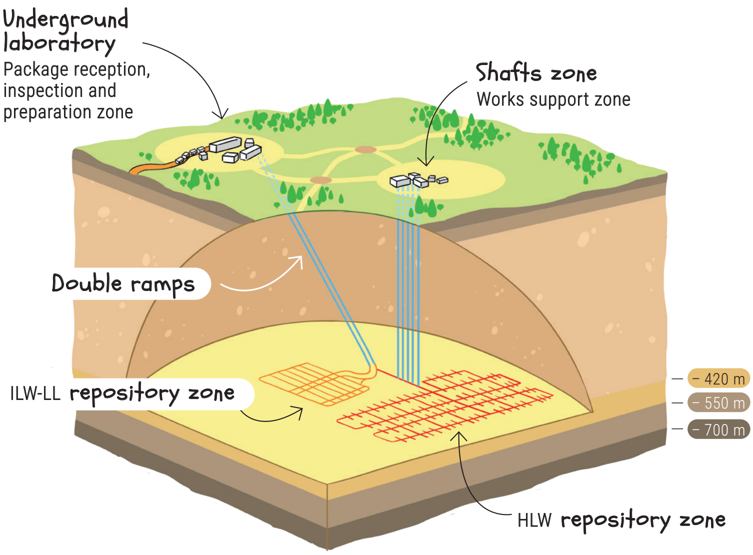
Since 2006, the purpose of the "radioactive waste conditioning and storage" facility (Cedra – BNI* 164) has been the storage of ILW-LL waste, pending the opening of appropriate disposal routes*. **Cedra stores radioactive waste from CEA's research laboratories**.

The site is running a serious risk of saturation: CEA anticipates saturation of the facility by about 2030. Studies on a project to increase Cedra's storage capacity began in 2020.



The case of **HLW-ILW/LL radioactive waste**

The *Cigéo* project is intended for the deep geological disposal* of high level and intermediate level long-lived waste (HLW/ILW-LL) in order to protect human health and the environment from the very long-term radiological and chemical hazards linked to these wastes.



THE BURE UNDERGROUND LABORATORY (MEUSE *DÉPARTEMENT*), situated at a depth of 490 metres, is a unique research tool for the *Cigéo* project. Its underground drifts allow in-situ study of a layer of clay 160 million years old, along with various concepts and techniques that could be used to construct the *Cigéo* facility.

The geological disposal industrial centre (*Cigéo*) will consist of surface facilities and an underground facility.

The surface facilities will primarily be used to accept and check the waste packages. The underground facility, located at a depth of about 500 metres, and comprising nearly 300 km of tunnels, will represent a surface area of about 15 km^2 where the waste packages will be emplaced by robotic systems in horizontal tunnels called "vaults" excavated in a layer of argilite.

The safety of *Cigéo* is based notably on the physical properties of this geological layer, which offers sufficient mechanical strength and prevents the migration of radionuclides* to the surface.

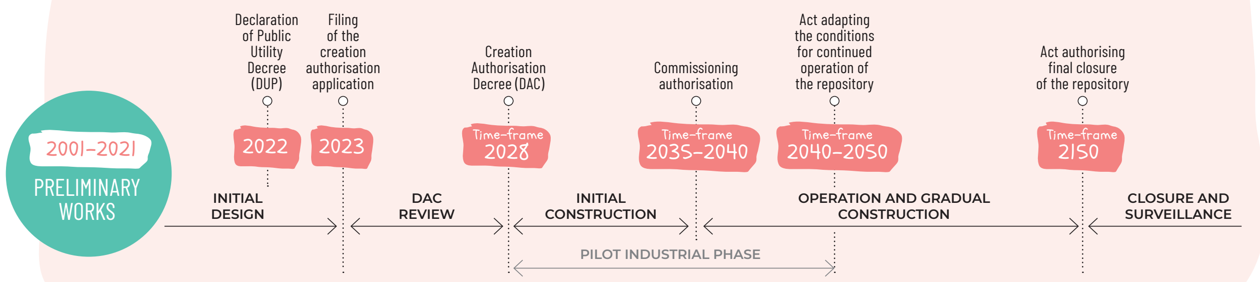
The choice of deep geological disposal

Owing to its depth, its design and its location in impermeable clay rock and a stable geological environment, this type of repository shelters the waste from human activity and natural events on the surface (such as erosion), while isolating the HLW and ILW-LL waste from human activity over a very long time-scale. This is the preferred solution internationally and was chosen by France *via* the Bataille Act (1991). These disposal zones will be developed on a modular basis over a period of a century, to allow the gradual construction of the vaults in which the waste packages will be emplaced (*see diagram*).

These packages represent a volume of 85,000 m^3. Once all the waste packages are emplaced,

* See glossary page 34

THE MAIN STEPS ENVISAGED IN THE *CIGÉO* PROJECT



the underground facility will be closed to guarantee the containment* of the waste over a very long time period, without requiring any human intervention and once the surface facilities have been dismantled. A surveillance phase of several hundred years will then begin.

Operation of the site will last for about a century and the risks linked to a nuclear installation cannot be ignored: criticality*, fire, containment, ventilation, falling packages, etc. In the design of the facility, the specific aspects are studied: depth, size, operating lifetime, etc.

The reversibility* requirement

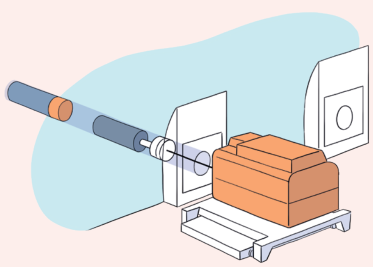
The disposal of waste in *Cigéo* will have to be reversible for a period of at least 100 years, in other words, it will be possible to extract the packages during this period in the event of a problem.

Inventories

The inventory to be adopted by Andra for the studies and research conducted with a view to designing the *Cigéo* disposal facility includes a reference inventory and a reserve inventory.

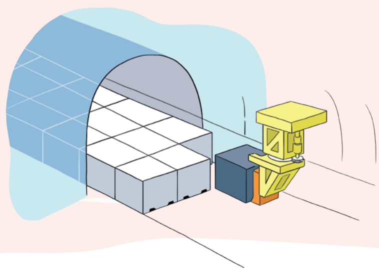
- **The reference inventory** takes account of all high level and intermediate level long-lived (HLW and ILW-LL) waste already produced and to be produced by the existing nuclear facilities (nuclear power plants, research centres, etc.), as well as that to be produced by the authorised nuclear facilities (Flamanville EPR, ITER, Jules Horowitz experimental reactor), assuming an average reactor operating life of 50 years.
- **The reserve inventory** take into account the uncertainties associated more specifically with putting in place new waste management routes* or with changes in energy policy. Thus, for the waste from the "new reactors" to be built (in particular six EPR 2), Andra shall be required to examine the waste to be included in the reserve inventory and ensure that the *Cigéo* adaptability studies enable it to be accepted.

CIGEO PROJECT DISPOSAL VAULTS



HIGH-LEVEL WASTE (HLW) PACKAGES

These will be emplaced in vaults about a hundred metres long and about 70 cm in diameter, with a metal liner.



INTERMEDIATE-LEVEL LONG-LIVED WASTE (ILW-LL)

These will be emplaced in horizontal disposal vaults a few hundred metres long and about ten metres in diameter.

POTENTIAL SOLUTIONS
for the future

A new project will be able to manage waste for which there is as yet no disposal solution*. In addition, thanks to technical progress, the radioactive wastes could be made less dangerous or less numerous. Overview of the potential solutions for the future.

THE LLW-LL WASTE REPOSITORY PROJECT

Since 2008, Andra has been studying a project for a LLW-LL waste repository. The project concerns a waste repository* in a clay layer at a depth of about thirty metres, at Vendeuvre-Soulaines, in the Aube *département*. It would be able to isolate the waste from human activity and erosion, limit the circulation of water in the repository and delay the transfer of radionuclides* to the biosphere. At the beginning of 2024, Andra will produce a file presenting the technical and safety options chosen for this facility.

NUCLEAR FUSION

In the fission process, heavy atoms are broken into several pieces by bombarding them with neutrons. In the fusion process, the opposite happens: **matter is compressed with such force that two light atoms merge into a single heavier atom**.

A fusion reactor would not therefore produce the same radioactive waste as the current NPPs (fission products*, actinides*, etc.) but lower level tritiated waste with a shorter lifetime.

However, the production of electricity using nuclear fusion still has to overcome significant technological hurdles.

FAST-NEUTRON REACTORS (FNRS)

This type of reactor produces fission reactions from a wide variety of fuels, spent fuels* in particular. For example, they can use the plutonium produced by the existing fleet of Pressurised Water Reactors (PWRs). They are also capable of running on natural uranium, with an energy efficiency higher than the current fleet, thereby using all of the natural uranium.

Finally, in certain conditions, some FNRs are able to transform the minor actinides* (americium, neptunium and curium) contained in high level radioactive waste into shorter lived elements. This transformation, called "transmutation*", would reduce the emission of heat and the inherent radiotoxicity of the ultimate waste.

RECYCLING OF VERY LOW-LEVEL WASTE (VLLW)

Recycling of some of the VLL metal materials would be one way of optimising waste disposal capacity by reducing the quantities of waste to be disposed of, and thereby the corresponding land artificialisation. This would also lead to savings in raw materials, which would be replaced by the recycled waste.

In concrete terms, this involves melting the waste, eliminating the contaminated fraction and using it to manufacture objects or structures.

SEPARATION/TRANSMUTATION

Separation/transmutation processes aim to isolate and then transform the long-lived radionuclides in radioactive waste into shorter-lived radionuclides or even stable elements. This would have an impact on the sizing and design of the repository, by reducing the thermal power, the harmfulness of the waste emplaced and the volume of the repository.

ASN considers that if transmutation studies were to be continued, they should cover the radioactive substances currently categorised as materials, or the waste produced by a future fleet of reactors.

* See glossary page 34

Radioactive waste management around the world

Although some countries have to manage radioactive waste from the nuclear industry, virtually all countries in the world have to manage radioactive waste from various medical and industrial applications.

For a large number of countries, the safe management of radioactive waste entails the construction of disposal sites in which the waste is in principle emplaced definitively. This type of repository exists around the world **for the lowest level waste**. These are generally surface, or near-surface sites.

For high level waste, the repository must be built at depths of several hundred metres, in order to guarantee the containment* of this waste for several thousand years.

Several types of rocks are preferred to accommodate this type of waste (clay, granite, salt, etc.). The construction of deep geological repositories represents a major investment. If it is to be seen through to completion, this type of project requires long-term involvement by Governments and Parliaments.

For the time being, no repository of this type is in operation in the world, but projects in several countries – including Finland – are well advanced.

However, as in the United States, which have abandoned their geological disposal project, numerous countries – including some industrialised nations – have postponed the decision and are thus adopting a *de facto* long-term storage policy.

Sweden

In 2022, Sweden authorised the construction of a geological repository (granite rock) in Östhammar for spent fuel, with operations planned to start between 2030 and 2035.

Sweden also has a centralised disposal facility on the Forsmark site, devoted to LLW/ILW-SL waste. For LLW/ILW-LL waste, Sweden is envisaging a specific geological repository.

Canada

A spent fuel* repository* project has been studied since 2007. Two sites in Ontario were pre-selected in 2019. The final choice should be made in 2024.

The construction permit application is expected in 2029 with construction planned to begin in 2033 with commissioning as of 2043. For LLW/ILW-LL waste, a geological repository at a depth of 600 m is envisaged close to the Bruce NPP.

A sub-surface repository is also being studied for low level waste from the research activities conducted at the Chalk River national laboratory. These two projects have not however been approved by the local populations. The consultation processes are ongoing.

Spain

Spain envisages creating a geological repository site for HLW waste. Candidate sites should be selected in 2032.

The country has surface and near surface disposal facilities for VLL and LLW/ILW waste on the El Cabril site. The concepts used in these facilities are similar to those employed in France (Cires and CSA).

United States

The spent fuel geological repository project on the Yucca Mountain site (Nevada), which has been studied since the 1980s, was abandoned in 2011 for political reasons, notably as a result of strong local opposition.

The search for a new site has begun, but none has so far been selected. In-situ dry storage* of the spent fuel is so far the preferred management method. The United States also has a geological repository, the WIPP, located in New Mexico, for transuranic waste from defence programmes (disposal in a layer of salt at a depth of about 650 metres). Civil LLW/ILW waste is disposed of in near surface facilities.

Ghana

Ghana has an advanced project for disposal of used sources in pits (depth of 150 metres) with the technical support of the American and Canadian safety regulators.

Two pits were constructed for testing purposes. The safety file was reviewed by the IAEA* in 2019 and the creation authorisation application is currently being examined by the authorities.

* See glossary page 34

Finland

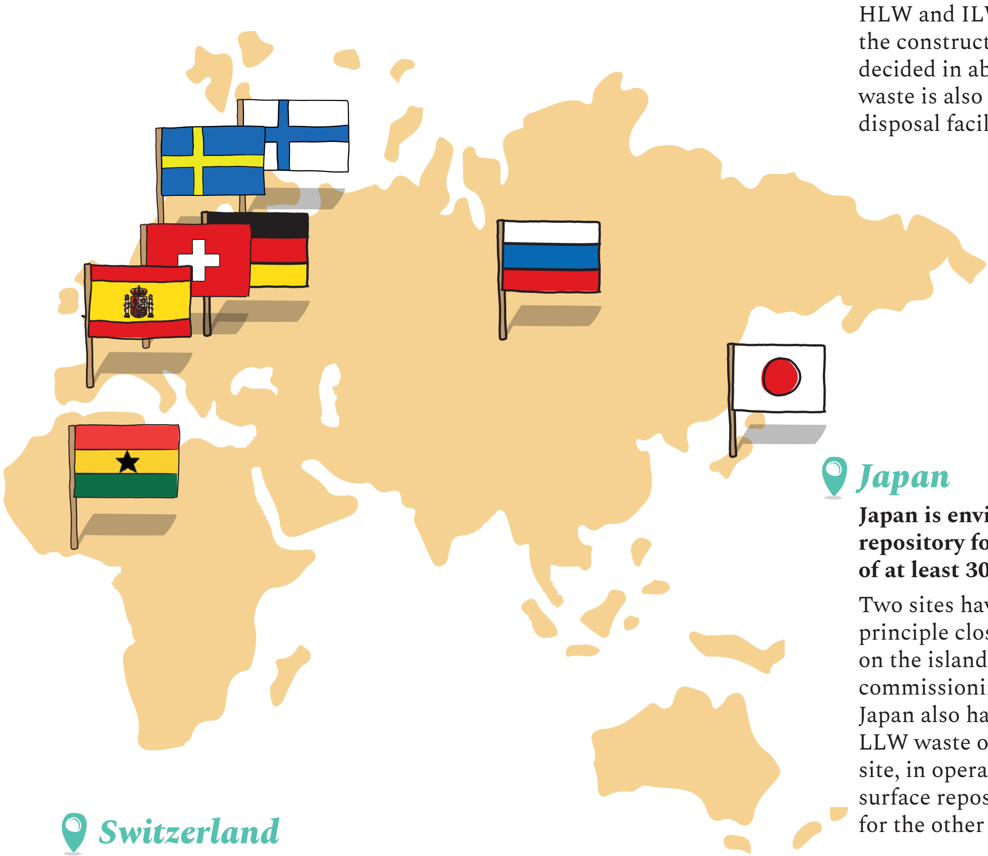
Finland is the first country to have authorised the construction of a deep geological repository (in granite rock) for HLW waste and spent fuel.

The repository is built as an extension to a research laboratory situated at a depth of 400 metres, in Olkiluoto. Commissioning is scheduled for 2025. Since the 1990s, Finland has also had near-surface disposal facilities (between 60 and 110 metres) for LLW/ILW waste on its two nuclear sites (Olkiluoto and Loviisa).

Russia

An underground laboratory for evaluating the feasibility of a deep geological repository for HLW and ILW-LL waste is under construction in the granite formation of Nijnekanski, in the Krasnoyarsk region of Siberia.

This site should also house the future HLW and ILW-LL waste repository, the construction of which could be decided in about 2025. The LLW/ILW waste is also being managed in several disposal facilities.



Japan

Japan is envisaging a geological repository for HLW waste at a depth of at least 300 metres.

Two sites have been identified in principle close to the Tomari NPP on the island of Hokkaido, with commissioning planned as of 2035. Japan also has a disposal facility for LLW waste on the Rokkasho Mura site, in operation since 1995. A sub-surface repository is being envisaged for the other LLW waste.

Switzerland

Switzerland intends to dispose of radioactive waste and spent fuel in a deep geological layer of clay (between 500 and 1,000 metres depth).

The Nördlich Lägern site was chosen in 2022. After the statutory procedure, this decision should be ratified by a popular referendum currently scheduled for about 2031. Commissioning is envisaged as of 2050 for the ILW-LL waste and 2060 for the HLW.

Germany

Germany intends to create a deep geological repository for HLW waste.

Potential sites are currently being identified. The siting choice is envisaged for 2031, with commissioning as of 2050. For LLW/ILW, disposal is planned on the Konrad site (former iron mine) at a depth of 800 metres. Construction started in 2023 with commissioning scheduled for 2030.

The French population and radioactive waste

Radioactive waste is one of the major concerns of the French population, which wishes to see firm action by the public authorities in this field. Involvement of the public is thus crucial so that they can be informed, take part in the drafting of projects and enhance the legitimacy of the decisions taken by the stakeholders.

How does the French population perceive radioactive waste [6]?

The production of radioactive waste remains a major argument against nuclear energy, even more so than the risk of accident. However, since 2019, the share of the French population associating radioactive waste with a high level of risk has been falling (48% in 2022 as compared with 57% on average between 1997 and 2018).

When it comes to waste management, 33% of the French population in 2022 considered that it is now "possible to dispose of radioactive waste safely", or 3 points more than the previous year. Moreover, most of the French population (68%) want to see rapid decision-making and action on this subject, with only 6% of them stating that the most reasonable position is to "leave the choice up to future generations". This opinion has indeed been unchanged since 2005.

Public participation

To accompany this strong concern on the part of society, new methods of consultation have been proposed to the public in recent years. One could mention the public debate and then the ongoing consultation on the *Cigéo* deep geological repository* project, the public debate concerning the 5th edition of the PNGMDR*, and the public consultation regarding the increased capacity of the industrial centre for the disposal of very low-level radioactive waste (Acaci).

For its part, ASN consults the public on each draft resolution concerning radioactive waste, via its website *asn.fr*. During its review of the *Cigéo* creation authorisation application, ASN for the first time conducted a consultation exercise with the stakeholders (producers, NGO, Anccli, Bure CLI and CLIS) concerning the draft of the referral sent to IRSN.

ASN's aim is thus to dialogue with the stakeholders, in order to understand and identify their primary expectations and concerns regarding nuclear safety* and radiation protection*, so that they can be considered in the technical review of the *Cigéo* creation authorisation application. The information collected will contribute to the selection, ranking and weighting of the technical subjects to be examined during the course of the review.

This consultation takes place within a regulated review period and will therefore be held in accordance with a defined schedule.

6. Results taken from the IRSN 2023 barometer on the perception of risks and safety.

* See glossary page 34

The public debate on the 5th edition of the PNGMDR

The National Commission for Public Debate (CNDP) decided to hold a public debate from 17 April to 25 September 2019, prior to the drafting of the 5th edition of the PNGMDR.

ASN and the General Directorate for Energy and the Climate (DGEC) produced a project manager's report to present the main issues relating to the drafting of the next Plan, notably the volumes of VLL waste expected from decommissioning and the creation of a deep geological repository.

Ahead of the debate, the Special Commission for Public Debate (CPDP) produced a "controversy clarification" file, aiming to explain the arguments put forward by experts or institutional organisations regarding questions relating to the Plan, in a manner accessible to a non-specialist public.

ASN and the DGEC took part in the debate in order to present the issues and answer questions from the public.

Although the institutional representatives (nuclear licensees, associations, CLIs, experts) were often present in large numbers, participation by the general public remained limited. The participative platform received 86 questions, 442 opinions, 62 individual stakeholder presentations and 22 contributions.

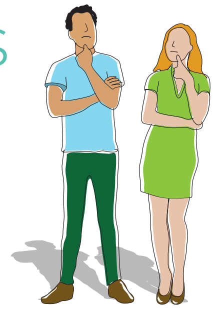
The questions primarily concerned the *Cigéo* project, the management of VLL waste, the separation/transmutation* of radionuclides*, the environmental and health consequences of waste management.

Other subjects were also raised during the public debate: the management of particular waste categories, such as those resulting from the conversion of uranium, legacy waste, mining waste, transportation and health.

The debate was able to explain certain technical controversies, clarify the expectations of the public and nuclear stakeholders and inform the prime contractors with a view to the drafting of the next PNGMDR.

- **6 general subjects meetings** in large cities.
- **14 thematic meetings** in the regions concerned.
- **2 discussion sessions** debating an ethical approach to the management of radioactive materials and waste.
- **A round-table on the question of trust and mistrust** felt by the public with respect to the decisions taken or envisaged.
- **Information and debate stands** in several towns around France.
- **An on-line participative platform** enabling people to express an opinion, submit comments on those already expressed, submit questions to the prime contractor and, for artificial persons, submit an individual stakeholder's presentation and contributions document. In parallel with these participation methods open to all, the CPDP set up some innovative systems.
- **A "mirror group" comprising 14 randomly selected citizens**, which produced a joint contribution on the topic "What did we inherit and what will we leave to our children?"
- **A "tomorrow's specialists workshop"** brought together students from different backgrounds to explore how radioactive waste management can be informed by different disciplines.

Your questions, our answers



Radioactive waste is a sensitive subject in public opinion, which raises both questions and concerns. We will attempt to provide clear answers.

How is radioactive waste management financed?

The Environment Code defines a specific system for financing the management of radioactive waste, which aims to safeguard the financing of nuclear costs according to the "polluter-pays" principle. It is therefore up to the nuclear licensees to take charge of this financing by setting up dedicated assets capable of covering the expected costs. These costs must be prudently evaluated, taking account of various uncertainties (decommissioning, any research and development programmes to be implemented, deployment of new industrial tools, etc.). The licensees are thus obliged to submit three-yearly reports on these costs along with annual update notices to the Government. Provisioning is carried out under direct control of the State, which analyses the situation of each licensee and can prescribe the necessary measures should it be found to be insufficient or inadequate. The General Directorate of the Treasury and the General Directorate for Energy and the Climate (DGEC) constitute the administrative authority with competence for this control. The DGEC asks ASN to issue a technical opinion on the hypotheses adopted by the licensees. ASN also rules on the robustness of the technical scenarios proposed by the licensees and on the justification of the associated schedules.

Whatever the case may be, the nuclear licensees remain responsible for the financing of their long-term costs.

Can renewed interest in nuclear power in France be reconciled with an increasing quantity of waste?

The prospect of an energy policy comprising a long-term nuclear component must be accompanied by an exemplary waste management policy. ASN considers that the necessary decisions must be anticipated so that all types of waste generated by the new nuclear policy (EPR 2 and innovative reactors) have safe and operational management solutions* once they become necessary.

The construction of new reactors would have an impact on the quantities of radioactive waste to be managed in the future, as would, for example, the decision to cease reprocessing spent fuels in the La Hague facilities, or extension of the service life of the reactors currently in operation. Concerning the handling of HLW and ILW-LL waste, see pages 22 and 23.

* *See glossary page 34*

Has radioactive waste been immersed in the oceans?

In the 1950s, some countries discharged their waste into the oceans. In Europe, the United Kingdom and Belgium dumped it into the Casquets trench north-west of the Cape of La Hague, and France did the same at a certain distance off the coasts of Galicia and Brittany.

The dumping of radioactive waste at sea was considered to be safe by the scientific community. The dilution and the presumed duration of isolation offered by the marine environment was felt at the time to be sufficient. No high-level waste was however discharged at sea.

France stopped dumping its waste after 1969. It has built disposal repositories* and storage* facilities on land.

The dumping of waste at sea is now banned by the London Protocol signed in 1996 and ratified in 2006 by 30 countries, including France.

How are the residues from the former uranium mines managed in France?

The working of the uranium mines in France, between 1948 and 2001, led to the production of 76,000 tons of natural uranium. The exploration, extraction and processing* activities concerned about 250 sites, which differed in size and were spread around 27 *départements*. Processing residues from the uranium mines refers to the products remaining after extraction of the uranium from the ore. Their quantity amounts to about 50 million tonnes, which are disposed of on 17 sites, close to uranium ore processing facilities and corresponding to low level or very low level, long-lived types of waste.

Every year, ASN conducts a survey to obtain the opinion of the general public and residents living around NPPs with regard to nuclear safety* in France, and their positions concerning nuclear energy.

Question

Do you consider that in France the precautions taken for the management of radioactive waste, in order to guarantee the safety of the public and the health of the consumer are very satisfactory, relatively satisfactory, not very satisfactory, or not at all satisfactory?

General public

Very satisfactory 5% — Relatively satisfactory 34% — **39%**

BNI residents* 0-10 km

Very satisfactory 6% — Relatively satisfactory 34% — **40%**

BNI residents 11-20 km

Very satisfactory 5% — Relatively satisfactory 43% — **48%**

The general public considers that the precautions taken for radioactive waste management are insufficient.

Survey conducted by Verian in October and November 2023. National sample of 2,008 persons representative of the entire population aged 18 and over.

YOUR QUESTIONS, OUR ANSWERS

Why is spent fuel* not always dealt with as waste?

France today reprocesses the spent fuel from its nuclear power plants, so that it can be partially reused. If this industrial choice were to be called into question in about 2040, this would lead to unprocessed spent fuels being recategorised as waste, with the creation of storage* facilities for this waste, pending its transfer to a management route*. The current PNGMDR* (2022-2026) does not anticipate either the cessation or continuation of reprocessing. ASN has recalled that it was necessary to conduct such studies.

Moreover, the national inventory of radioactive waste, drawn up by Andra every five years, also contains “forecast inventories”. The purpose of these inventories is to estimate the quantities of radioactive materials and waste on different time-scales and according to various scenarios. They aim to present the impact on the quantities of radioactive materials and waste of different strategies or possible changes to France’s long-term energy policy.

How can waste resulting from a nuclear accident be managed?

A nuclear accident can create a large volume of radioactive waste, primarily as a result of environmental decontamination work. The nature of this waste is extremely variable, ranging from liquid waste, to earth, to metal parts, or to perishable waste, for example agricultural crops that could not be sold. Apart from the waste resulting from dismantling of the installation, the radioactivity of most of the waste resulting from environmental contamination is low.

The accident at the Fukushima Daiichi NPP will thus eventually lead to 20 million m^3 of solid waste, mainly earth slightly contaminated by caesium and strontium. These volumes would easily exceed the current capacity of the French disposal* or storage* facilities.

In order to address these issues, the Steering Committee for managing the post-accident phase of a nuclear accident (Codirpa), a pluralistic group chaired by ASN, published its first recommendations in 2023. On the basis of a report from IRSN, the Codirpa assessed the consequences of different decontamination strategies on the quantity and type of waste produced.

For a major accident comparable to that of Fukushima Daiichi, the volume of waste can vary significantly, from 10 to 300 million m^3, depending on the decontamination solutions adopted, in particular for agricultural land.

Given the scale of these volumes, the choices regarding mitigation of environmental contamination must be made consistently with the disposal and storage capacities for the waste that could be generated following the accident. Various options to reinforce the disposal and storage capacity for VLL waste, in the event of an accident in France, were proposed.

The Codirpa also proposed a methodology for characterising and classifying this waste and for reducing its volume.

* *See glossary page 34*

What will happen once *Cigéo* is full?

After the repository is closed, most of the radioactive elements will remain trapped in the repository and the Callovo-Oxfordian layer. Only a few soluble radioactive elements, not trapped by the clay and long-lived (such as iodine-129, chlorine-36 and selenium-79) will migrate in the Callovo-Oxfordian layer by diffusion, slowly and in a limited manner. Andra's long-term scenarios conclude that there is no health or environmental impact. This will take at least several hundred thousand years.

Why is the reprocessed uranium stored at Tricastin considered to be a radioactive material rather than waste?

Reprocessed uranium is obtained from spent fuels – based on enriched natural uranium – used in the pressurised water reactors and which have been reprocessed* in the Orano plant in La Hague since the 1980s.

Reprocessed uranium was used to fabricate new fuel assemblies until 2013, and has been used in certain 900 MWe reactors. EDF resumed this utilisation in 2024, at Cruas-Meysse, and plans to expand it. The reuse of reprocessed uranium in the past, and the prospects for future reuse, explain why this radioactive substance is classified as a material rather than a waste.

Reprocessed uranium is chemically transformed into uranium hexafluoride (UF6) in a plant in Seversk, Russia, the only facility in the world currently capable of performing this operation.

What happens to legacy waste?

Given the absence of structured and operational waste management solutions in France in the first decades of the French nuclear programme, some of the waste from the nuclear installations was stored in facilities which do not meet the safety standards in force today (silos, trenches). At the time, the licensees did not precisely characterise this waste and did not systematically produce detailed inventories.

As part of the projects to decommission their old facilities, the licensees (CEA, EDF, Orano) are today carrying out "Waste Retrieval and Conditioning (WRC*)" projects for this legacy waste. Owing to their complexity, these projects generally take place over long periods of time. The licensees do not always have records or reliable knowledge of the waste stored in these facilities and have to carry out studies to physically and chemically characterise it, and identify the process(es) for retrieving it, along with the management solution associated with each type of waste (either already in existence or planned).

For example, on the Orano La Hague site, silo 130 was designed for dry storage of solid waste produced by cladding removal from gas cooled reactor (GCR) irradiated fuels. It was operated from 1973 to 1981. It now contains solid waste, water, sludges and rubble. WRC operations started in 2019 and should be completed in 2056.

GLOSSARY

Actinide: natural or artificial radionuclide, with an atomic number between 89 (actinium) and 103 (lawrencium). Some authors start the actinides series with element 90 (thorium).

BNI: Basic Nuclear Installation. Installation which, due to its nature or the quantity or activity of the radioactive substances it contains, is governed by a particular regulatory system, defined by the Environment Code and the Order of 7 February 2012.

Conditioning (of radioactive waste): industrial process using a blocking material to immobilise the waste in a matrix, the type and performance of which depend on the type of waste.

Containment (of radioactive materials): keeping radioactive materials inside a determined space, thanks to a range of systems (or barriers) aiming to prevent the dispersion of unacceptable quantities of them outside this space.

Criticality: in the field of nuclear engineering, criticality is a discipline which aims to assess and prevent the risks of an unwanted chain reaction in nuclear facilities. It is a sub-discipline of neutronics. The criticality risk is the risk of triggering an uncontrolled fission chain reaction.

Disposal (or Repository): this consists in definitively placing the radioactive waste in a safe place, where its radioactivity will decrease over time.

Fission products: fission products are nuclides resulting from the fission of a fissile element (a nucleus). Each nucleus of fissile material undergoing nuclear fission breaks into two (exceptionally three) pieces, which stabilise in the form of new atoms.

IAEA: International Atomic Energy Agency. Intergovernmental organisation created in 1957, with the same legal structure as the United Nations Organisation (UNO), mandated to foster and promote the safe, secure and peaceful use of nuclear technologies throughout the world.

Management route: refers to all the operations performed on the radioactive waste which, from production to disposal, contribute to ensuring that it is made safe, once and for all. It is adapted to certain types of radioactive wastes.

PNGMDR: French National Radioactive Materials and Waste Management Plan. The State's strategic oversight tool for the management of radioactive materials and waste. It defines the management solutions for these substances and the conditions in which they are implemented (recycling, disposal, interim storage, etc.).

Processing: set of mechanical, physical or chemical operations designed to modify the characteristics of the waste. The purpose of processing is to make the waste suitable for conditioning.

Radiation protection: aims to prevent or reduce the health risks linked to ionising radiation, on the basis of three broad principles, justification, optimisation and limitation of radiation doses. To apply these principles, radiation protection implements regulatory and technical means adapted specifically to three categories of persons: the public, patients and workers.

Radioactive half-life: time needed for the decay of half the atomic nuclei of a radioactive nuclide.

Radionuclide: radioactive atomic species defined by its mass number, its atomic number and its nuclear energy state.

Reversibility: this is a prudent approach in the light of the available knowledge. Reversibility entails the ability, for a limited period of time, to recover and transfer the waste packages (recoverability), the ability to intervene in the disposal process (flexible management in stages, maintenance and surveillance) and the ability to modify the design.

Safety (nuclear): the set of technical provisions and organisational measures – related to the design, construction, operation, shutdown and decommissioning of Basic Nuclear Installations, as well as the transport of radioactive substances – which are adopted with a view to preventing accidents or limiting their effects.

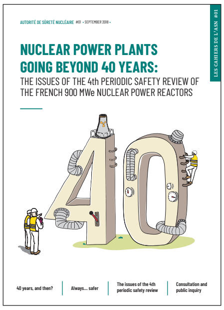
Spent fuel: nuclear fuel having being irradiated in the core of a reactor, from which it is removed once and for all.

Storage: operation consisting in placing radioactive substances for a temporary period in an above-ground or near-surface facility specially fitted out for the purpose, with the aim of subsequently retrieving them.

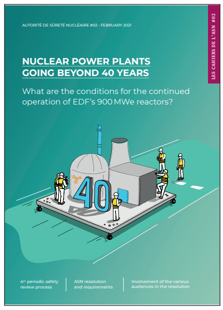
Transmutation: following an intentional or spontaneous nuclear reaction, transformation of one element into another. The aim is to reduce the harmfulness or make for easier management of long-lived or high-level radionuclides, by transforming them into other radionuclides which are either lower level or shorter lived.

WRC: retrieval and conditioning of legacy waste.

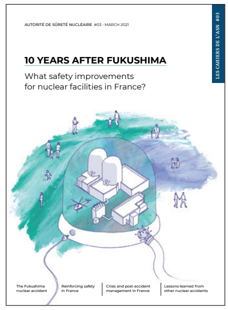
“Les cahiers de l’ASN” magazines
can be downloaded from ***asn.fr***



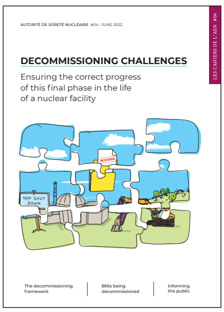
Les cahiers de l’ASN No. 1



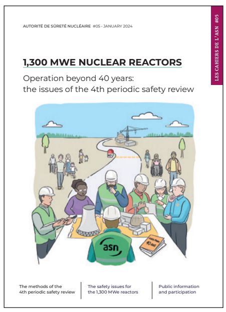
Les cahiers de l’ASN No. 2



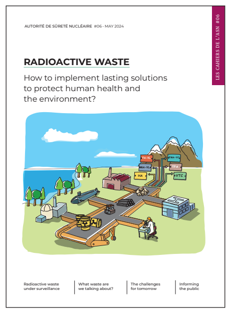
Les cahiers de l’ASN No. 3



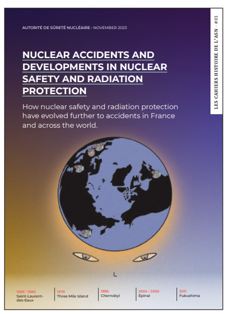
Les cahiers de l’ASN No. 4



Les cahiers de l’ASN No. 5



Les cahiers de l’ASN No. 6



Les cahiers Histoire de l’ASN No. 1

Editor: Autorité de sûreté nucléaire (ASN) • 15-21, rue Louis Lejeune, 92120 Montrouge
Publications Director: Bernard Doroszczuk, ASN Chairman
Chief Editor: Emmanuel Bouchot • **Editorial secretary:** Lucas Patriat
This issue was produced with the ASN Waste, Research Facilities and Fuel Cycle Department (DRC).
Thanks to Olivier Lareynie, Head of the radioactive waste management office.
Design and production: BRIEF • **Illustrations:** Jonathan Shalev and Alix Tran Duc / BRIEF
Printer: Imprimerie Fabrègue, 87500 Saint-Yrieix-la-Perche
ISSN: 2647-8005 (printed version) 2648-7683 (on-line version)
Date of publication: May 2024

AUTORITÉ
DE SÛRETÉ
NUCLÉAIRE

15-21, rue Louis Lejeune – 92120 Montrouge – Tel.: +33 (0)1 46 16 40 00