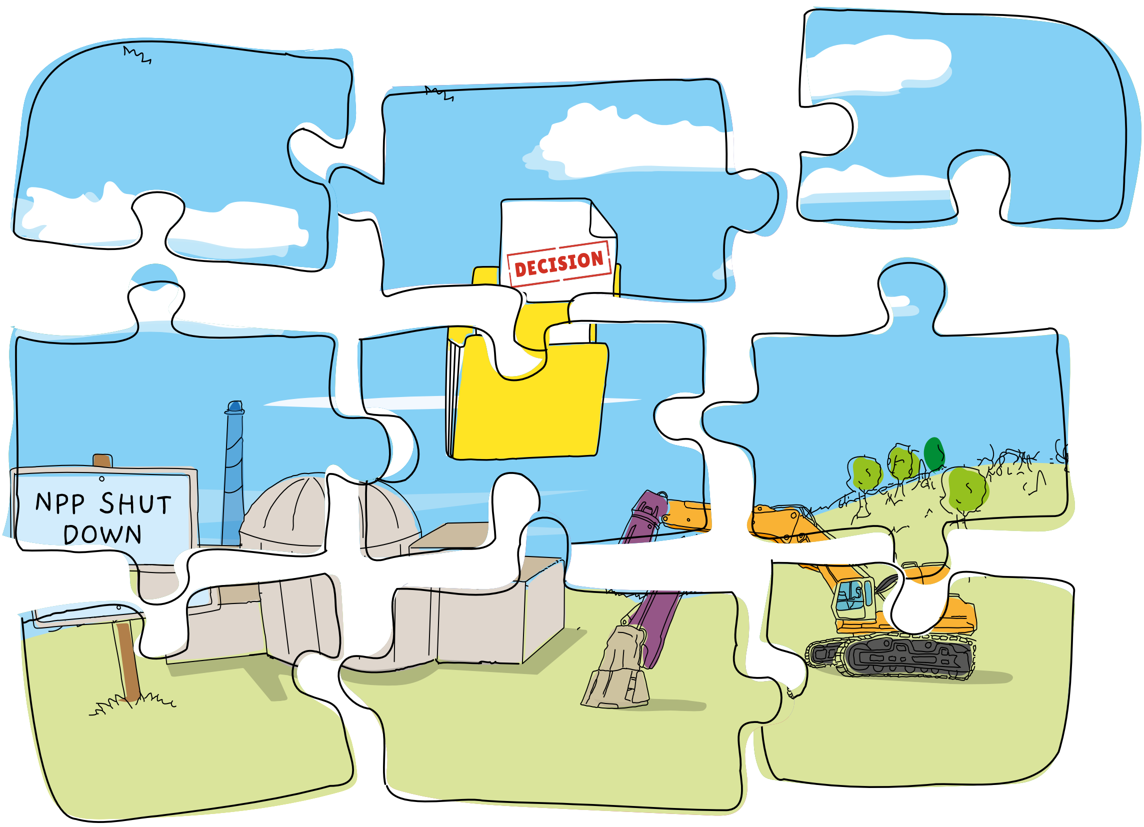
AUTORITÉ DE SÛRETÉ NUCLÉAIRE #04 • JUNE 2022

LES CAHIERS DE L'ASN #04

DECOMMISSIONING CHALLENGES

Ensuring the correct progress of this final phase in the life of a nuclear facility



The decommissioning framework

BNIs being decommissioned

Informing the public

Contents

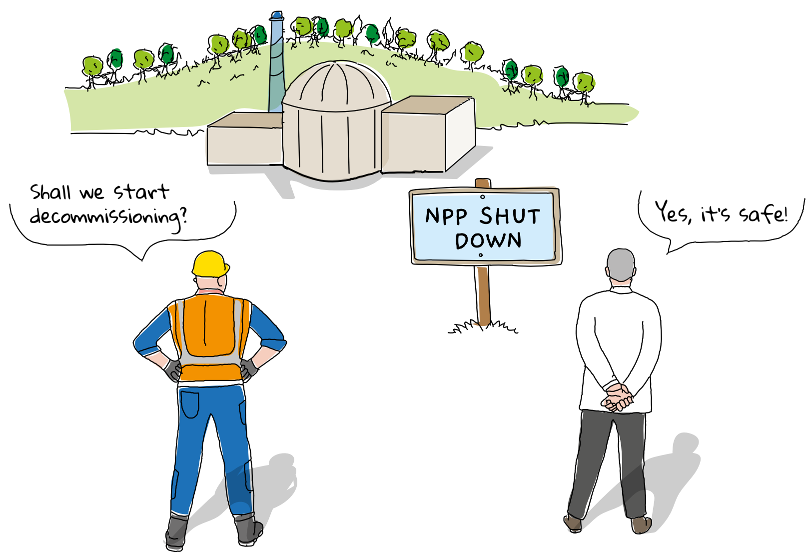
The lifetime of a basic nuclear installation (BNI*) comprises **four main phases:** design, construction, operation and decommissioning.

ASN intervenes at each of these phases. It issues an opinion on the draft creation authorisation or decommissioning decrees for the installations, and regulates operation by means of binding requirements.

Decommissioning concerns removal of radioactive substances and waste, equipment disassembly operations, and clean-out of structures and soils. **Responsibility for this lies with the site licensees.**

In France, decommissioning of a BNI* is governed by regulations based on the principle of dismantling as rapidly as possible and in economically acceptable conditions.

The decommissioning process concerns a large number of installations in France. It comprises technical challenges regarding the safety, environmental or radiation protection aspects. It can take one or more decades.



* *See glossary page 30*

Decommissioning, **a complex phase under surveillance**

The final shutdown of a BNI* marks the beginning of a phase that is often lengthy, and comprises new and changing risks. ASN conducts its oversight in accordance with the Decrees setting out the main steps in decommissioning, the date of completion of decommissioning and the final state to be attained.

The regulatory framework: work as rapidly and as effectively as possible...

The decommissioning of a BNI* is regulated by the Environment Code and the Order of 7 February 2012 "setting the general rules relative to BNIs*". It is based on two key objectives:

"**Work rapidly**" so that future generations do not bear the burden of decommissioning, while benefiting from the knowledge and skills of the teams present during the operation of the installation;

"**Work effectively**", means gradually removing the radioactive or dangerous substances from the structures and soil, with a view to the delicensing* of the installation. Clean-out will be taken as far as reasonably achievable.

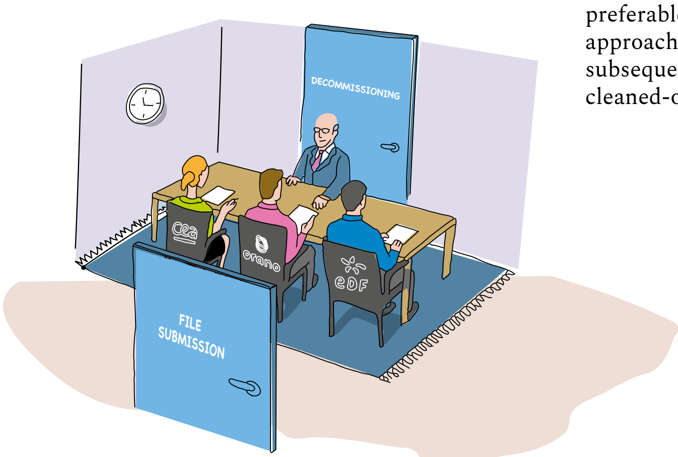
• **With regard to "Work rapidly", decommissioning operations are often lengthy and costly.** They represent a real challenge for the licensee. The licensee must be able to draw on the installation's operating history, in particular the know-how and knowledge of the personnel teams present during its operation. Since 2015, the strategy adopted in France aims for the following:

• the licensee makes provision for the decommissioning of its installation as of the design stage;

• the time between final shutdown of the installation and the first decommissioning operations is as short as possible.

• **With regard to "work effectively"**, ASN asks that the licensees study a complete clean-out scenario. This scenario aims to guarantee lasting, long-term protection for people and the environment.

If, owing to the nature of the contamination, it were to prove difficult to apply this approach, ASN considers that the licensee must go as far as reasonably possible in the site clean-out process. Similarly, in accordance with the general radiation protection principles, the dosimetric impact of the site after delicensing* shall be As Low As Reasonably Achievable (ALARA principle). ASN is not in favour of introducing general thresholds and considers that it is preferable to adopt a case-by-case approach according to the intended subsequent use of the site once cleaned-out.



* See glossary page 30

...in compliance with a rigorous process

Once a BNI* is definitively shut down, it must be decommissioned. The decommissioning of a BNI* is prescribed by a Decree, issued after consulting ASN.

A decommissioning file describes all the envisaged work and, for each step, explains the nature and scope of the risks presented by the facility, as well as the means used to manage them. This file is the subject of a public inquiry among the local residents, associations and competent administrative authorities.
On the basis of the file, the decommissioning decree specifies the main steps in decommissioning, its completion date and the final state to be attained.

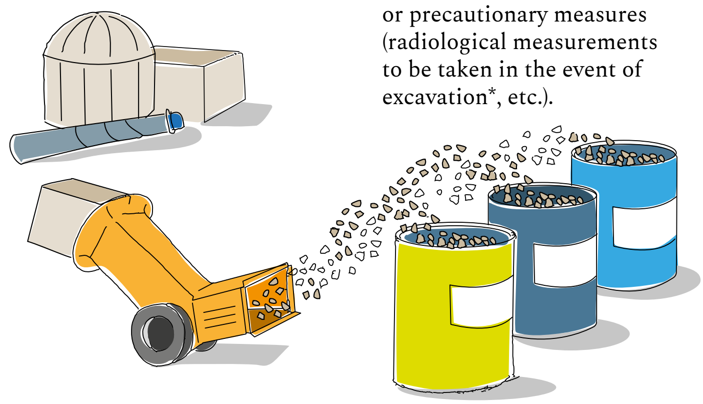
In addition, the Environment Code requires that the safety of a facility being decommissioned, in the same way as that of all the other BNIs*, must undergo a periodic safety review.
This periodic safety review shall take place every 10 years.

ASN ensures that the installation complies with the provisions of its decommissioning decree and the safety and radiation protection requirements through to its delicensing*. These requirements are consistent with an approach that is proportionate to the safety implications of the installation.

On completion of decommissioning, a BNI* can be delicensed by an ASN resolution approved by the Minister responsible for nuclear safety.
It is then removed from the list of BNIs* and is no longer governed by this system.

In support of its delicencing* application, the licensee must notably provide a file containing a description of the state of the site after decommissioning (analysis of the state of the soils, remaining buildings or equipment, etc.) and demonstrating that the planned final state has indeed been reached.

Depending on the final state reached, ASN may require the implementation of active institutional controls* as a condition of delicensing*. These may set a number of restrictions on the use of the site and buildings – as is the case on certain industrial sites (limited to industrial use only for example) - or precautionary measures (radiological measurements to be taken in the event of excavation*, etc.).



WHO PROVIDES THE FINANCING?

The Environment Code defines the system for securing the funds to meet the nuclear costs for the decommissioning of nuclear installations, and managing the spent fuel and the radioactive waste.

The financing of decommissioning is inspired by the “polluter-pays” principle. As of the creation of the installation, the nuclear licensees are required to cover the cost of this financing, taking care to make provision for the funds needed for its decommissioning.

They are obliged to submit triennial reports on these costs and 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. In any case, the nuclear licensees remain responsible for the satisfactory financing of the decommissioning costs.

What happens after final shutdown?

Once a BNI* has been definitively shut down, it must be decommissioned. France has opted for "immediate" dismantling. A regulatory procedure is implemented to oversee decommissioning of the installation up to its delicensing*.

END OF OPERATION

Shutdown declaration

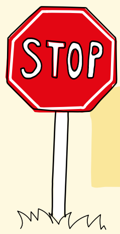
2 years maximum

Transmission of decommissioning file

At least 2 years before the date envisaged for final shutdown, the licensee informs the Minister responsible for nuclear safety, and ASN, of its intention to definitively shut down its installation.
This declaration is made known to the public.

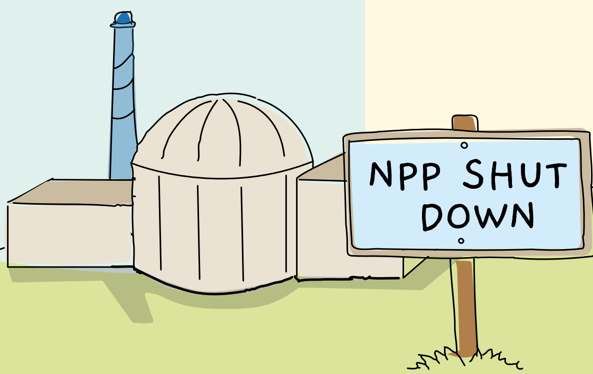
No later than 2 years after the shutdown declaration, the licensee must send the Minister its decommissioning file.
This file presents the decommissioning operations proposed by the licensee, as well as the steps it takes to mitigate the impacts on persons and the environment.

PREPARATION FOR DECOMMISSIONING



Final shutdown

As of the date of final shutdown, the licensee is no longer authorised to operate its installation. It begins to prepare for its decommissioning.
The operations in preparation for decommissioning often consist in removing the radioactive and chemical substances present in the installation (spent fuel), in preparing the premises (organisation of storage areas), or adapting the utility networks (ventilation, electricity distribution).



* See glossary page 30

From the legal viewpoint, the “decommissioning operations” only begin once the Decommissioning Decree has entered into force. Between final shutdown of the installation and this moment of entry into force, the licensee carries out “operations in preparation for decommissioning”.

In this document, for reasons of simplification, all the operations performed after final shutdown are defined as “decommissioning operations”.

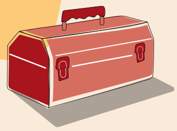
Decommissioning

Decommissioning Decree

On the basis of the decommissioning file submitted by the licensee, the Minister issues a Decree stipulating the decommissioning operations to be performed on the installation, along with the duration of decommissioning.

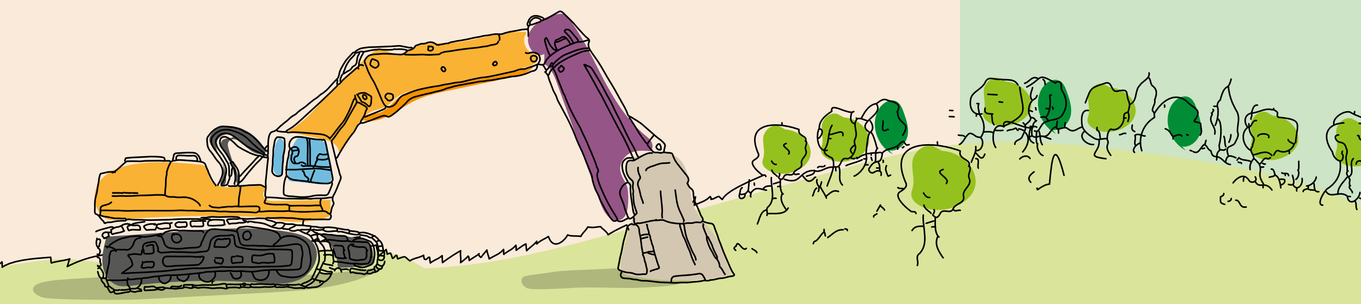
In a resolution, ASN may also issue technical requirements to further regulate decommissioning.

Decommissioning operations



Decommissioning concerns all the technical operations carried out with a view to achieving a final state that makes delicensing* of the installation possible.

It concerns the electromechanical decommissioning and clean-out of soils and structures.



Delicensing*

Delicensing resolution*

Delicensing* consists in removing an installation from the BNI* list, which implies that the installation is no longer subject to the BNI* legal and administrative system.

Delicensing* takes place at the end of the decommissioning operations, on the basis of a file presenting the final state of the installation.

Usage restrictions may be implemented if necessary, if some of the pollution could not be removed. In this case, the State’s decentralised departments are responsible for ensuring compliance with these restrictions.

ASN’s oversight duties cease.

What types of facilities and what stakes?

With the exception of pressurised water reactors (PWR) in NPPs, which are all designed using the same model, most BNIs* undergoing decommissioning represent a variety of technologies, uses and past histories which often complicate the decommissioning operations.

NUCLEAR POWER REACTORS

Different reactor technologies have been used to produce electricity in France. Their decommissioning must take account of their specific characteristics.

As of the final shutdown of these reactors, removal of the fuel is a means of achieving a 99% reduction in the radioactivity present in the installation.

Pressurised water reactors

After decommissioning of the Chooz A reactor (Ardennes *département***), which began in 2007, decommissioning started on the two reactors of the Fessenheim NPP (Haut-Rhin *département*), which was shut down in 2020. There is considerable operating experience feedback from PWR decommissioning: 42 PWRs are being decommissioned worldwide in 2021. There are no major technical difficulties in the decommissioning of these installations, which takes about twenty years.

Other reactors

In France, several NPP reactors undergoing decommissioning were based on technologies no longer in use: gas-cooled reactors (GCRs – located in Bugey, Chinon and Saint-Laurent-des-Eaux), heavy water reactor (Brennilis), fast breeder reactors (Phénix and Superphénix). For these reactors, some of which have not been operating for several decades, there is no significant operating experience feedback, unlike with the PWRs. The fact that they are unique means that specific and often complex decommissioning operations must be designed, such as specific remote-operated systems.

RESEARCH REACTORS

These are characterised by a far lower power level than nuclear power reactors (from 100 Watts thermal – Wth – to 70 Megawatts thermal – MWth).

Nine experimental reactors, operated by CEA, are currently definitively shut down; when they were designed back in the 1960s to 1980s, the question of their decommissioning was not considered.

There is significant operating experience feedback for decommissioning of research reactors, owing to the decommissioning of numerous similar installations in France, notably on CEA's Grenoble site. During the course of decommissioning, the radioactivity risks rapidly give way to conventional industrial risks, for example the chemical risk during the clean-out phase, or that linked to the management of several simultaneous worksites.

** See glossary page 30*

*** Administrative region headed by a Prefect.*

FUEL PRODUCTION

Two installations designed and used to fabricate nuclear fuel are being decommissioned on the Tricastin site (Drôme *département*): one specialised in the conversion* of uranium (Comurhex), the other in the enrichment* of uranium by gaseous diffusion (Eurodif).

The operating history of these old installations is not fully known; determining the pollution present in the soils beneath the structures therefore remains an important issue. Furthermore, the industrial processes used at the time involved large quantities of toxic chemical substances (uranium, chlorine trifluoride and hydrogen fluoride, for example): the containment of these chemical substances is also an issue, as are the risks related to internal contamination of the workers.

FUEL REPROCESSING AND WASTE MANAGEMENT

This concerns the spent fuel and waste storage and reprocessing installations, located on the La Hague site and operated by Orano. Their decommissioning usually entails prior retrieval and conditioning of legacy nuclear waste (WRC*).

Of these installations, the UP2-400 plant, the first reprocessing plant for the fuel from the first generation reactors (GCRs) is being decommissioned. It contains highly irradiating waste, such as technological waste, rubble, earths and sludges, sometimes stored loose, without preliminary sorting. Decommissioning is thus carried out in parallel with WRC* operations, which require the implementation of complex, unique engineering processes.

SUPPORT INSTALLATIONS

“Support installations” are certain installations intended for the storage and processing of radioactive effluents and waste. Most of them were commissioned in the 1960s and are located at Cadarache, Fontenay-aux-Roses, La Hague and Saint-Laurent-des-Eaux.

These installations were not initially designed to allow the removal of their waste, and in some cases they were seen as being the definitive waste disposal site. Retrieval of the waste from these facilities is all the more complex and will span several decades. The decommissioning operations must take account of severe corrosion and soil pollution phenomena, caused by ageing of the installations and events which occurred during their operation. These difficulties are compounded by incomplete knowledge of the operating history and the state of the installation to be decommissioned.

LABORATORIES

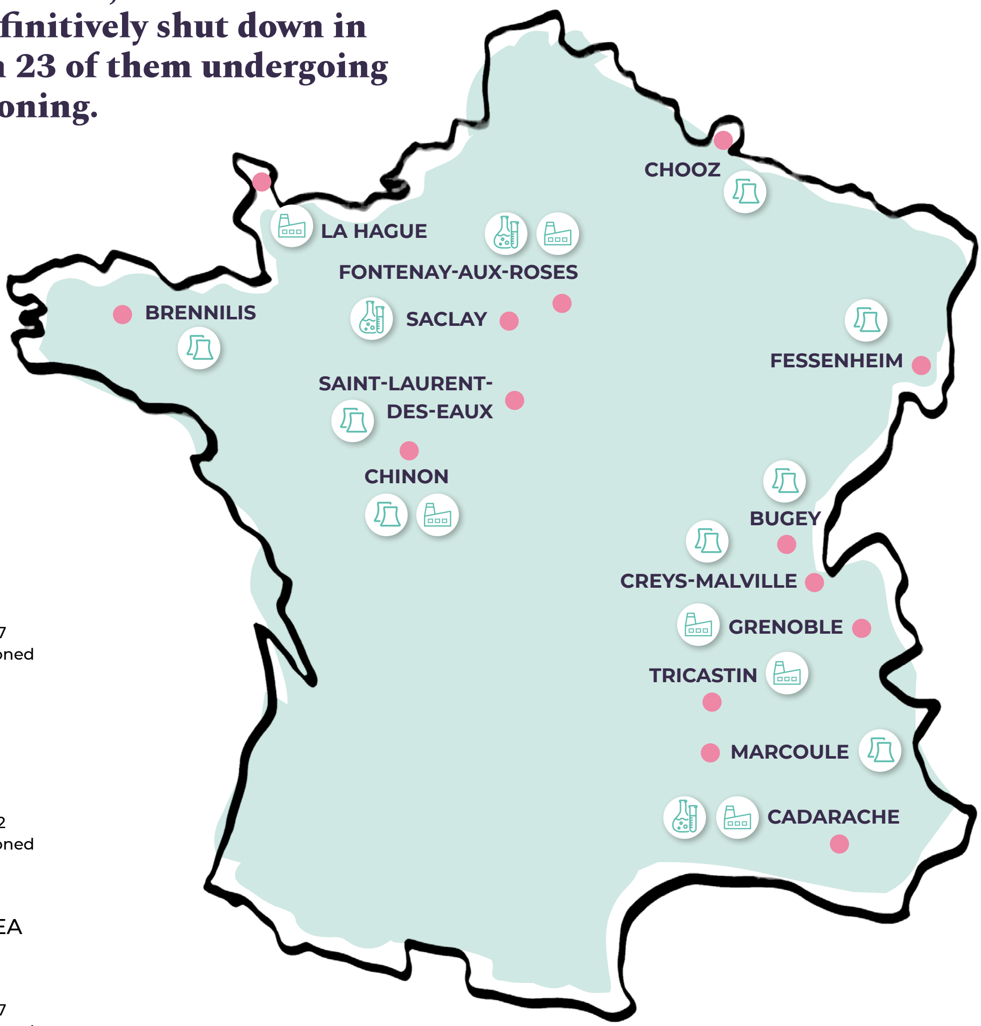
These installations, which date from the 1960s, were devoted to research, in order to support an emerging nuclear power industry.

Four civil laboratories have so far been definitively shut down in France.

Owing to the incomplete record of their history, the waste inventory and radiological status of these installation are hard to establish. The laboratories are faced with the problem of management of the waste stored on the site at a time when the storage or disposal solutions had not yet been put into place.

Nuclear installations definitively shut down

At the end of 2021, 35 installations had been definitively shut down in France, with 23 of them undergoing decommissioning.



BRENNILIS – EDF

REACTOR

BNI 162 • EL4-D
- Commissioned: 1967
- Being decommissioned

BUGEY – EDF

REACTOR

BNI 45 • Bugey 1
- Commissioned: 1972
- Being decommissioned

CADARACHE – CEA

REACTORS

BNI 25 • Rapsodie
- Commissioned: 1967
- Being decommissioned

BNI 39 • Masurca
- Commissioned: 1966
- Final shutdown

BNI 42 • ÉOLE
- Commissioned: 1965
- Final shutdown

BNI 92 • Phébus
- Commissioned: 1978
- Final shutdown

BNI 95 • Minerve
- Commissioned: 1977
- Final shutdown

MANUFACTURE, TRANSFORMATION OR STORAGE OF RADIOACTIVE SUBSTANCES

BNI 32 • Plutonium technology facility (ATPu)
- Commissioned: 1962
- Being decommissioned

BNI 52 • Enriched uranium processing facility (ATUe)
- Commissioned: 1963
- Being decommissioned

BNI 37-B • Effluent Treatment Station (STE)
- Commissioned: 2015 (1)
- Final shutdown

BNI 53 • Central fissile material warehouse (MCMF)
- Commissioned: 1966
- Final shutdown

BNI 54 • Chemical Purification Laboratory (LPC)
- Commissioned: 1966
- Being decommissioned

* See glossary page 30

CHINON – EDF

UTILISATION OF RADIOACTIVE SUBSTANCES

BNI 94 • Irradiated Materials Facility (AMI)
- Commissioned: 1964
- Being decommissioned

REACTORS

BNI 133 – BNI 153 – BNI 161 Chinon A1D – A2D – A3D
- Commissioned: 1963 – 1965 – 1966
- A1D et A2D: Final shutdown
- A3D: Being decommissioned

CHOOZ – EDF

REACTOR

BNI 163 • Chooz A
- Commissioned: 1967
- Being decommissioned

CREYS-MALVILLE – EDF

REACTOR

BNI 91 • Superphénix
- Commissioned: 1985
- Being decommissioned

FESSENHEIM – EDF

REACTORS

BNI 75 • Fessenheim 1 – 2
- Commissioned: 1977
- Final shutdown

FONTENAY-AUX-ROSES – CEA

RESEARCH FACILITY

BNI 165 • Procédé
- Commissioned: 2006 [2]
- Being decommissioned

EFFLUENT REPROCESSING AND WASTE STORAGE FACILITY

BNI 166 • Support
- Commissioned: 2006 [2]
- Being decommissioned

GRENOBLE – CEA

TRANSFORMATION OF RADIOACTIVE SUBSTANCES

BNI 36 • Radioactive effluent and solid waste treatment station (STED)
- Commissioned: 1964
- Being decommissioned

BNI 79 • High-level waste storage unit
- Commissioned: 1972
- Being decommissioned

LA HAGUE – Orano Recyclage

TRANSFORMATION OF RADIOACTIVE SUBSTANCES

BNI 33 • Spent fuel reprocessing plant (UP2-400)
- Commissioned: 1964
- Being decommissioned

BNI 38 • Radioactive effluent and solid waste treatment station (STE2)
- Commissioned: 1964
- Being decommissioned

BNI 47 • ELAN IIB Unit
- Commissioned: 1970
- Being decommissioned

BNI 80 • Oxide High Activity facility (HAO)
- Commissioned: 1974
- Being decommissioned

MARCOULE – CEA

REACTOR

BNI 71 • Phénix
- Commissioned: 1973
- Being decommissioned

SACLAY – CEA

RESEARCH REACTORS

BNI 18 • Ulysse
- Commissioned: 1961
- Being decommissioned

BNI 40 • Osiris and Isis
- Commissioned: 1966
- Final shutdown

BNI 101 • Orphée
- Commissioned: 1980
- Final shutdown

UTILISATION OF RADIOACTIVE SUBSTANCES

BNI 49 • High activity laboratory (LHA)
- Commissioned: 1954
- Being decommissioned

SAINT-LAURENT-DES-EAUX – EDF

REACTORS

BNI 46 • Saint-Laurent A1 – A2
- Commissioned: 1969 and 1971
- Being decommissioned

TRICASTIN – Orano Chimie enrichissement

TRANSFORMATION OF RADIOACTIVE SUBSTANCES

BNI 105 • Comurhex uranium hexafluoride* preparation plant
- Commissioned: 1978
- Being decommissioned

BNI 93 • Georges Besse plant for separating uranium isotopes by gaseous diffusion
- Commissioned: 1979
- Being decommissioned

Key

Reactor

Plant

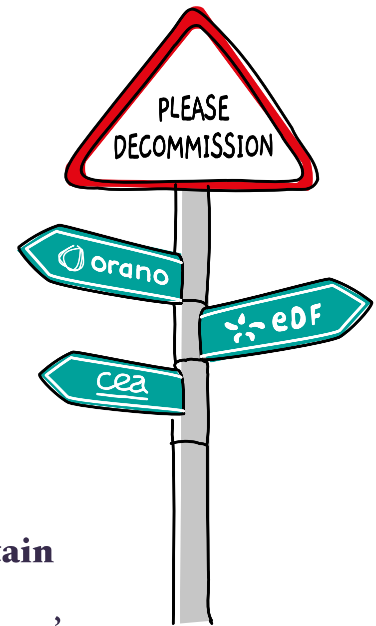
Laboratory and research reactor

1. This date is because of the separation of BNI 37 (commissioned in 1964) into two BNIs: 37-A and 37-B.

2. This date is because of the merging of former BNIs, commissioned in 1966 and 1968.

For more information, scan this QR code.

Licensee decommissioning strategies assessed by ASN



With the final shutdown of a large number of installations in recent years, the major nuclear licensees are faced with having to carry out several decommissioning projects at the same time. To obtain an overview of these various projects and how they interface with each other, ASN examines the licensees' decommissioning and waste and materials management strategies.

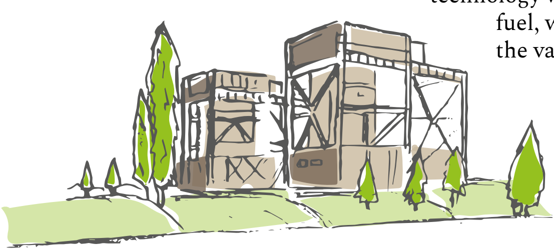
EDF

Decommissioning strategies appropriate to the reactor model and changing technologies

EDF is the licensee of the French nuclear fleet, consisting of 56 PWR reactors in operation in 18 NPPs and it also has to manage the decommissioning a dozen installations.

The gas-cooled reactor (GCR) decommissioning strategy

EDF's first generation of nuclear reactors are of the GCR type, operating with natural uranium. The first GCR reactor was commissioned at Chinon (Indre-et-Loire *département*) in 1963. A total of six reactors of this type were built in France. These reactors were shut down between 1973 and 1994, when this technology was abandoned. The fuel, which accounted for the vast majority of the risk to the safety of these installations, has been removed.



However, some of these installations were only partially decommissioned before being placed under surveillance, pending final dismantling. The pertinence of "immediate" dismantling of nuclear installations was in fact only recognised by all players in the early 2000s.

An initial scenario studied by EDF consisted in filling the reactor core with water so that the decommissioning operations could be carried out, thus mitigating the radioactivity risks. EDF originally planned to complete decommissioning of these reactors between 2024 and 2031. Given the major technical difficulties (tightness of the reactor vessel and treatment of the contaminated water), but also technological progress which has identified other solutions, remote-operation in particular, EDF in 2016

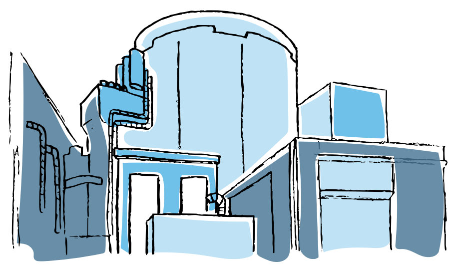
* See glossary page 30

announced that the "under water*" dismantling scenario was no longer the reference solution, resulting in a change in strategy. **EDF thus opted for an "in air*" dismantling scenario, eliminating the problems linked to the use of water.** This change entailed a significant postponement in the dismantling operations. EDF decided to use an industrial demonstrator to validate certain complex operations, followed by complete dismantling of one reactor vessel before beginning dismantling of the other five vessels. EDF has also significantly increased the time needed to decommission a reactor.

For more information, scan this QR code.

The PWR decommissioning strategy

The current French NPP fleet consists entirely of PWRs. They operate with enriched uranium. Considerable experience feedback from the decommissioning of these reactors has been acquired through numerous projects internationally: 42 reactors of this type are currently undergoing decommissioning around the world, and 6 have already been decommissioned in the United States. There are thus no major technical issues regarding the feasibility of the decommissioning operations which, according to international experience feedback, last about twenty years. They start following the issue of the decommissioning decree, which sets out the main steps: in the reactor building, removal of the primary system after any necessary decontamination, followed by cutting of the reactor pressure vessel.
The systems of the other buildings of the nuclear island are also decontaminated at the same time. After removing all dismantled equipment and waste, the licensee continues with clean-out of the various buildings and then their demolition, with a view to delicensing* of the BNI* and remediation of the site.
In France, the first decommissioning decree for a PWR concerned the Chooz A reactor, installed in a cavern in the Ardennes mountains, in 2007. The next one will concern the Fessenheim NPP.



ASN'S POSITION

- **For the GCRs,** ASN duly notes the difficulties being encountered for continued decommissioning "under water*" and considers the scenario change to be acceptable. It will examine the safety of the operations to be carried out "in air*" and the corresponding time-frames. In resolutions of March 2020, and following public consultation, ASN instructed EDF to submit an application file for modification of the existing decommissioning decrees for the Bugey 1, Saint-Laurent A1 and A2 and Chinon A3 reactors, and to submit the decommissioning files for those reactors as yet not covered by one (Chinon A1 and Chinon A2), no later than the end of 2022. ASN also indicated that EDF will need to shorten the decommissioning time-frames set out in its strategy, in order to meet the legislative obligation for decommissioning in a period as short as possible for each reactor. Finally, in order to make the reactor decommissioning schedule more reliable, ASN asks EDF to identify adequate waste management routes which could, if necessary, lead to the creation of new waste storage facilities.
- **For the PWRS,** whatever the service life of the reactors currently in operation, EDF will be faced with the simultaneous decommissioning of several PWRs in the coming years. EDF will therefore have to organise itself to industrialise the decommissioning process in order to meet the requirement to decommission each installation in the shortest time possible. Decommissioning of the Fessenheim NPP will provide useful industrial feedback in this respect.

orano

In order to deal with a high level of industrial complexity, a strategy which envisages reusing certain structures

In the future, Orano will have to conduct several large-scale decommissioning projects: that of the first generation fuel reprocessing plant at La Hague (UP2-400 and its support units), as well as that of the uranium conversion* and enrichment* plants at Tricastin. **The licensee adopts the principle of immediate dismantling**; it must carry out certain particularly complex operations, notably those linked to WRC*, for which the safety and radiation protection stakes are high. These operations must be based on characterisation of the waste and qualification of the processes envisaged, for which the licensee must reinforce its methods to confirm the feasibility of the envisaged solutions.

The WRC* worksites are of particular importance, given the inventory of radioactive substances present and the age of the facilities in which they are stored, which do not meet current safety standards. WRC* projects are becoming increasingly complex owing to the interactions with the plants in operation on the site. Some work could span a period of several decades. In addition, Orano does not systematically envisage demolishing the structure of the facilities: some of them will continue to be used for industrial purposes (equipment storage, etc.). In order to achieve the target final state, clean-out of the structures and soils is Orano's reference option. However, the licensee does not rule out a two-stage operation, in order to meet the need for temporary use of all or part of the facility.

The decommissioning and WRC* operations will generate a large quantity of waste, for which there is no disposal route. When disposal routes are not yet available, the management solution adopted by Orano is interim storage.

For more information, scan this QR code.

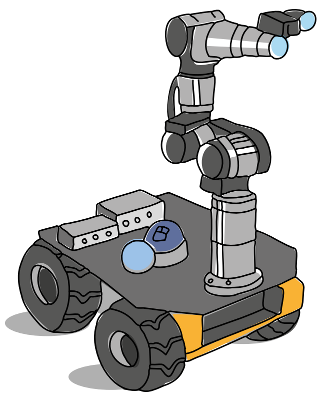
ASN'S POSITION

In 2016, Orano transmitted its decommissioning and waste management strategy for the La Hague and Tricastin sites. After reviewing these aspects, which led to a cycle of discussions with Orano, ASN notes progress in the assimilation of the immediate dismantling objectives, progress in the decommissioning operations on several facilities at Tricastin and the definition of conditioning processes for radioactive waste from the La Hague site. ASN nonetheless asked it to improve the following four aspects of its strategy:

- **decommissioning and waste management must be prioritised according to the risks** and Orano must design new reprocessing, conditioning, storage and transport capacity for effluents and waste, in order to replace certain ageing equipment and increase storage capacity;
- **implementation of the clean-out strategy must be based on sufficient knowledge of the current state of the facilities** and more particularly the civil engineering structures and soils. It also ensures that clean-out is taken as far as reasonably achievable if complete clean-out is not possible for technical or economic reasons;
- **WRC* must be better managed:** the issue is to characterise the waste and qualify processes so that it can be retrieved and conditioned in order to reduce the risks from its radioactivity as early as possible;
- **the oversight of complex projects* must be improved:** Orano must analyse the causes of delays to the priority projects and ensure the adequacy of the resources devoted to these projects so that it can submit detailed 5-year activity schedules to ASN, presenting the key milestones.

* See glossary page 30

A strategy that ranks the priorities according to the risks, taking account of limited resources



For more information, scan this QR code.

In France, nearly 40 CEA civil and defence nuclear facilities have been finally shut down or are being decommissioned. The ageing and varied design of these facilities did not take account either of decommissioning or of radioactive waste management in accordance with current safety requirements. Given the number and complexity of the operations to be carried out, CEA defined priorities, based primarily on an analysis of the potential hazards, in order to mitigate the risks presented by these facilities.

The highest-priority operations concern certain individual facilities on the defence basic nuclear installation (DBNI) in Marcoule (Gard *département*), as well as on the BNIs* in Saclay (Essonne *département*) and Cadarache (Bouches-du-Rhône *département*). An accident in one of these facilities could lead to significant nuclear safety and radiation protection consequences.

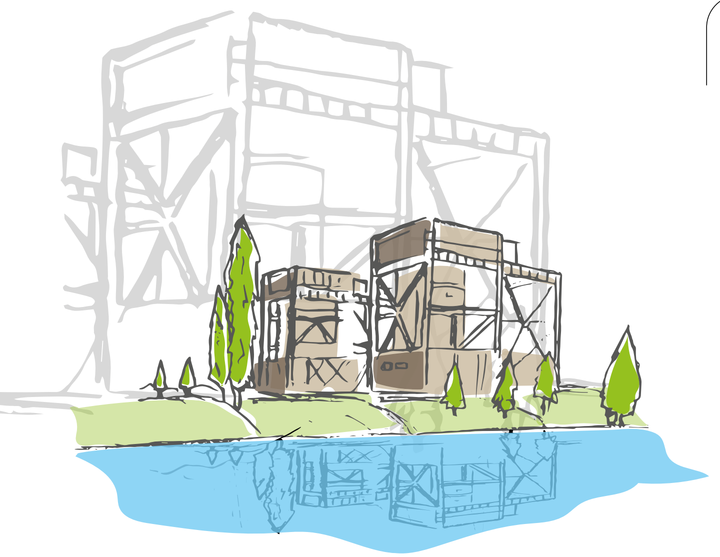
With regard to the lower priority facilities, CEA is moving towards a “two-stage” decommissioning of each facility. First of all, most of the dispersible radiological inventory* will be removed. Secondly, following a potentially lengthy period of interruption, the operations will be completed. The resulting surveillance, upkeep and operations needed to maintain a sufficient level of safety in these facilities, for a period of decades up until delicensing*, will significantly increase the final cost of the decommissioning of all the CEA facilities. Moreover, the priority decommissioning of facilities with significant safety implications will lead to the modification of the regulatory requirements already issued for those facilities for which decommissioning is postponed.

ASN’S POSITION

- **In their joint opinion of 27 May 2019**, ASN and the Defence Nuclear Safety Authority (ASND) confirmed the overall pertinence of the prioritisation proposed by CEA, taking account of the resources allocated by the State and the large number of nuclear facilities being decommissioned, which implies massive investment.
- **ASN and ASND have concerns regarding the human and financial resources** that are planned in order to address all the situations with safety implications or the most significant environmental harmful effects in the coming 10 years. A specific investment effort, as well as the creation of engineering units and the reinforcement of the safety teams dedicated to these projects, would seem to be necessary.
- **If these projects are to progress, the licensee’s oversight capabilities will have to be reinforced**, allied with rigorous and transparent State monitoring of CEA’s actions, in terms ofcost, time and effectiveness.
- **The public must be regularly informed** of the progress of the programme as a whole.

A close look at a few BNIs undergoing decommissioning

The installations vary widely and the decommissioning constraints may differ from one BNI* to another.



Saint-Laurent A

Installation: two 500 MWe GCR type reactors in Saint-Laurent-Nouan (Loir-et-Cher *département*)
Licensee: EDF
Commissioned: 1969 and 1971
Final shutdown: 1990 and 1992

Decommissioning phases

- The fuel is removed and some of the equipment "outside the reactor vessel" is being dismantled (spent fuel pool, etc.).
- Dismantling, initially planned to be "under water*" will now be performed "in air*".
- New decommissioning file planned for the end of 2022.
- End of decommissioning envisaged by EDF: end of the century.

Decommissioning challenges

The licensee must ensure that management solutions are available for the graphite components and reduce the overall decommissioning time-frame.

Brennilis

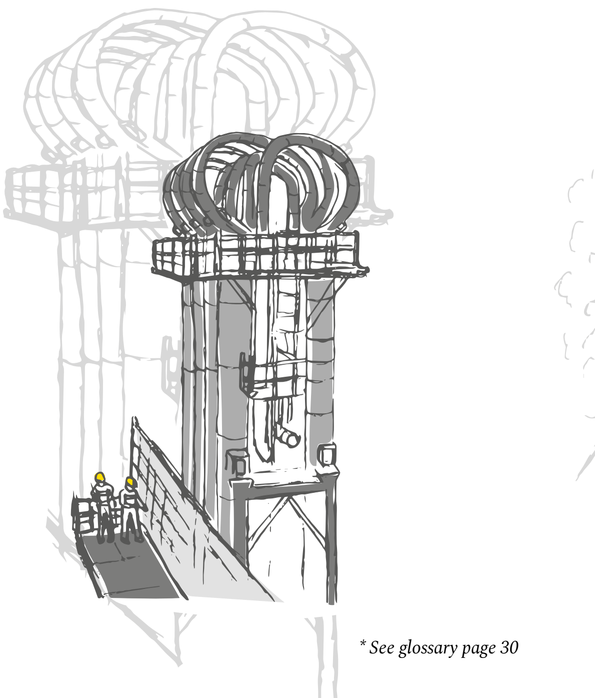
Installation: 70 MWe CO_2-cooled heavy water reactor in Brennilis (Finistère *département*)
Licensees: CEA, then EDF
Commissioned: 1967
Final shutdown: 1985

Decommissioning phases

- The fuel is removed, and decommissioning is completed for the buildings "outside the reactor block" (exchangers, effluent treatment station, waste hangar, etc.).
- Since 2018, a new file has been under review for management of the reactor block decommissioning operations.
- End of decommissioning envisaged by EDF: in the 2040s.

Decommissioning challenges

Decommissioning of this unique reactor in a confined space, which notably requires the use of remote-operated resources.



* See glossary page 30

Fessenheim

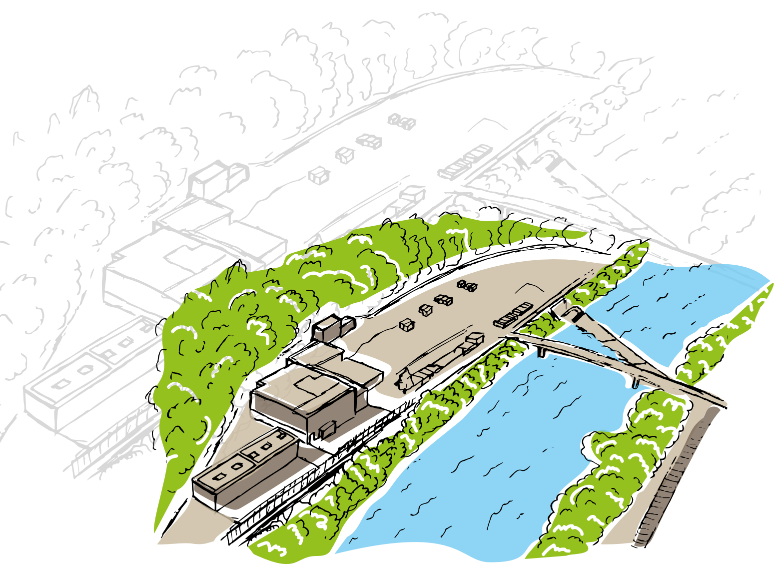
Installation: two 900 MWe PWRs (Haut-Rhin *département*)
Licensee: EDF
Commissioned: 1977 and 1978
Final shutdown: 2020

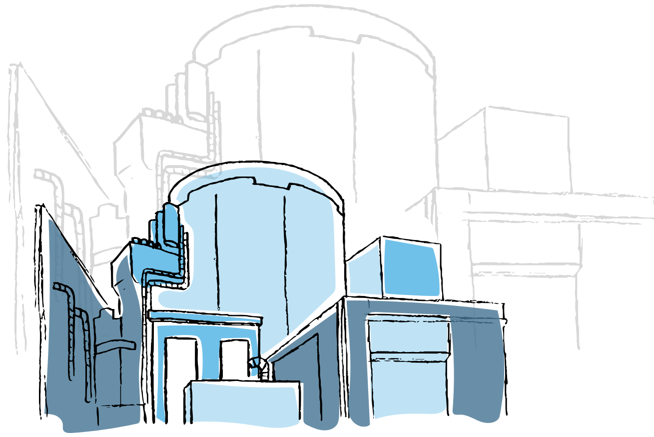
Decommissioning phases

- The spent fuel from reactor 1 was completely removed in 2021; removal of the spent fuel from reactor 2 should be completed in 2023.
- In 2022, ASN continues to review the decommissioning file transmitted by EDF and will notably call on its technical support organisations for their analysis of the file: the Institute for Radiation Protection and Nuclear Safety (IRSN) and the Advisory Committee of Experts for Decommissioning (GPDEM).
- The licensee is currently performing a certain number of operations in preparation for decommissioning: drainage and decontamination of systems, removal of waste and chemical products, preparation of spaces for processing of future waste from decommissioning, collection of spares for other sites, etc.
- End of decommissioning envisaged by EDF: end of the 2040s.

Decommissioning challenges

Once the fuel has been removed, the main decommissioning challenges lie in managing a large-scale worksite with a radiological dimension: worker radiation protection, worksite safety, waste management consistent with the conditioning, storage and disposal facilities, etc., without forgetting project management, and building on experience that is as exemplary as possible with a view to future decommissioning projects on other reactors.





Chooz A

Installation: first PWR operated in France, with a power of about 300 MWe (Ardennes *département*)
Licensee: EDF
Commissioned: 1967
Final shutdown: 1991

Decommissioning phases

- Installations partially located in underground caverns.
- The fuel has been removed, the systems have been drained, the turbine hall, the pumping station and the outside buildings have been demolished; the decontamination and removal operations for the steam generators and primary system components (except for the pressure vessel) have already been carried out. The spent fuel pool and all the auxiliary systems have to a large extent been dismantled. In 2021, dismantling work on the "reactor pressure vessel internals" was completed.
- Next step: with a view to dismantling of the reactor pressure vessel, installation of an evaporator to treat the cavity water before discharge (currently in progress). Operation scheduled to start in the first quarter of 2022.

Decommissioning challenges

The main challenge of this decommissioning is to manage radiation protection, in particular the risk of contamination of the workers by alpha particles*.

UP2-400
La Hague

Installation: the UP2-400 plant consists of four BNIs* operated on the La Hague site (Manche *département*). The installations were intended for reprocessing of certain reactor fuels (those from the GCR reactors for example – BNI 33), the treatment of effluents and the storage of waste and residues from the activities of the various units (BNI 38), the manufacture of sealed radioactive sources* (BNI 47) or the reprocessing of light water reactor fuels (BNI 80). The units, consisting of cells, silos and pools, contain large quantities of waste and residues from the activities of UP2-400: sludges and resins, equipment (mixers-decanters, vessel, etc.), residues of chemical products used to process waste, etc.
Licensee: Orano
Commissioned: 1964 (except for BNI 47 and BNI 80, which were commissioned in 1970 and 1974 respectively)
Final shutdown: 2004 (1973 for BNI 47)

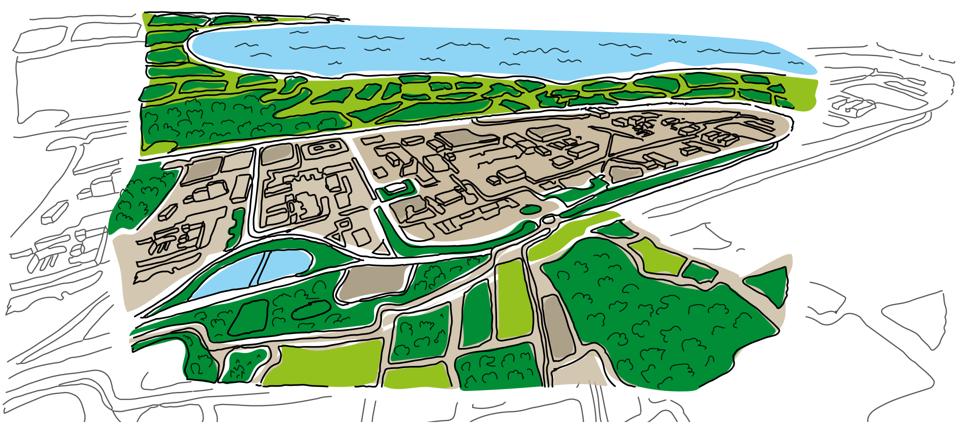
Decommissioning phases

- For BNI 33, the decommissioning operations in the main units consist in dismantling numerous rooms, as well as the numerous shielded cells, vessels, pipes, gloveboxes, used in the process. The retrieval and conditioning of ion exchange resins used to filter the spent fuel pool water also need to be completed.
- For BNI 80, the decommissioning operations consist primarily in collecting the waste stored in the pool and in a silo, by means of a special shielded cell, which will be commissioned in a few years. The fuel stored in the pools of the HAO/Nord unit has been removed.
- For BNI 47, the decommissioning operations consist in completing the removal of the last process equipment, followed by the clean-out operations.
- For BNI 38, the current decommissioning operations are focusing on the retrieval and removal of legacy radioactive waste, notably solid waste and sludges stored loose in silos.

Decommissioning challenges

Taken together, the four BNIs* constitute an industrial complex housing about ten main units, thousands of rooms each containing numerous items of process equipment (shielded cells, silos, vessels, gloveboxes, pools, etc.) in which highly radioactive and chemical substances were handled.

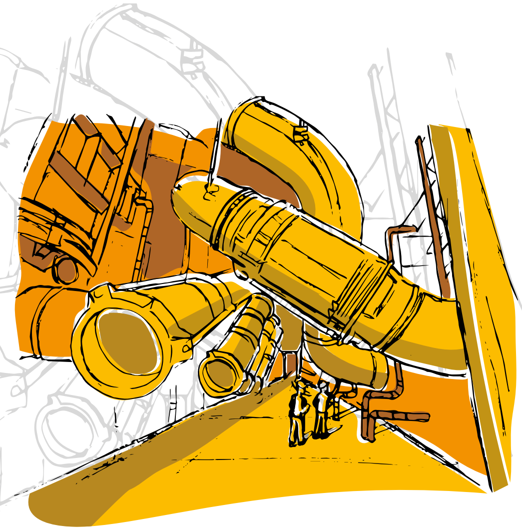
The WRC* operations are a preliminary to the decommissioning and clean-out operations and will span several decades. They require the performance of additional work to characterise the waste, implement new equipment based on remote-operated systems, and to develop specific retrieval and conditioning processes, some of which are still at the design stage.



* See glossary page 30

Eurodif
Tricastin

Installation: the Georges Besse 1 plant (or "Eurodif") was intended for the enrichment* of natural uranium by a gaseous diffusion process, for subsequent use in the nuclear power reactors (Drôme *département*).
On the Tricastin site, the four plants constitute BNI 93, covering a total surface area of 190,000 m^2.
Licensee: Orano
Commissioned: 1978
Final shutdown: 2012

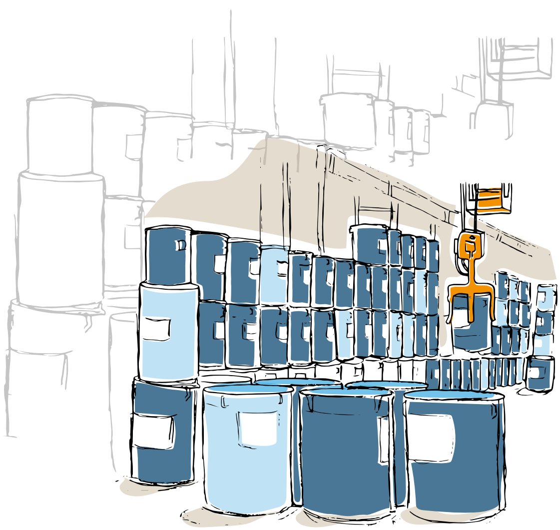


Decommissioning phases

- Scheduled time-frame for complete decommissioning of the installation: 15 years after the study phase.
- Rinsing of diffuser cascades* during the work in preparation for decommissioning (reduction in the quantity of uranium).
- As of 2024: demolition of the two cooling towers.
- Studies are in progress to design the future equipment for cutting and conditioning the diffuser cascades*.

Decommissioning challenges

The decommissioning challenges will first of all concern the diffusers, notably their disassembly, cutting and compacting of massive parts. These operations will require the use of specific tools and the operation of new units. The licensee will be required to ensure that the waste is shipped to the final disposal route (on average about 8,000 m^3/year). The decommissioning of Eurodif could generate 130,000 tons of very-low level (VLL) metal waste that could potentially be recycled.



Storage yard
Cadarache

Installation: BNI 56 consists of a range of storage facilities for the radioactive waste produced on the Cadarache site (Bouches-du-Rhône *département*): pits (6), pools (3), trenches (5) and hangars (11).
Licensee: CEA
Commissioned: 1965
Final shutdown: scheduled for 2023

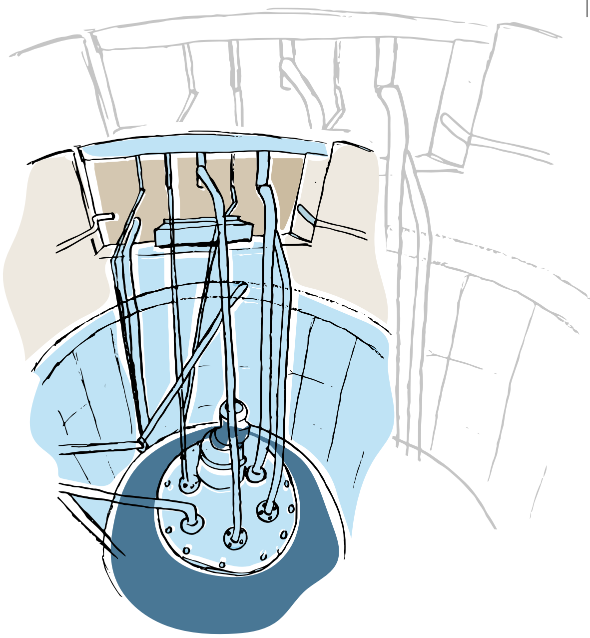
Decommissioning phases

With a view to decommissioning, the preparation operations have started.

- The retrieval and removal of waste from the pools are complete and the pools are being cleaned-out.
- Trench T2 has been emptied of the waste it contained. The scenario for waste recovery from the other trenches (T1, T3, T4 and T5) is being defined; it will be based on the lessons learned with trench T2, for which the operations were seriously slowed down by difficulties relating in particular to the uncertainties regarding the physical condition and the radiological inventory* of the waste packages.
- At present, the decommissioning operations focus on the retrieval and removal of "intermediate level" radioactive waste from the recent pits, as the "low level" waste has already been removed.
- The retrieval, removal and conditioning of the waste from the old pits should complete the decommissioning operations on BNI 56. They will notably require the construction of appropriate buildings for handling and conditioning this highly radioactive waste.

Decommissioning challenges

These relate to the retrieval and conditioning of legacy waste from an installation which, until 1983, was designed to act as its final disposal location. This bulk waste represents a significant dispersible radiological inventory*. The storage conditions led to considerable soil pollution. Clean-out is also a major challenge.



High activity laboratory
Saclay

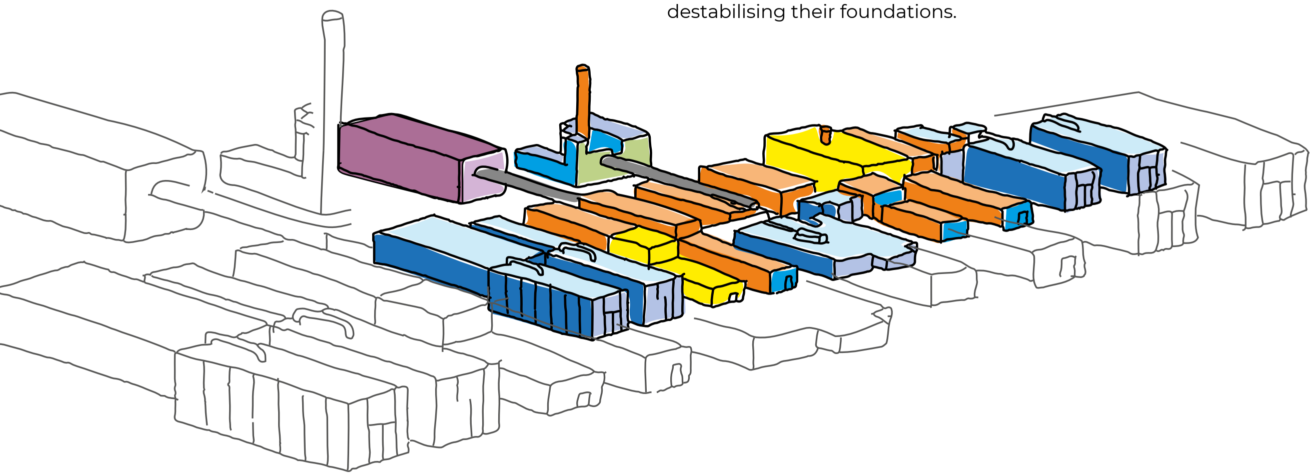
Installation: 18 laboratories (called "cells") make up the High Activity Laboratory (LHA) on the Saclay site (Essonne *département*). Performance of research work or production of various radionuclides.
Licensee: CEA
Commissioned: 1954
Final shutdown: 1996

Decommissioning phases

- Decommissioning of the laboratories has been authorised since 2008.
- The licensee has removed radioactive processes and equipment present in all the cells (except for the shielded line* in cell 10). Some cells have been completely cleaned-out and downgraded.
- In 2022, ASN will review the file applying for a modification of the decommissioning decree. This file was submitted by the LHA licensee following the 2017 discovery of significant soil pollution between certain cells.
- CEA envisages completing the decommissioning and clean-out operations by the 2040 time-frame.
- Three laboratories still in operation should remain, but under the installations classified for protection of the environment (ICPEs*) system. After clean-out, some cells will be kept for the storage of certain equipment and drums of intermediate level, long-lived waste (ILW-LL).

Decommissioning challenges

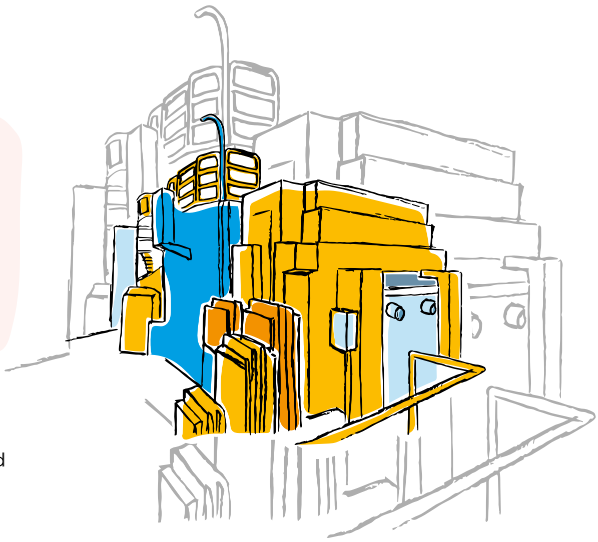
The licensee must clean-out the soils to depths ranging from 1 to 10 m, under containment, with excavations close to the cells, but without destabilising their foundations.



* *See glossary page 30*

DECOMMISSIONING WORK COMPLETED

After 5 years of work, decommissioning of the Ulysse nuclear reactor was completed in 2019. The work was done on-time.

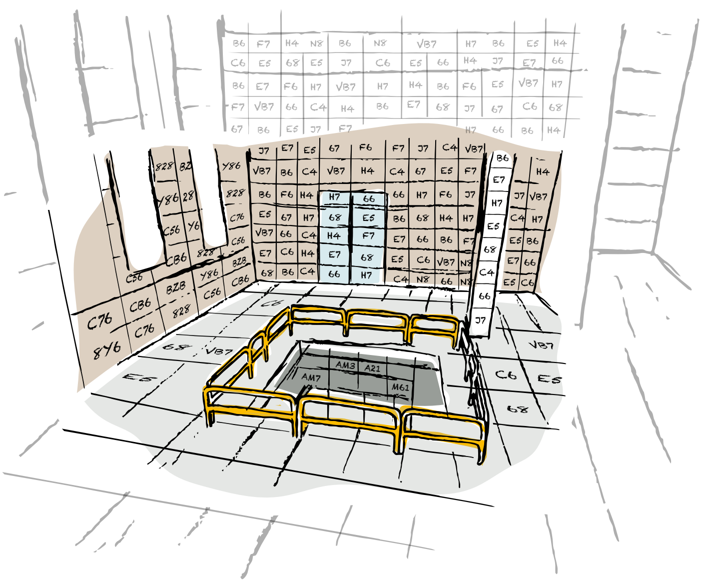


Ulysse
Saclay

Installation: Ulysse low-power research reactor (100 kilowatts thermal – kWth), used for teaching and experimentation activities, in Saclay (Essonne *département*)
Licensee: CEA
Commissioned: 1961
Final shutdown: 2007
Start of decommissioning: 2014
Decommissioning completed: August 2019

Decommissioning phases

- The fuel has been removed and the clean-out operations were completed in 2019, supplemented by radiological cleanness checks on the buildings and soils.
- After the decommissioning operations, the installation's building was kept and comprises no areas with any irradiation or contamination risk.



Decommissioning challenges

Over and above the organisational challenge, linked to sub-contracting of the operations, decommissioning of the Ulysse reactor represented 1200 days of work. Given the low power of the reactor, the safety and radiation protection issues were minimal.
No significant event was reported during the decommissioning operations.

- 226 tons of radioactive waste were removed to the VLL waste management route.
- 512 tons of conventional waste were taken away.
- ASN is currently reviewing the BNI* delicensing application*.

Using specific tools or technologies

Some BNI* decommissioning work uses standard techniques, albeit adapted to a nuclear environment. However, certain operations require innovative technologies and tools (robotics, virtual reality, remote-operation, new decontamination processes, etc.), which are specially developed to replace humans in irradiating or inaccessible environments, or to address complex needs on a case by case basis. Round-up of some of the practices used.

CUTTING TOOL DESIGNED FOR DECOMMISSIONING

In the auxiliaries cavern, an operator remotely controls the decommissioning operations on contaminated vessels. View on the control screen of a vessel being cut. Here in the Chooz A NPP.

©Philippe Dureuil/Médiathèque IRSN

DECOMMISSIONING OF THE CHOOZ A REACTOR PRESSURE VESSEL

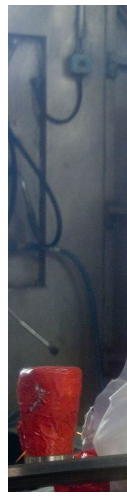
Demolition worksite. Raising and removal of the reactor pressure vessel closure head.

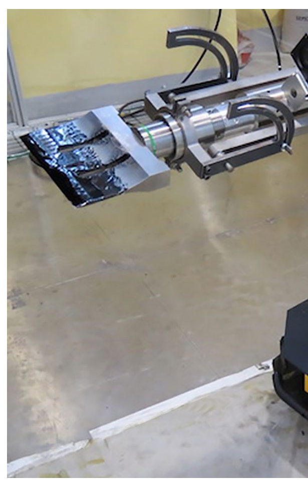
©EDF

OPERATORS WORKING IN A CONTAMINATED ZONE WEARING A VENTILATED HAZMAT SUIT

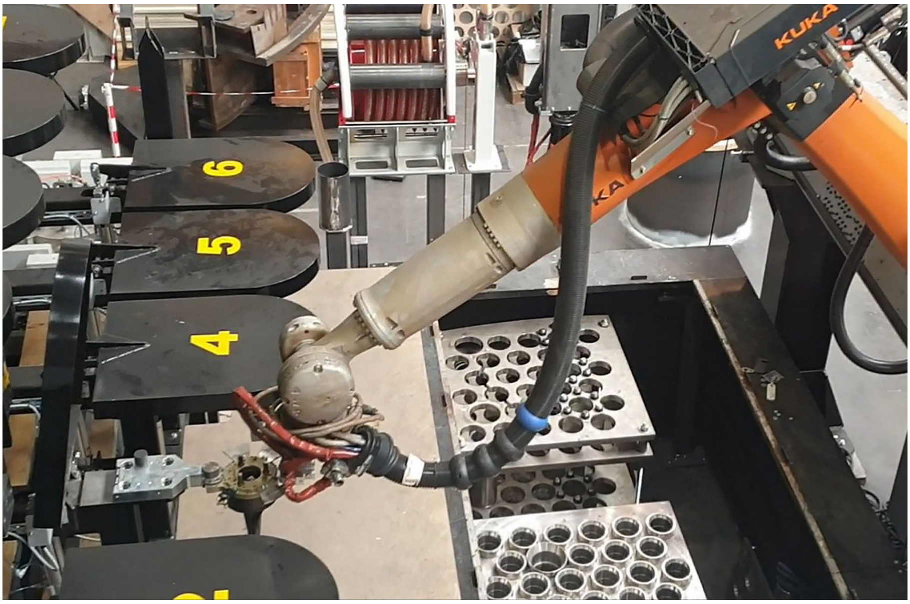
The ventilated hazmat suit, connected to a breathable air generating unit, is at a slight overpressure by comparison with the contaminated outside environment; it enables the operator to breathe and protects them from any contamination.

©C.Jandaureck/Cadam/ CEA – CEA Valduc





* See glossary page 30



"RODEC" CUTTING ROBOT WITH ITS RACK AND ACCESSORIES

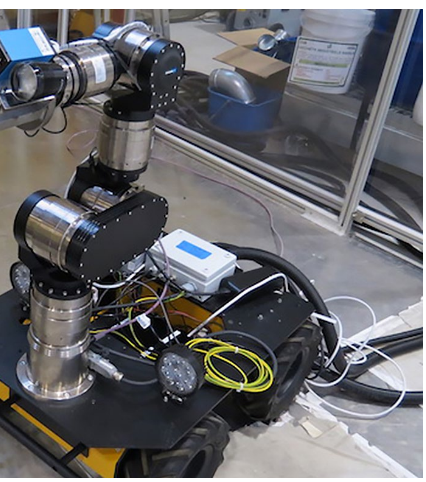
Three cutting processes are used: plasma, wire-drawing, laser. Here in the Creys-Malville NPP.

©EDF – Creys-Malville

WORK WEARING A PROTECTION SUIT

Here in the nuclear waste zone on the site of the Brennilis NPP.

©EDF



"SERVAL" RADIOACTIVE MATERIALS CUTTING ROBOT

This robot enables a remote operator to carry out decommissioning operations using a remote-operated robotic arm mounted on a mobile platform.
It has two cameras.

©CEA

And elsewhere?

Decommissioning strategies can vary from one country to another. However, most of them refer to the standards set out by the International Atomic Energy Agency (IAEA).

With regard to the decommissioning of nuclear installations following their final shutdown, the international consensus, as expressed in the IAEA safety standards, recognizes two strategies:

- **deferred dismantling:** the parts of the installation containing radioactive substances are kept in or brought to a safe state for several decades before the decommissioning operations begin;
- **immediate dismantling:** decommissioning is initiated as soon as the facility is shut down, without a waiting period, although the dismantling operations can take a long time.

Canada

In Canada, the NPP delicensing* plans cover a 50-year period. The licensee wishing to obtain an operating license for an NPP is required to present a delicensing* plan which specifies how they intend to manage the decommissioning and decontamination of their installation. As soon as the delicensing* permit is obtained, implementation of the plan can begin. The activities in this phase include the decontamination and dismantling of the installation. At present, 6 pressurised heavy water nuclear reactors (PHWRs) are undergoing decommissioning.

United States

In the United States, the licensees of nuclear installations (**civil or military**) **can choose from among three decommissioning strategies:** immediate dismantling, deferred dismantling, or isolation of the installation by encapsulation (entombment) until radiological levels compatible with delicensing* are attained. To date, about ten nuclear installations have been decommissioned and twenty are undergoing decommissioning. Twelve reactors, including 6 PWRs and 4 boiling water reactors (BWR) are undergoing deferred dismantling and 10 others immediate dismantling, including 4 PWRs and 5 BWRs.

United Kingdom

The United Kingdom has about thirty definitively shut down power reactors, the vast majority of which are gas-cooled, but there are also a few reactors using other technologies (advanced gas-cooled reactors, heavy water reactors, fast neutron reactors), as well as half-a-dozen definitively shut down research reactors.

Although immediate dismantling is legally possible, the strategy currently most widely used in the United Kingdom for power reactors is deferred dismantling. The main reasons put forward are the high level of activation of certain materials (such as graphite), which require decay times of several decades before handling, and the lack of disposal routes for radioactive waste in general.

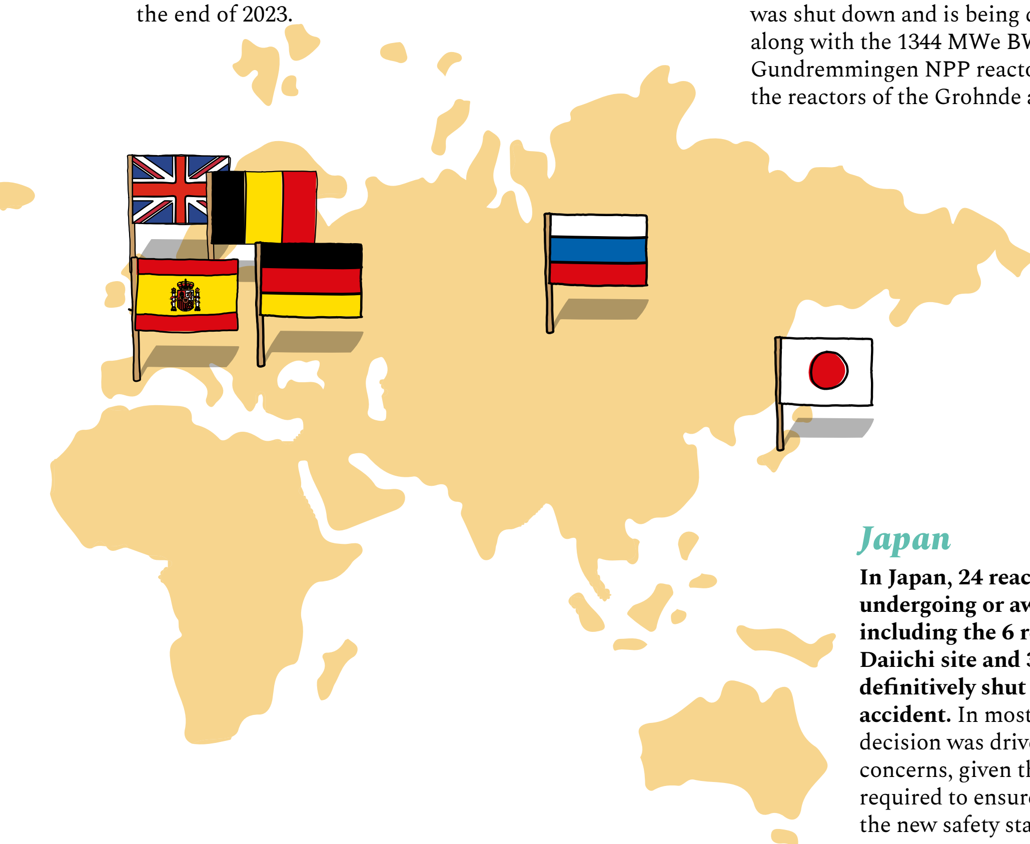
* *See glossary page 30*

Belgium

The decommissioning of the RB3 pressurised water reactor, which started in June 1987, is the first of its kind in Belgium and indeed in Western Europe. The European Commission selected BR3 as the pilot project to demonstrate the technical and economic feasibility of reactor decommissioning in real conditions. According to the decommissioning plan, the reactor will be fully decommissioned by the end of 2023.

Germany

After the Fukushima Daiichi accident, Germany decided to abandon nuclear power before the end of 2022. A total of 29 reactors are currently being decommissioned. The site of the 100 MWe heavy water reactor in Niederaichbach has been completely cleaned out and decommissioning of 3 other reactors has been completed. Recently, the 1400 MWe PWR type Phillipsburg 2 reactor was shut down and is being decommissioned, along with the 1344 MWe BWR type Gundremmingen NPP reactor C, the and the reactors of the Grohnde and Brokdorf NPPs.



Japan

In Japan, 24 reactors are currently undergoing or awaiting decommissioning, including the 6 reactors on the Fukushima Daiichi site and 3 reactors already definitively shut down prior to the accident. In most cases, the final shutdown decision was driven by profitability concerns, given the scale of the work required to ensure compliance with the new safety standards.

The strategy generally adopted comprises an initial period of about a decade in which the reactor is kept in safe conditions, before decommissioning operations begin.

Spain

In Spain, 3 reactors have been definitively shut down, but the dismantling strategies differ according to the reactor technology. The Vandellós 1 gas-cooled reactor is undergoing deferred dismantling, owing to the lack of a management route for graphite waste. Deferred dismantling is also the option chosen for the Santa María de Garoña reactor, shut down in 2013. In 2011, decommissioning of the José Cabrera NPP in Zorita began, after its shutdown in 2006. As at 31 December 2020, it is estimated that more than 90% of the envisaged decommissioning operations have been carried out.

Russia

In Russia, several power reactors are undergoing or awaiting decommissioning. These are mainly PWRs and reactors with a graphite moderator. Although the decommissioning preparatory operations have been performed, the dismantling strategy for these reactors has not yet been completely determined.

Your questions, our answers

How long does it take to decommission a nuclear installation?

The time needed to decommission a BNI* can vary significantly from one installation to another and depends on a number of factors; all of them have an impact on the complexity of decommissioning. About twenty years are needed to decommission pressurised water reactors, with the plant series effect generating considerable amounts of experience feedback.

Conversely, research reactors are usually unique prototypes, so their decommissioning entails resources specific to each one: for some of them (Ulysse, Strasbourg university reactor), decommissioning takes between 5 and 10 years, while for other types of reactors, it could take several decades.

Similarly, certain facilities at La Hague or old waste storage facilities, for example at Cadarache, still contain a large quantity of waste which has to be retrieved and conditioned: for these facilities, new equipment and processes are needed, leading to lengthy and complex decommissioning operations.

What is ASN's role regarding installations being decommissioned?

ASN is responsible for overseeing all BNIs*, including those being decommissioned. ASN monitors the decommissioning operations being carried out, by means of inspections and by reviewing the technical files submitted by the licensees.

ASN more particularly provides the Ministry for Ecological Transition with support, by carrying out a technical review of the decommissioning files. To do this, it can call on the expertise of the Institute for Radiation Protection and Nuclear Safety (IRSN), the main technical support organisation it draws on when preparing its position statements. For those files for which the stakes are highest, it can also request the opinion of the Advisory Committee for Decommissioning, which comprises qualified persons, for example from civil society or institutional bodies.

On what points does ASN particularly focus with regard to decommissioning?

ASN oversees the entire decommissioning process, which is the subject of inspections in the same way as during operation of the installation. It ensures that the risk prevention measures set out in the regulations are adhered to, as are the deadlines set for the performance of decommissioning.

It pays particular attention to the radiation protection of workers, in the light of the new risks created by the dismantling operations, and to mitigating their consequences on the environment. Finally, it regulates and monitors the management of the installation's radioactive waste.

** See glossary page 30*

Will the decommissioning of the Fessenheim NPP act as a "laboratory" for the reactors to be shut down in the coming years?

In France, the 56 reactors of the NPP fleet in operation* are all PWRs and although their power varies from one reactor to another, they are of similar design.

The lessons learned from the decommissioning of the two Fessenheim reactors will be valuable for those that are to follow in the coming years. They will supplement the lessons already learned from the ongoing decommissioning of Chooz A.

These decommissioning operations will also benefit from significant international experience feedback: 42 PWRs are being decommissioned around the world at the present time.

How is decommissioning financed? Is advance provision made for these costs?

The licensees are required to cover the cost of decommissioning (and all related operations) of their installations, on the basis of the "polluter-pays" principle.

They are required to make provision for all the costs linked to decommissioning and waste management and must thus create a "portfolio of assets able to cover the anticipated costs". This is under the direct control of the State, based on an analysis of the options that could be reasonably expected for carrying out all the operations.

This financial guarantee system is defined in the Environment Code and takes account of decommissioning, including clean-out of structures and soils, as well as management of waste and spent fuels.

Every year, ASN produces a barometer measuring the opinion of the general public and local residents around the NPPs regarding nuclear safety in France as well as their positions concerning nuclear energy.

One of the questions deals with decommissioning.

Do you think that nuclear installations will be decommissioned safely?

	Yes	No
GENERAL PUBLIC	40%	46%
LOCAL RESIDENTS 0-10KM AROUND A BNI*	49%	40%
INFORMED PUBLIC	72%	26%

The general public and local residents are divided over the fact that the installations will be decommissioned in good conditions, while the informed public (journalists, politicians/local elected officials, teachers, health professionals, association militants, etc.) are far more confident.

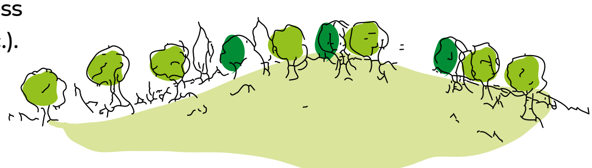
Survey conducted with 2309 respondents by KANTAR Public, between October and December 2019: Total – n = 2007 for the general public (including 329 for BNI* local residents * 0-10 km) / n = 302 for the informed public.

YOUR QUESTIONS, OUR ANSWERS

What can happen to a BNI* site once decommissioning has been completed and the installation "delicensed"?

On completion of decommissioning, a BNI* can be delicensed by an ASN resolution. With a view to delicensing*, the licensee submits a file to ASN summarising the decommissioning operations already carried out and demonstrating attainment of the cleanness objectives set by ASN. Once "delicensed", the installation is no longer subject to the nuclear installations legal system.

Depending on the final state reached, ASN may require the implementation of active institutional controls* as a condition of delicensing*, determining **a certain number of restrictions on the use of the site (and any remaining buildings), or precautionary measures that will have to be adhered to.** Depending on its radiological cleanness level, a delicensed installation may become a new industrial site – whether or not nuclear – or house public access buildings (offices, commercial activity zone, etc.).



Where do things stand with decommissioning of the Brennilis NPP, in the Monts d'Arrée hills?

The Brennilis NPP (BNI 162) reactor was a prototype power reactor operating with heavy water. It was operated by CEA, and then by EDF, and was shut down in 1985 after 18 years of service. The nuclear fuel has been completely removed from the installation and dismantling of the equipment, except for the "reactor block" (exchangers, effluent treatment station, waste hangar, etc.) is now complete.

A specific reactor building dismantling file is currently being reviewed, pending the publication of a new decommissioning decree. This project was the subject of a public inquiry. The reactor block dismantling operations, carried out with remote-operated resources in a relatively restricted space, will be complex owing to the close proximity and congestion of the equipment items. The end of decommissioning of Brennilis is scheduled for the 2040s and the final state envisaged is currently complete demolition of the buildings.

* See glossary page 30

WHAT THE CLI AND THE ANCCLI HAVE TO SAY

For several years now, the Local Information Committees (CLIs) and the National Association of Local Information Committees and Commissions (Anccli) have been closely monitoring decommissioning (two White Papers were produced in 2017 and 2021).

In these works, the question of the continuity of the monitoring performed by the CLIs is addressed, including the preservation of memory over several generations. To preserve this memory, the CLIs and the Anccli propose creating a National Committee for the archival of their works.

For more information, scan this QR code.

The CLIs and the Anccli also expressed the need:

■ to consolidate their roles

- They wish to be better informed and more closely involved, on the occasion of updates to the decommissioning plan and during the decommissioning operations.
- ASN recently suggested to the CLIs and the Anccli that they help with the drafting of ASN's "Decommissioning Plan" guide, intended for the licensees. The joint desire is to have the CLIs involved throughout the decommissioning process.

■ to guarantee public participation

- The shutdown of nuclear reactors will entail generic aspects in the decommissioning operations. The CLIs and the Anccli are asking that a participative process be created, on the one hand concerning the generic aspects of the decommissioning of the reactors of the same family and, on the other, concerning the management of the very low level waste resulting from decommissioning.
- The CLIs and the Anccli will also be vigilant with respect to compliance with the regulations and to the conditions for any changes to the schedules (for example, the decommissioning of the GCR reactors).

■ to ensure that decommissioning is possible

- The CLIs and the Anccli recall that securing the financing and human resources is a key condition for the success of the decommissioning operations and the processing of the resulting waste.

GLOSSARY

Active institutional controls: depending on the final state reached on a site, active institutional controls may be implemented to take account of the planned subsequent uses of the site and buildings. These can contain a number of restrictions on use (industrial use only, for example) or precautionary measures (radiological measures in the event of excavation, etc.). ASN may make the application of such institutional con-trols a pre-condition for delicensing a BNI*.

ALARA *(As Low As Reasonably Achievable):* protection optimisation principle, the end-purpose of which is to reduce exposure to the ionising radiation received by each individual to a level that it as low as reasonably achievable, taking account of technical and economic constraints.

Alpha particles: alpha particles are easily absorbed by matter but can only travel a few centimetres through air. They can be stopped by a sheet of paper or by the outer part of the skin and are therefore not generally considered dangerous to health – unless the source is inhaled or ingested.

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.

Complex project: a project which involves a large number of interdependent elements which can interact at the same time and lead to unpredictable results liable to seriously impact the objectives of the project.

Conversion: range of chemical transformations used to obtain uranium hexafluoride (UF_6) from uranium ore, with a view to its enrichment, its storage, or the fabrication of nuclear fuel.

Delicensing: consists in removing an installation from the BNI list, which implies that the installation is no longer subject to the BNI legal and administrative system.

Diffuser cascade: range of large equipment items and piping which represent the heart of the gaseous diffusion process used to enrich uranium with isotope 235.

Dispersible radiological inventory: the quantity of radio–active substances that could be involved in an incident or accident.

Enrichment: process whereby the fissile isotopes content of an element is increased. The process leads to the separation of the product into two parts, referred to as "enriched" and "depleted" respectively in terms of the particular isotope. The enrichment of uranium with isotope 235 (^{235}U) aims to make it usable as a fuel in the NPPs. Thus, the uranium which, its natural state, consists of 0.7% uranium-235, ^{235}U (fissile) and 99.3% uranium-238, ^{238}U (non-fissile) is enriched with uranium-235, the proportion of which will then be increased to about 3 to 4%.

Excavation: the intentional extraction of soil in order to conduct works on the land (for example, digging the foundations of a construction).

ICPE: Installation Classified for Protection of the Environment. Owing to its potential impact on the public and the environment, an in-stallation subject to the regulations defined in Title I of Book V of the Environment Code.

"In air" (dismantling): As opposed to "under water" dis–mantling, this involves dismantling operations performed directly in the ambient air, with no water to limit the dispersal of contamination or attenuate the dose rate.

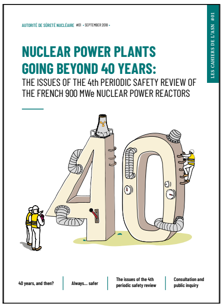
"In water" (dismantling): mechanical cutting technique guaranteeing worker radiation protection and visibility during the operations.

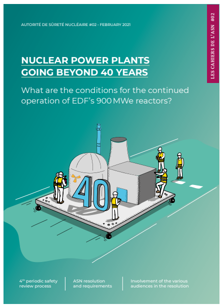
Sealed radioactive sources: Source for which the structure or packaging prevents all dispersion of radioactive substances into the ambient environment, in normal use.

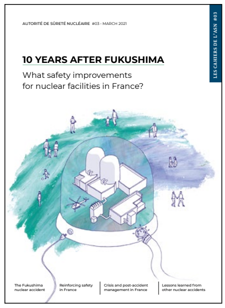
Shielded line: radiation protection device used for remote handling of radioactive or chemical products.

Uranium hexafluoride – UF_6: the uranium contained in nuclear fuels must be enriched with fissile isotope 235. Before being enriched, the uranium is first of all converted into a gas called "uranium hexafluoride".

WRC: retrieval and conditioning of legacy waste. This operation consists in retrieving legacy waste, stored in bulk, or in old and even damaged packages, and in reconditioning it in waste packages compliant with current safety standards. For example, this waste can be non-reusable substances from spent fuels from gas-cooled, light-water reactors (fission products and metal structures of spent fuels), as well as waste generated by the use of reprocessing processes (solvents, effluent treatment residues, ion exchange resins, etc.).







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