French National Plan

for the management of Radioactive Materials and Waste

2016 – 2018

SUMMARY

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

MINISTÈRE
DE LA TRANSITION
ÉCOLOGIQUE
ET SOLIDAIRE

asn AUTORITÉ DE SÛRETÉ NUCLÉAIRE

Table of contents

Refers to the corresponding part in the full report

Paragraph summarising the recommendations set out in the plan

Radioactive materials and waste must be managed sustainably, to protect individual health, security and the environment.

The National Plan for Radioactive Materials and Waste Management (PNGMDR) is a key tool in ensuring the long-term implementation of these principles, within the framework set out in the Environment Code and in the Programme Act of 28th June 2006 concerning the sustainable management of radioactive materials and waste.

This three-year plan aims to provide a regular picture of the management policy for radioactive substances nationwide, to assess needs that are coming out and determine objectives to be met in the future, more specifically in terms of studies and research. The interest of this approach was confirmed at European level by the directive establishing a community framework for the responsible and safe management of spent fuel and radioactive waste, adopted on 19th July 2011, which generalised the adoption of such approach.

This new PNGMDR was drafted on the basis of works and exchanges within a pluralistic working group, comprising environmental protection associations and regulatory authorities and regulatory assessment bodies, alongside radioactive waste producers and managers. It was the subject of an environmental assessment for the first time, followed by a public consultation, thus enabling obtained comprehensive understanding of the stakes and challenges associated with the management of radioactive materials and waste. Furthermore, this new PNGMDR takes account of the guidelines of the Energy Transition for Green Growth Act.

The 2016-2018 PNGMDR also proposes possible solutions for improving the management of all radioactive materials and waste. These proposals continue the work carried out since the first version of the plan, covering the period 2007-2009, and more specifically request to undertake studies and to implement management measures for some of these substances. Although much progress has been made, we cannot overstate the extent to which we consider the implementation of the recommendations presented in this 2016-2018 edition to be essential. New avenues for work are today open, in particular concerning the long-term harmfulness of radioactive waste from a more global environmental perspective, the further use prospects of certain radioactive materials, or the storage strategies adopted by the licensees pending the availability of final management solutions. The answers to the questions raised will determine our capacity to avoid imposing the burden of managing this waste on future generations.

Laurent Michel
General Director for Energy and Climate (DGEC)

Pierre-Franck Chevet
Chairman of ASN (French nuclear safety regulator)

The National Plan for Radioactive Materials and Waste Management (PNGMDR) draws up an inventory of management policy, assesses needs and determines objectives for the future. The 2016-2018 edition continues on and expands the actions initiated in the previous plans. It in particular reinforces its prescriptions with regard to the waste and radioactive material volume forecasts, making them consistent with the objectives set by the energy transition Act, to addressing the challenges linked to further use prospects for radioactive materials, as well as to the need to determine a coherent and optimised approach for each category of waste, more particularly in environmental terms.

This summary presents the main components of the 2016-2018 PNGMDR. It follows the same structure so that the reader can obtain greater detail on any particular subject by referring to the full report available on the DGEC and ASN websites. Throughout the summary, pictograms indicate the corresponding part of the full report. The summary is organised into four parts. The first part recalls the principles and objectives of radioactive materials and waste management. The management modes and further use prospects for radioactive materials are then presented, as are the results and the development prospects of the existing management solutions. Finally, the last part presents the needs and prospects for the management solutions to be put into place.

Management of radioactive materials and waste: principles and objectives

What is radioactive waste? §1.1.1

Of the radioactive substances, some are materials while others are waste. Therefore, as defined by the Environment Code, **radioactive materials** are substances for which further use is planned or foreseen. This mainly concerns new or spent nuclear fuels based on uranium (natural, enriched, depleted or reprocessed) and plutonium.

Radioactive waste consists of **radioactive substances** for which no further use is planned or foreseen.

Where does the waste come from? §1.1.2

Since the early 20th century, radioactive materials and waste have mainly been produced by five economic sectors:

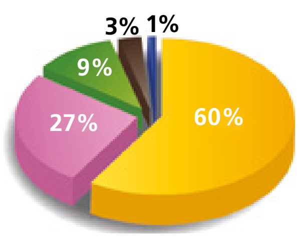
- **the nuclear power generating sector:** primarily nuclear power plants generating electricity, as well as the plants dedicated to the fabrication and reprocessing of nuclear fuel;
- **the research sector:** laboratories in the civil nuclear, medical research, particle physics, agronomy, chemistry, etc. fields;
- **the defence sector:** mainly activities related to the nuclear deterrent force, including the nuclear propulsion of certain ships or submarines, as well as the corresponding research activities;
- **Industry other than nuclear power generation:** notably the extraction of rare earths, the manufacture of sealed sources, but also various applications such as weld inspections, the sterilisation of medical equipment, the sterilisation and conservation of food products, etc.;
- **the medical sector:** therapeutic, diagnostic and research activities.

DEFINITION

Radioactivity

Radioactivity is a natural phenomenon during which unstable atomic nuclei are transformed, after a series of disintegrations, into stable atomic nuclei. These transformations are accompanied by the emission of ionising radiation. There are sources of both natural radioactivity (granite, cosmic rays, etc.) and artificial radioactivity (nuclear electricity generating reactors, medical radiotherapy activities, etc.).

KEY FIGURES



- Nuclear power generation
- Research
- Defence
- Industry apart from the nuclear power generation
- Medical

Breakdown per economic sector of the volume of waste as at the end of 2013.

What are the different types of waste? §1.1.3

With regard to radioactive waste, the usual French classification is based on two parameters which are important when defining the appropriate management method:

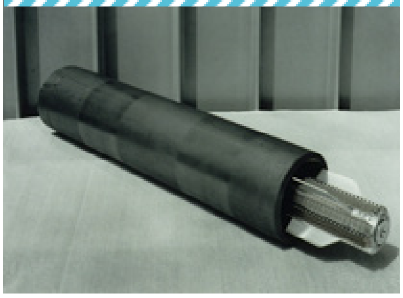
- **the activity level,** in other words the radioactivity, which corresponds to the number of disintegrations per unit of time of the radioactive elements contained in the waste. Depending on the quantity and nature of the radioactive substances contained in the waste, it can be very low, low, intermediate or high level;
- **the radioactive half-life** of the radionuclides contained in the waste. The radioactive half-life corresponds to the time needed for half the quantity of atoms in a radioactive element to have decayed. A particular distinction is made between waste for which the radioactivity comes primarily from radionuclides with a half-life of less than 31 years (waste referred to as short-lived – SL) and waste for which the radioactivity comes primarily from radionuclides with a half-life of more than 31 years (waste said to be long-lived - LL).

This classification comprises the following main categories:

- **high-level waste** (HLW), mainly from spent fuels after reprocessing. It is conditioned in glass packages;
- **intermediate level, long-lived waste** (ILW-LL), mainly from spent fuels after reprocessing and activities involved in the operation and maintenance of fuel reprocessing plants. This comprises structural waste, hulls and end-pieces making up the nuclear fuel cladding, along with technological waste (used tools, equipment, etc.) or waste resulting from the treatment of effluents, such as bituminised sludges;
- **low level, long-lived waste** (LLW-LL), mainly graphite waste and radium-bearing waste. Graphite waste comes mainly from the decommissioning of the gas-cooled reactors. Radium-bearing waste is mainly produced by the industrial activities unrelated to power generation (such as the processing of ores containing rare earths). This category also comprises other types of waste, such as certain legacy bitumen packages, uranium conversion treatment residues, and so on;
- **low level and intermediate level, short-lived waste** (LLW/ILW-SL), mainly from the operation, maintenance and decommissioning of nuclear power plants, fuel cycle facilities, research centres and, to a far lesser extent, from medical research activities;
- **very low level waste** (VLLW), from the operation, maintenance and primarily the decommissioning of nuclear power plants, fuel cycle facilities and research centres;
- **very short-lived waste,** mainly from the medical and research sectors. It is stored on the utilisation site to allow radioactive decay, before disposal through a conventional route, corresponding to its physical, chemical and biological characteristics.

This classification enables each waste category to be schematically associated with one or more management solutions, as concisely shown in the following table.

Example of packages of compacted ILW-LL (intermediate level, long-lived): technological waste, hulls and end-pieces



Example of LLW-LL (low level waste, long-lived): graphite sleeve from operation of gas-cooled reactor

Example of LLW/ILW-SL (low and intermediate level, short-lived waste) from laboratory operations

Example of VLLW (very low level waste) packaging

Hundreds Bq/g

Millions Bq/g

Billions Bq/g

<table>
<tr><th></th><th>Very short lived waste containing radionuclides with a half-life of < 100 days</th><th>Short lived waste in which the radioactivity comes mainly from radionuclides with a half-life ≤ 31 years</th><th>Long lived waste containing mainly radionuclides with a half-life > 31 years</th></tr>
<tr><td>Very low level (VLL)</td><td rowspan="3">Management by radioactive decay on the production site
then disposal through routes dedicated to conventional waste</td><td colspan="2">Recycling or dedicated surface disposal
(disposal facility of the Industrial centre for collection, storage and disposal in the Aube département)</td></tr>
<tr><td>LOW LEVEL (LL)</td><td rowspan="2">Surface disposal
(Aube waste disposal repository)</td><td>Subsurface disposal
(studied pursuant to the 28th June 2006 Act)</td></tr>
<tr><td>Intermediate level (IL)</td><td rowspan="2">Deep geological disposal
(planned pursuant to the 28th June 2006 Act)</td></tr>
<tr><td>High level (HL)</td><td>Not applicable
The category high level, very short-lived waste does not exist</td><td></td></tr>
</table>

SPOTLIGHT

The national inventory is available on the www.andra.fr website, under Éditions/Inventaire national.

KEY FIGURES

Radioactive waste for which there is a disposal route in service at end 2013

90 % of the volume of waste

< 0,02 % of the total radioactivity of French radioactive waste

The HLW waste in existence at end 2013

0,2 % of the total volume of French radioactive waste

97 % of the total radioactivity of French radioactive waste

The LLW/ILW-SL waste in existence at end 2013

60 % of the total volume of French radioactive waste

0,02 % of the total radioactivity of French radioactive waste

What is the volume of waste?

§1.1.4

A National inventory of radioactive materials and waste is produced every three years by the French National Waste Management Agency (Andra). It is available on the Andra website.

(in m³ equivalent packaged)	Stocks at end 2013	Forecasts at end 2020	Forecasts at end 2030	Forecasts at completion*
HLW	3 200	4 100	5 500	10 000
ILW-LL	44 000	48 000	53 000	72 000
LLW-LL	91 000	92 000	120 000	180 000
LLW/ILW-SL	880 000	1 000 000	1 200 000	1 900 000
VLLW	440 000	650 000	1 100 000	2 200 000
Total	~ 1 460 000	~ 1 800 000	~ 2 500 000	~ 4 300 000

Completion: envisaged end of operation (including decommissioning) of the installations producing radioactive waste.

What are the legal and institutional frameworks for radioactive waste management?

§1.3

At the European level, the directive of 19th July 2011 establishes a community framework for the safe and responsible management of spent fuel and radioactive waste. It reaffirms the responsibility of each Member state for setting up a national programme for the management of spent fuel and radioactive waste, as is already the case in France, with the PNGMDR and the National Inventory.

The national framework for the management of radioactive materials and waste is defined by the Environment Code and by the Programme Act 2006-739 of 28th June 2006 concerning the sustainable management of radioactive materials and waste.

The PNGMDR organises the implementation of research and studies into the management of materials and waste, in accordance with the three orientations defined by the Act:

- reduction in the quantity and harmfulness of the waste;
- storage as a preliminary or interim step pending fuel and waste reprocessing, or disposal of the waste;
- after storage, deep geological disposal of ultimate waste that cannot be disposed of on the surface or at shallow depth, for nuclear safety or radiation protection reasons.

How is waste management financed? §1.4

Under the control of the State, radioactive materials and waste management is financed by the nuclear licensees, in accordance with the polluter-pays principle. A system to secure the financing of long-term nuclear costs was thus set up by the 28th June 2006 Act. The licensees are required to assess the long-term costs, including the cost of decommissioning and the costs linked to management of the spent fuels and radioactive waste. They must be able, today, to guarantee coverage of future cost by a portfolio of dedicated assets.

Compliance with these regulatory obligations is verified by the ministries for economy and for energy. Therefore, the Government receives a three-yearly report assessing the long-term costs, the methods and choices made for management of the dedicated assets and a quarterly inventory of these dedicated assets.

How is information and consultation organised with respect to the management programme? §1.5

One of the cornerstones of the radioactive materials and waste management policy is to ensure transparent information and consultation:

- at the local level, through local information committees;
- at Parliamentary level, with regard to the framework for final management of high level waste and intermediate level, long-lived waste and to the assessment of the national management system and the advances made in it;
- with the general public, via the PNGMDR and the public debates.

In this approach, all the work associated with the PNGMDR and monitored by a pluralistic working group is made public.

MILESTONES

1991: Act on research into the management of radioactive waste (mainly concerning high level and intermediate level, long-lived waste)

2005-2006: public debate on radioactive waste management

2006: Act on the sustainable management of radioactive materials and waste (concerning all reusable materials and radioactive waste), prepared after the assessment of the research carried out pursuant to the 1991 Act

2011: European directive establishing a community framework for the responsible and safe management of spent fuel and radioactive waste

2013: public debate on the reversible deep geological disposal repository

2016: Act setting out the reversibility conditions for the deep geological disposal repository

Future milestones

2018: submission by Andra of the creation authorisation application for the reversible deep geological disposal repository

2025: start of pilot industrial phase for the reversible deep geological disposal repository

SPOTLIGHT

Drafting of the PNGMDR and information of the public

The PNGMDR is drafted by a pluralistic working group chaired by the ministry for energy and by ASN. It draws on the work carried out by the licensees and on the opinions issued by ASN. As of this 2016-2018 edition, the PNGMDR is also the subject of an environmental assessment which accompanies the plan during the public consultation prior to its adoption. All the work associated with the PNGMDR is made public and is available on the following websites www.ecologique-transition.gouv.fr and www.asn.fr

Management of radioactive materials and further use prospects

DEFINITION

Radioactive materials are reusable radioactive substances, in other words for which further use is planned or foreseen, if necessary after processing.

KEY FIGURES

94 % of the spent fuel, after burn-up in the nuclear reactors, consists of uranium which can be extracted as recycled uranium for subsequent reuse.

Development of new cancer treatments. Extraction and purification of Pb-212 from thorium in the Maurice Tubiana Laboratory, for the purpose of pre-clinical and clinical trials.

A radioactive material is defined as being a radioactive substance for which further use is planned or foreseen, if necessary after processing. These materials can be used in France or abroad. The law enables the State to reclassify materials as waste if any serious doubts were to arise with regard to their further use.

The 2016-2018 PNGMDR presents the procedures for assessing the actual usability of these materials, the volumes concerned and the potential changes in stock levels, along with their further use solutions.

Radioactive materials	Current or envisaged use
Natural uranium	Its use in the enrichment plants produces two substances: enriched uranium and depleted uranium
Enriched uranium	This is intended for the fabrication of fuels, to produce electricity of nuclear origin
Depleted uranium	• Used for the fabrication of the MOX fuel used in some EDF reactors • Can be partially re-enriched, which can be economically advantageous if the price of natural uranium rises or in the event of developments in enrichment techniques • In the longer term, it could be used in possible future fast neutron reactors
Recycled uranium from reprocessed spent fuel (URT)	Extracted from spent fuels, can be re-enriched to produce enriched recycled uranium (URE) used in the fabrication of fuel
Plutonium	• Contained in spent fuel assemblies, extracted when they are reprocessed and used for the fabrication of the MOX fuel used in some EDF reactors • In the longer term, the plutonium contained in spent MOX fuels could be used in possible future fast neutron reactors
Thorium	• Could be used in various types of reactors as a fuel in a thorium cycle, but not before several decades have passed, given the amount of research and development work still necessary • Other applications are currently under development, in particular for the treatment of certain cancers

France has opted for the reprocessing – recycling model, which enables spent fuels to be recycled in the form of MOX fuel and URE fuel.

What the Plan recommends

In accordance with the recommendations from the environmental authority, Areva – together with EDF, CEA and Andra – is required to perform a comparative assessment of the environmental impacts of spent fuel strategies with and without reprocessing.

The 2015 edition of the national inventory of radioactive materials and waste produced by Andra presents an estimate of the production of radioactive waste and spent fuels, according to two possible energy policy scenarios (continued operation or non-renewal of the nuclear power generating fleet) and their impact on the further use possibilities of radioactive materials.

What the Plan recommends

The possible future scenarios in the future editions of the national inventory of radioactive materials and waste will need to provide some scenarios with objectives set by the Energy Transition for Green Growth Act. They shall also be more extensively developed, more particularly to present the actual further use possibilities of the materials.

As requested by the 2013-2015 PNGMDR, the owners of radioactive materials conducted precautionary studies of the management options in the eventuality of the materials being classified as waste at some time in the future.

What the Plan recommends

The studies into the disposal of these substances if they were to be classified as waste at some time in the future will need to be taken further by Andra, jointly with the owners of the materials, for spent fuels, depleted uranium, URT and thorium.

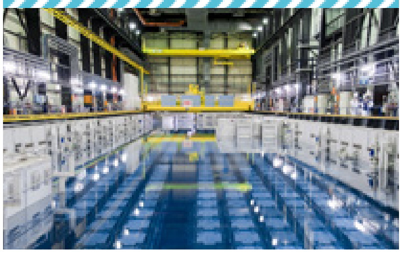
Finally, the prospects for the long-term further use of plutonium and depleted uranium in possible future fast neutron reactors will need to be consolidated.

What the Plan recommends

CEA, together with EDF and Areva, shall draw up a study program to be carried out in the Astrid technology demonstrator reactor, so that the ability of the proposed technologies to reutilise and thus stabilise or reduce the plutonium inventories can be demonstrated on a representative scale.

SPOTLIGHT

Spent fuel storage capacities
Spent fuels are stored in pools, pending reprocessing or reutilisation. New storage capacity for these fuels will be needed between 2025 and 2035.
EDF is studying the options to ensure that new capacity is available by this time-frame.



The spent fuel pools at La Hague can be used to store fuels pending reprocessing, in order to reutilise the radioactive materials they contain.

Improving existing management modes

This part provides an overview of the existing management modes. It underlines the areas for improvement and the management recommendations of the PNGMDR:
• legacy situations ;
• mining processing residues and waste rock;
• waste with high levels of natural radioactivity;
• radioactive waste, more particularly VLLW and LLW/ILW-SL.

Management of legacy situations

§3.1

Certain radioactive waste may in the past have been managed in ways that have since changed. This is particularly the case with disposal within or close to the production sites. This waste may also, in certain cases, have been used as backfill, or handled in routes defined specifically for the management of conventional waste.

The term legacy disposal site is used to describe those places (except for mining residue and waste rock repositories) for radioactive waste which is not under Andra responsibility and for which those who produced or possessed it did not at the time of disposal envisage management in the existing or planned external routes dedicated to radioactive waste management.
This primarily concerns:

- thirteen conventional waste disposal facilities which had received VLL waste from the conventional or nuclear industries;
- waste disposed of near or within civil or secret basic nuclear installations or defence-related nuclear experimentation sites and installations (SIENID);
- depots of TENORM waste (waste created by the transformation of raw materials naturally containing radionuclides but which are not used for their radioactive properties), which are not covered by the environmentally-classified installations regulation. This in particular concerns phosphogypsum waste from the production of fertilisers, residues from the production of alumina (aluminium oxide), coal ash from thermal power plants and residues from the production of rare earths from monazite.

What the Plan recommends

By the end of 2017, Areva, CEA and EDF will be required to complete their investigations into the search for legacy disposal sites within or near to nuclear installations and present the management strategies envisaged for the sites identified.

Management of mining processing residues and waste rock

§3.2

In France, the uranium mines were worked from 1948 to 2001. The exploration, extraction and processing activities concerned about 250 sites in 27 French départements. Ore was processed in eight plants. Exploration and the working of the uranium mines generated:

- **processing residues** consisting of products remaining after extraction by processing of the uranium;
- **waste rock** consisting of soil and rock excavated to access uranium-bearing seams.

Given the large quantities of waste produced, the management method currently adopted for these substances is in-situ management, including verification of the steps taken to limit the current and long-term impact to a level that is as low as reasonably possible. The mining residues disposal sites are subject to the regulations on installations classified on environmental protection grounds, under the responsibility of Areva.

DEFINITIONS

Mining residues
Mining residues are very low-level or low-level type waste created during ore processing operations.

Mining waste rock
The waste rock is the material (soil, rock, etc.) excavated to access the uranium deposits one is looking to exploit. It has not undergone any special mechanical or chemical processing.

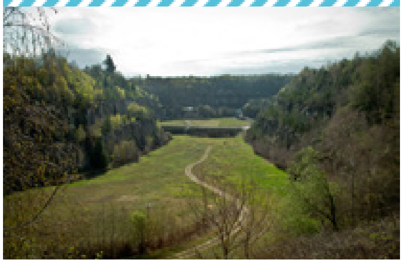
Radon
Radon is a naturally occurring radioactive gas. It emanates in particular from granite and volcanic subsoils.
It is one of the decay products of uranium, which is why it is present on the former uranium mining sites.

Processing residues

The studies conducted by Areva mean that it is now possible to assess the long-term impacts of the processing residues disposal sites. Those included in the 2013-2015 PNGMDR in particular led to:

- the provision of data concerning modelling of the impact of the mining residues disposal sites;
- improved understanding of the phenomena of uranium migration from the waste rock disposed of on the mining sites to the environment;
- improved understanding of the mechanisms regulating uranium and radium mobility within uranium-bearing mining residues.

With regard to the treatment of water and the impact of discharges from the former mining sites, the progress report submitted provides data to help assess the strategy for changes to the treatment of these waters.
With regard to the embankments around the residues disposal sites, the work done by the PNGMDR working group means that a methodology is now available for assessing their long-term mechanical strength.



Bellezanne former mining site after rehabilitation

Mining waste rock

Areva is continuing to process the places on which it is reutilised, outside the perimeter of the former mining sites, within the framework of the survey and inventory campaign initiated in 2009.

PLAN ***What the Plan recommends***

The various studies will need to be continued for the next two PNGMDR in order to complete the assessment of the long-term evolution of mining processing residues and waste rock, and the studies into the methodology to assess the long-term strength of the embankments, to study the possibilities for modifying or shutting down the water treatment plants and finally to propose tangible steps to reduce the risks and impacts on the various sites.

With regard to mining waste rock, the processing of the sites with waste rock outside the perimeter of the former mining site will need to be continued.

The consultation process must continue with the stakeholders on all these subjects, within the framework of the PNGMDR, but also at the local level.

Management of waste containing high levels of naturally-occurring radionuclides

§ 3.3

Waste with high levels of naturally-occurring radionuclides are generated by the utilisation or transformation of raw materials naturally rich in natural radionuclides but which are not used for their radioactive properties. These are low level, long-lived, or even very low level type waste.

DEFINITION

Waste with high levels of naturally-occurring radionuclides
This is waste generated by the transformation of raw materials naturally containing radioactive elements but used for reasons other than their radioactive properties.

Depending on their radiological characteristics, waste with high levels of naturally-occurring radionuclides is either managed in-situ, or reutilised, or taken away to conventional waste disposal facilities (four installations are authorised to receive it) or to Andra's dedicated radioactive waste disposal centres.

What the Plan states

The management framework for waste with high levels of naturally-occurring radionuclides will be modified by the transposition of the provisions of Council Directive 2013/59/Euratom of 5th December 2013 setting the basic standards for health protection against the hazards arising from exposure to ionising radiation, scheduled for no later than 6th February 2018.

Example of very short-lived waste in a medical research laboratory

Management of very short-lived waste

§ 3.4

Very short-lived waste, in other words only containing radionuclides with a half-life of less than 100 days, is produced by nuclear medicine units and research laboratories. It can be managed by means of radioactive decay in appropriate storage facilities and is then sent to conventional management routes.

These radioactive decay management methods are not however appropriate for all very short-lived waste. Certain waste in fact present other risks (waste containing infectious products, carcinogens, etc.). This waste is generally incinerated as rapidly as possible in order to minimise the risks of biological contamination.

Management of very low level (VLL) waste

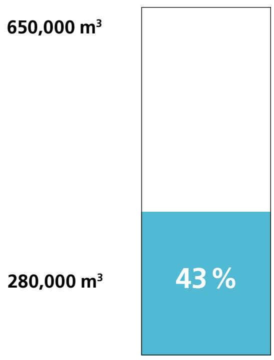
§ 3.5

In France, the identification of waste from nuclear installations which does not warrant radiation protection checks (conventional waste) is based more specifically on where the waste was produced within the installation.

In this way, all the waste from nuclear installations which is contaminated, activated or liable to be so owing to its production zone, is considered to be radioactive waste and must undergo specific management in a route dedicated to radioactive waste. This is part of the reason for the large-scale production of very low-level (VLL) waste which comes mainly from nuclear installation decommissioning operations. It mainly consists of inert waste (rubble, earth, sand) and metal waste. Andra thus anticipates the production of 2,200,000 m³ of VLL waste by the existing installations until they are delicensed.

A disposal facility, located in the industrial centre for collection, storage and disposal (Cires) operated by Andra, has been accepting this type of waste since 2003. At the end of 2014, the total volume emplaced in Cires was about 280,000 m³, 43% of the authorised regulation capacity (650,000 m³).

KEY FIGURE



Occupation of Cires disposal capacity
(data as at 31/12/2014)

The creation of a new disposal facility or extension of the authorised capacity of the existing facility could be necessary by 2025. In order to preserve this scarce disposal capacity, solutions for reducing the volume of ultimate radioactive waste, such as densification, or the reutilisation of certain waste, are being examined in parallel, in strict compliance with requirements for the protection of individual health, security and the environment, in accordance with the provisions of Article L. 542-1 of the Environment Code.

Work on reutilisation

The reutilisation conditions are regulated by the Public Health Code. Barring waivers, its Article R. 1333-3 prohibits except derogation the use of materials or waste from nuclear activities, liable to be contaminated by radionuclides, in the manufacture of consumer goods and building materials. Recycling options are thus for the time being limited to the nuclear sector.

In compliance with the regulatory framework, the Centraco melting facility has since the 2000s been used to recycle ferrous metal waste as radiological shields integrated into radioactive waste packages. The recycled volumes however remain limited.

The studies of the conditions for the reutilisation of metal materials and VLL rubble continued within the framework of the 2013-2015 PNGMDR, in particular with the creation of a pluralistic working group comprising representatives of the licensees, Andra, the Ministry of the Environment, the safety regulators (ASN and ASND), CLI members, representatives of industry and French and foreign experts. This working group made recommendations for the continuation of studies of the development of a reprocessing process for homogeneous batches of metal materials for reutilisation in certain conditions and for implementation of the reutilisation of rubble, in compliance with the requirements regarding the protection of individual health, security and the environment.

What the Plan recommends

Concerning metal waste

The reutilisation capacity for materials within the nuclear sector will need to be fully exploited before resorting to any other solutions. On this basis and in accordance with the other recommendations by the working group, Areva and EDF shall submit a report before mid-2018 presenting the technical and safety options of a reprocessing facility for their large homogeneous batches of very low-level metal materials (related with the decommissioning of the George Besse 1 plant) and describing the associated management solutions.

Concerning rubble

No later than the beginning of 2017, Andra shall complete its study of the use of very low level rubble as infill material for the voids in the Cires vaults. Unless anything is found to rule it out, this reutilisation solution shall be deployed before the end of 2018.

SPOTLIGHT

Work on reutilisation

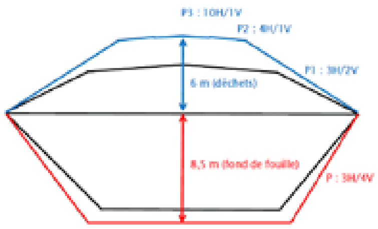
A pluralistic working group was set up in 2015 by the Ministry for the Environment and ASN, to study the possible conditions for the reutilisation of VLL waste. The report from this working group is available on the following websites www.ecologique-solidaire.gouv.fr et www.asn.fr

Operator working on the Centraco melting furnace

Steam generator for use in EDF's pressurised water reactors

Intensive rinsing operations followed by air venting - decommissioning of the George Besse 1 plant

VLL (very low level) waste disposal centre in the industrial centre for collection, storage and disposal (Cires) in the Aube département



Schematic drawing - Optimisation of the Cires vaults in order to increase the volume of waste which can be stored in the same occupied surface area

KEY FIGURES

3 disposal facilities:

- **2** in the Aube département: the Industrial centre for collection, storage and disposal (CIRES) and the Aube disposal repository (CSA)
- **1** in the Manche département: the Manche disposal repository (CSM)

Disposal works

The VLL waste disposal facility (Cires) is based on the concepts and techniques of hazardous industrial waste disposal facilities: surface disposal in vaults excavated from clay, with the base modified to collect any water infiltration for the duration of disposal. The experience acquired with the operation of the centre has enabled Andra to optimise the geometry of the disposal vaults, thus improving the use of the disposal space available that is the ratio between the volume of waste emplaced and the surface area occupied.

What the Plan recommends

Andra shall study the conditions for increasing the volume capacity of Cires for the same ground footprint and, provided that these conditions are favourable, shall submit the capacity increase application at least 6 years before the anticipated saturation of this facility.

The disposal of certain radioactive waste within or near the decommissioning sites producing large quantities of VLL waste could be considered in order to limit radioactive waste transportation in terms of distance and volume, in accordance with the principles set out in Article L. 541-1 of the Environment Code. It would concern certain VLL waste for which the specific activity and physical-chemical properties would allow regional management arrangements.

What the Plan recommends

Areva, CEA and EDF shall set up an iterative approach with Andra in order to reach a decision, no later than mid-2020, on the feasibility of creating disposal facilities within or close to their respective sites, suitable for certain types of VLL waste, the characteristics of which mean that their disposal in dedicated facilities other than Cires could be envisaged, in compliance with the requirements concerning the protection of individual health, security and the environment.
The environmental impact of these management arrangements shall be the subject of a comparative analysis between this option and the option of transportation to Cires.

An overall update on VLL waste management is expected by the end of 2020

The additional solutions for the management of VLL waste need to be studied in greater detail, in particular with regard to the improvements they could make to application of the waste management principles of the Environment Code (hierarchy of waste management modes, prevention and reduction at source of the volume and harmfulness of waste, limitation of transports).

What the Plan recommends

A revised overall industrial scheme shall be submitted before the end of 2020. It shall take account of the various optimisations required by the PNGMDR for the management of VLL waste: volume reduction, densification and reutilisation. Consolidation of the production forecasts for these waste, especially those created by post-operational clean-out and remediation of structures, installations and soils, is also required and constitutes an essential step in determining the future choices for overall optimisation of the VLL waste management.

Management of low and intermediate level, short lived waste (LLW/ILW-SL)

§3.6

"Short-lived" low and intermediate level waste (in which the radioactivity mainly comes from radionuclides with a half-life of less than 31 years) has since 1969 been disposed of in dedicated surface repositories.

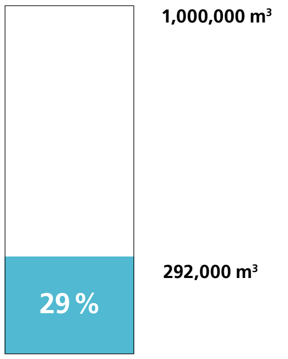
The Manche disposal repository received 527,000 m^3 of waste packages between 1969 and 1994. The leaktightness of the facility is based on the installation of a cover, the long-term stability of which requires consolidation (reducing the steepness of the slopes) which will take place over a period of about fifty years. Steps have been taken to ensure that a recorded trace (memory) of the facility and the waste emplaced in it is kept for future generations.

At the end of 2014, the total volume of packages emplaced in the Aube repository (CSA) was about 292,000 m^3, 29% of the authorised regulation capacity (1,000,000 m^3). Efforts made at source to reduce the amount of VLLW/ILW-SL waste produced, and the commissioning of a VLLW waste repository in Cires, plus melting and incineration by the Centraco facilities, has enabled the lifetime of the repository to be extended, thus ruling out saturation in the short to medium term.

What the Plan recommends

Work is continuing on the optimisation of LLW/ILW-SL waste management. Areva, CEA and EDF, together with Socodei as necessary, shall submit the preliminary design for a lead reprocessing facility before the end of 2018.

KEY FIGURE



Occupation
of CSA disposal capacity
(data as at 31/12/2014)

MILESTONE

Incineration is a way of reducing the volume of ultimate radioactive waste by a factor of 10 to 20.

Aube disposal facility – vaults being filled

The management routes to be implemented: current needs and future outlook

SPOTLIGHT

Storage
The storage of radioactive substances consists in placing them temporarily in a facility for holding, grouping, monitoring and observation, pending their recovery.

Disposal
The disposal of radioactive waste consists in placing these substances in a facility specially fitted out for this purpose, in principle definitively.

This part presents the long-term management modes under development for certain waste categories currently without a solution, in particular low level, long-lived waste (LLW-LL), high level and intermediate level, long-lived waste (HLW/ILW-LL), waste containing tritium and certain sealed radioactive sources. It also looks at the case of very small quantities of waste which cannot at present be linked to any long-term solution under development. The PNGMDR provides for studies to define management routes for these waste.

Management of low level long-lived waste (LLW-LL)

Low level, long-lived radioactive waste (LLW-LL) requires specific management, appropriate to its long lifetime, which rules out disposal in Andra's existing industrial facilities in the Aube département. This waste in particular comprises graphite waste from the operation and future decommissioning of EDF's gas-cooled reactors, radium-bearing waste, mainly from the processing of ores containing rare earths, some of the bitumen-encapsulated waste drums in Marcoule and certain uranium conversion residues. Pending their disposal, following reprocessing as and when applicable, the packages of LLW-LL waste are currently stored in facilities on the sites of the producers.

The two gas-cooled reactors in the Saint-Laurent des Eaux NPP

As a result of difficulties encountered in the initial siting process for a LLW-LL disposal repository, a further process was initiated in 2012 on the basis of the recommendations of an HCTISN report. Within the framework of the 2013-2015 PNGMDR, Andra supplied a progress report on the creation of a disposal facility in the Soulaines region. A 10 km² area was selected in the north of this region for more detailed geological investigations.

What the Plan recommends

Andra shall continue with geological investigations on the site studied, assess the LLW-LL waste inventory liable to be disposed of in it and submit a report by mid-2019 presenting the technical and safety options for this disposal facility. Andra and the waste producers shall also continue with their studies of the radiological inventory, behaviour in the repository and the possibilities for reprocessing of their LLW-LL waste. An overall industrial scheme for management of all the LLW-LL radioactive waste shall also be submitted before the end of 2019.
By precaution, the inventory of the planned Cigeo deep geological disposal project shall comprise reserve capacity to possibly take LLW-LL type waste which could not be sent for subsurface disposal.

Management of high level and intermediate level, long lived waste (HLW/ILW-LL)

§4.2

The management of HLW/ILW-LL waste is studied according to the three complementary research topics identified in the 28th June 2006 Act on the sustainable management of radioactive materials and waste, now codified in the Environment Code: reversible disposal in a deep geological layer, storage and the separation and transmutation of long-lived radionuclides. Research is also being carried out into the processing and packaging of these waste.

The Environment Code identifies deep geological disposal as the solution for the long-term management of ultimate radioactive waste which cannot be disposed of on the surface or at shallow depth, for nuclear safety or radiation protection reasons. The underground installations of the planned disposal facility called Cigeo (French acronym for geological disposal industrial centre) would be situated within a layer of clay at a depth of about 500 m. The research carried out by Andra in the Meuse/Haute Marne underground laboratory enabled significant results to be obtained on the Bure site with regard to the feasibility and safety of a repository.

Following the 2013 public debate on the planned reversible deep disposal facility for radioactive waste in Meuse/Haute-Marne, Andra made a number of adjustments to the project, more specifically including the submission of a safety options file in 2016 and the integration of a pilot industrial phase prior to start-up of the installation. The notion of disposal reversibility was also defined by the 25th July 2016 Act specifying the procedures for the creation of a reversible deep geological disposal facility for high and intermediate level, long-lived radioactive waste. Reception of the first radioactive waste packages is scheduled for approximately 2030.

Pending the commissioning of the repository, the packages of HLW/ILW-LL waste are currently stored in facilities on the sites of the producers.

What the Plan recommends

The analysis of the storage needs for HLW and ILW-LL waste packages shall be completed by Areva, CEA and EDF, together with Andra, adopting significant time margins and taking account of the scheduling of shipments to the planned Cigeo repository and of the principle of reversibility.

Andra shall define a preliminary version of the acceptance criteria for the deep geological disposal facility it is designing, as soon as possible. The producers of HLW and ILW-LL waste shall, within a period not to exceed 24 months following the date of transmission of the above-mentioned document, shall produce an acceptability analysis for the radioactive waste packages already conditioned in the light of the preliminary version of the Cigeo acceptance criteria transmitted by Andra.

SPOTLIGHT

Reversibility

The 25th July 2016 Act specified the procedures for the creation of a reversible deep geological disposal facility. Reversibility is the possibility for successive generations either to continue with previously defined choices, or to reassess these choices and modify the management solutions. Implementation of this principle is through incremental construction, the adaptability of the design and the flexibility of operation in order to incorporate technological progress and adapt to any changes in the waste inventory, more particularly as a result of a change in energy policy. Reversibility includes the possibility of recovering packages of waste already emplaced in the disposal facility, in accordance with procedures and over a time-frame consistent with the operating and closure strategy of the disposal facility.

SPOTLIGHT

Cost of Cigeo

In 2016, the cost of the reversible deep disposal facility (Cigeo) was estimated by the Ministry responsible for Energy at 25 billion for the entire construction and operating period of the facility (140 years). This cost evaluation will be regularly updated, in particular at each Cigeo development milestone.

High-level vitrified waste storage hall – La Hague facility

Waste management requiring specific work

Because of their properties, certain categories of radioactive waste require special management routes. This is in particular the case with waste containing tritium (tritiated waste) and used sealed sources, as well as radioactive waste from small producers outside the nuclear power generating sector, which represents very small quantities.

Most of the tritiated waste cannot be accepted directly in the surface repositories owing to the high mobility of tritium through the media. The creation of new storage facilities by CEA over a period of about forty years offers a satisfactory solution in terms of short to medium term safety, pending future transfer to disposal facilities. The work done to identify management solutions, initiated by the 2010-2012 PNGMDR, must be continued with regard to liquid and gaseous tritiated waste from the small producers outside the nuclear power generating sector.

What the Plan recommends

CEA and Socodei, together with Andra, will make a comparison by the end of 2017 of the various tritiated waste management solutions, comprising storage, incineration (with or without prior storage) and direct disposal. This analysis will concern the various types of tritiated waste, in terms of protection of individual health, security and the environment.

Most used sealed sources are currently stored pending a final management solution. Given their concentrated activity and the present repository acceptance criteria, only a small share of the used sealed sources can be disposed of in Andra's repositories.

What the Plan recommends

Andra shall examine the possibility of adapting the acceptance criteria for its installations, so that certain categories of used sealed sources can be accepted, while ensuring compliance with the requirements for protection of individual health, security and the environment.

As at the end of 2013, some other waste of various types, representing less than 0.3% of the volume of the waste produced, have no existing or planned disposal route, for example owing to only partial knowledge of their characteristics, the physical or chemical characteristics of the waste, or the absence of procedures for processing or packaging the waste prior to disposal.

SPOTLIGHT

Small producers outside the nuclear power generating sector
Some hospitals, research centres and industries use radioactivity for activities other than the production of electricity, national defence or nuclear research. The radioactive waste they produce comes more particularly from medical scintigraphy examinations, experiments to develop certain drugs or certain industrial welding tests. Although there are a large number of producers of this type of waste, the volume generated remains small.

DEFINITIONS

Tritium
Tritium is a radioactive element with a half-life of 12 years. It is an isotope of hydrogen.

Sealed radioactive sources
Sealed radioactive sources are small objects, used for their radioactive properties in a large number of applications (medical, scientific or industrial). They concentrate the radioactivity in small volumes and are usually made of stainless metals which offer a long lifetime.

What the Plan recommends

The studies concerning processing of waste with no disposal route shall be continued. The aim is to ensure that all the waste without a disposal route produced before the end of 2015 shall have a final management solution by 2030.

Management of Malvési waste

The Areva NC industrial site in Malvési (Narbonne) has since 1960 been carrying out the first step in the conversion necessary for the nuclear fuel cycle. It is the point of entry into France of the natural uranium from the mines and it carries out purification and conversion of this uranium. In accordance with the recommendation of the 2013-2015 PNGMDR, Areva has conducted an overall, in-depth study of the short, medium and long term management of the conversion process waste.

Aerial view of the Malvési site

With regard to "legacy" waste, in part already stored on the site, the selection of the most appropriate management scenario comprises two aspects:
- safe short and medium-term storage of the waste, maintaining it in a condition compatible with its final management;
- the search for a long-term management solution close to the site, organised around an ongoing study and research programme.

With regard to the waste that will be produced as of 1st January 2019, in order to ensure continued operation of the site, Areva is working on two projects aiming on the one hand to reduce the volume of solid waste produced, with emphasis on existing management routes and, on the other, to treat future liquid effluents from the process (by thermal means), jointly with those already stored in the evaporation ponds.

What the Plan recommends

The very low level or low level, long-lived waste produced by the Areva NC plant in Malvési as of 2019, shall be integrated into the VLLW and LLW-LL disposal routes and included in the forecasts of the national inventory of radioactive materials and waste.

Management of waste resulting from a nuclear accident

The interministerial directive of 7th April 2005 on the action of the public authorities in the case of an event leading to a radiological emergency situation tasked ASN, together with the ministerial departments concerned, with establishing the framework and defining, preparing and implementing the necessary provisions for dealing with post-accident situations. Corresponding aspects of doctrine were formulated by a steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation (Codirpa).

Storage facility for the radioactive waste resulting from the nuclear accident in Fukushima, in the Tohoku region of Japan.

The accident which occurred in March 2011 in the Fukushima Daiichi NPP in Japan recalled the importance of an approach such as that adopted by the Codirpa, but also identified new challenges for the management of such an event.

What the Plan recommends

In order to develop Codirpa doctrine on the management of radioactive waste, a dedicated working group was set up in 2015, with ties to the PNGMDR working group. Its work will first of all focus on the following points:

- *an analysis of the lessons learned from Fukushima and in particular the good and bad practices in the field;*
- *an examination of current Codirpa doctrine as formulated in the 21st November 2012 report, in the light of the lessons learned from Fukushima;*
- *as applicable, proposals to modify this doctrine.*

Radioactive materials and waste must be managed sustainably, to protect individual health, security and the environment, in accordance with the provisions of the Environment Code. For this purpose, the definitive safeguarding of radioactive waste must be sought and implemented in order to prevent or minimise the burdens to be borne by future generations.

There is a wide variety of radioactive waste, according to the activity and half-life of their radionuclides and according to the chemical substances they contain. Each type of waste, from production to disposal, must thus undergo management appropriate to its type, in order to control the risks inherent in it, more specifically the radiological risks.

Long-term management solutions for radioactive waste have been determined for VLLW and LLW/ILW-SL waste, which represent the vast majority of the volume of radioactive waste. The search for long-term management solutions must however be continued for LLW-LL and HLW/ILW-LL waste that are currently stored pending the availability of the disposals.

The 2016-2018 edition of the PNGMDR draws on the results of the work done by the previous plans as well as on the information in the national inventory of radioactive materials and waste published in 2015 by Andra.

The 2016-2018 plan:

- reinforces the management route approach, recommending the creation or updating of overall industrial systems for these routes;
- requests the identification of new capacity and management equipment, in particular for storage, necessary for the correct working of the solutions, so that the implementation deadlines can be determined;
- stresses the need to consolidate the forecasts for the production of radioactive waste, in particular very low level waste.

The 2016-2018 plan develops the handling of issues relating to radioactive materials, by requesting that the prospects for further use be consolidated and that, in the meantime, studies of management methods be continued by precaution, to deal with the eventuality of these substances being reclassified as waste.

This fourth edition of the PNGMDR also underwent an environmental assessment and a public consultation such as to reinforce the consideration given to environmental aspects, while recalling the beneficial purpose of the plan itself. It also presents indicators for assessing the progress made in implementing the plan, pursuant to the directive of 19th July 2011 establishing a community framework for the responsible and safe management of spent fuel and radioactive waste.

Appendices

The main stakeholders in radioactive materials and waste management in France

- The producers of radioactive materials and waste, in particular Areva, CEA and EDF

- The French National Radioactive Waste Management Agency (Andra), which is the manager for radioactive waste and whose duties include the design and operation of the storage facilities and disposal repositories, the performance of studies and research into storage and deep geological disposal, the collection of radioactive waste for which the parties responsible have defaulted, and information of the public

- Research institutes working in the field of radioactive materials and waste management, other than Andra: CEA, CNRS and the Institute for Radiation Protection and Nuclear Safety (IRSN)

- The ministries responsible for Energy, the Environment and Research. In particular, at the Ministry for the Environment, Energy and the Sea, the General Directorate for Energy and Climate (DGEC) drafts policy and implements the Government's decisions concerning the civil nuclear sector, except for those dealing with nuclear safety and radiation protection

- The Nuclear Safety Regulator (ASN), an independent administrative authority which regulates nuclear safety and radiation protection for civil nuclear facilities and activities; the Defence Nuclear Safety Regulator (ASND) performs the same role for defence-related matters

- The Institute for Radiation Protection and Nuclear Safety (IRSN) provides the nuclear safety regulators with technical support

- The Parliamentary Office for the Evaluation of Scientific and Technical Choices (OPECST) whose role is to inform Parliament of the consequences of scientific and technological choices, so that it can take informed decisions

- The National Assessment Commission (CNE) which carries out an annual assessment of research and forwards its report to Parliament

- Representatives of civil society, environmental protection associations and representatives of elected officials, who take part in the debates organised to promote transparency and consultation.
  In this field, it is important to underline the role of the High Committee for Transparency and Information on Nuclear Security (HCTISN), the local information and monitoring committee (CLIS), set up for the Meuse – Haute-Marne underground laboratory, and the local information committees set up for each of the basic nuclear installations (BNI) and grouped into a National Association of Local Information Committees and Commissions (ANCCLI).

Glossary

ANCCLI: National Association of Local Information Committees and Commissions
Andra: French national radioactive waste management agency
ASN: French nuclear safety regulator
ASND: Defence nuclear safety authority
ASTRID: Advanced Sodium Technological Reactor for Industrial Demonstration
Bq: Becquerel
Cigeo: Industrial centre for geological disposal
Cires: Industrial centre for collection, storage and disposal
CLI: Local Information Committee
CLIS: Local Information and Monitoring Committee
CNE: National Assessment Commission
CNRS: French National Centre for Scientific Research
CODIRPA: Steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation
CSA: Aube waste disposal facility
DGEC: General directorate for energy and climate
LLW-LL: Low Level Waste, Long-lived
LLW/ILW-SL: Low Level and Intermediate Level - Short-lived waste
HLW: High level waste
HCTISN: High Committee for Transparency and Information on Nuclear Security
BNI: Basic Nuclear Installation
IRSN: French Institute for Radiation Protection and Nuclear Safety
ILW-LL: Intermediate Level Waste, Long-lived
MOX: Plutonium and uranium oxides based fuel
OPECST: Parliamentary Office for the Evaluation of Scientific and Technical Choices
PNGMDR: National Plan for Radioactive Materials and Waste Management
SIENID: Defence-related nuclear experimentation sites and installations
VLLW: Very low level waste
URE: Enriched Reprocessed Uranium
URT: Reprocessed Uranium
SL: short-lived
LL: long-lived

Useful links

www.ecologique-solidaire.gouv.fr/headings Énergies > Nucléaire
www.asn.fr
www.andra.fr
www.cea.fr
http://pacen.in2p3.fr
www.irsn.fr
www.senat.fr/heading Travaux parlementaires - Offices et délégations - Office OPECST
www.hctisn.fr
www.anccli.fr

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