French National Plan

for the Management of Radioactive Materials and Waste

2013–2015

SUMMARY

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

Ministère
de l'Écologie,
du Développement
durable
et de l'Énergie

asn
AUTORITÉ
DE SÛRETÉ
NUCLÉAIRE

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Refers to the corresponding part of the full report

Paragraph summarising the recommendations given in the plan

Foreword

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

The National Radioactive Materials and Waste Management Plan (PNGMDR) is a key tool in ensuring the long-term implementation of the principles laid down in the Programme Act of 28th June 2006 concerning the sustainable management of radioactive materials and waste. It aims primarily to produce a regular picture of radioactive substances management policy, to evaluate new requirements and to determine the objectives to be met in the future, particularly with regard to studies and research. Its validity was confirmed at a European level, by the adoption on 19th July 2011 of the directive establishing a community framework for the responsible and safe management of spent fuel and radioactive waste.

The 2013-2015 edition of the Plan is the third PNGMDR. In aiming to share views and proposals , the DGEC and ASN decided to once again draft the PNGMDR on the basis of presentations and discussions from a pluralistic working group, comprising environmental protection associations, regulatory authorities and regulatory assessment bodies, alongside the producers and the managers of radioactive waste.

The PNGMDR proposes possible solutions for improving the management of all radioactive materials and waste. These proposals are the result of extensive work carried out since the first version of the PNGMDR covering the period 2007-2009, in particular the production and subsequent assessment of the studies required by the Government. Though much progress has been made, it is essential that the work be continued. The aim is to maintain progress in the sustainable management of radioactive materials and waste, by defining final, long-term solutions for all these substances. It is our responsibility not to pass this burden on to future generations.

Laurent Michel
Director General for Energy and Climate

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

The National Radioactive Materials and Waste Management Plan (PNGMDR) draws up an inventory of management policy, assesses requirements and determines objectives for the future.

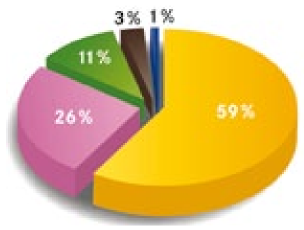
The 2013-2015 PNGMDR continues with and expands on the actions initiated by the previous plan and stresses the need to develop overall industrial management systems and management methods for high-level and intermediate level, long-lived waste.

This summary presents the main aspects of this inventory and the needs identified by the PNGMDR. It follows the same structure as the 2013-2015 PNGMDR full report, so that the reader can find out more about particular subjects by referring to the full report, available on the ASN and DGEC websites. Throughout the summary, pictograms indicate the corresponding part of the full report. The summary is thus organised into three parts. The first part summarises the principles and objectives of radioactive materials and waste management. The results and the development prospects of the existing management solutions are then presented in the second part. Finally, the third part presents the needs and prospects for the management solutions to be put into place.

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 natural radioactivity (granite, cosmic rays, etc.) and artificial radioactivity (nuclear electricity generating reactors, medical radiotherapy activities, etc.).

KEY FIGURES



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

Breakdown by volume of waste at end 2010 per economic sector.

Vitrification of HLW (high level waste).

Management of radioactive materials and waste: principles and objectives

What is a radioactive material? What is radioactive waste?

Some radioactive substances are materials, while others are waste.
As defined by the Environment Code, radioactive materials are substances for which subsequent use is planned or envisaged. This chiefly concerns fuels in use or spent fuels, natural, enriched, depleted or reprocessed uranium, plutonium and thorium.
Radioactive waste consists of radioactive substances for which no subsequent use is planned or envisaged.

Where does the waste come from?

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, plus the plants dedicated to the fabrication and reprocessing of nuclear fuel (extraction and processing of uranium ore, chemical conversion of uranium concentrate, enrichment and fabrication of fuel, reprocessing of spent fuel and recycling);
- the **research sector:** research in the civil nuclear field (mainly CEA research activities), medical research, particle physics, agronomy, chemistry, etc. laboratories;
- 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 for 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.

What are the different types of waste?

With regard to radioactive waste, the usual French classification relies on two main parameters, when defining the appropriate management method:

- **the activity level,** which corresponds to the number of disintegrations per unit of time of the radioactive elements contained in the waste. In other words, this refers to the level of radioactivity. 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. The half-life varies with the characteristics of each radionuclide. After 10 half-lives, the level of radioactivity of an element is divided by about 1000. This period of ten half-lives is generally considered to represent the lifetime of a radionuclide. 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), also 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, conditioned in cement-encapsulated or compacted waste packages, 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 primarily from the decommissioning of the gas-cooled reactors. Radium-bearing waste is mainly produced by the nuclear industry 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 from the Comurhex plant in Malvési, and so on;
- **low level and intermediate level, short-lived waste** LL/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), mainly from the operation, maintenance and decommissioning of nuclear power plants, fuel cycle facilities and research centres;
- **very short lived waste,** mainly from the medical and research sectors. This waste is stored on the site on which it was used, 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 associated with one or more management solutions, as summarised in the following table.

Example of ILW-LL (intermediate level, long-lived) waste – Fuel end-pieces.

Some objects of our everyday lives can contain radioactivity. They are usually LLW-LL (low level, long-lived) waste. For example, certain ionisation chamber smoke detectors contain Americium 241 which is radioactive.

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

Example of VLL (very low level) waste: pieces of metal and plastic from the decommissioning of nuclear facilities.

FOCUS

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

Hundreds Bq/g

Millions Bq/g

Billions Bq/g

	Very short lived waste *containing radionuclides with a halflife of < 100 days*	Short lived waste *in which the radioactivity comes mainly from radionuclides with a half-life ≤ 31 years*	Long lived waste *containing mainly radionuclides with a half-life > 31 ans*
Very low level (VLL)	**Management by radioactive decay on the production site**	***Recycling or dedicated surface disposal*** *(Industrial centre for collection, storage and disposal (Cires) disposal facility in the Aube département)*	
Low level (LL)	*then disposal through routes dedicated to conventional waste*	***Surface disposal*** *(Aube waste disposal facility)*	***Shallow depth disposal*** *(being studied pursuant to the Act of 28 June 2006)*
Intermediate level (IL)			
High level (HL)	Not applicable[1]	***Deep geological disposal*** *(being planned pursuant to the 28th June 2006 Act)*	

[1]The category high level, very short lived waste does not exist.

KEY FIGURES

Waste for which there is an operating disposal route at the end of 2010

90 % of the volume of waste

< 0,03 % of the total radioactivity of the French radioactive waste

Existing HLW waste at end 2010

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

96 % of the total radioactivity of French radioactive waste

Existing LLW/ILW-SL waste at end 2010

63 % of the total volume of French radioactive waste

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

This usual waste classification is a simplified guide to the orientation of radioactive waste and the identification of its disposal solutions. It does not however take into account of certain complicating factors which lead to a management solution being chosen which is different from the waste's particular category. Other criteria, such as stability, or the presence of toxic chemical substances and even attractiveness of the waste, must be considered.

A National inventory of these radioactive materials and waste is produced every three years by the French National Waste Management Agency (Andra). The 2012 edition identifies the material and waste holdings as at the end of 2010 and gives forecasts for the end of 2020 and the end of 2030. This inventory also presents the radioactive materials stored in France pending reuse and reviews legacy waste and past management methods (waste immersion, mining sites, polluted sites, etc.).

(en m³ équivalent conditionné)	Déchets existants à fin 2010	Prévisions à fin 2020	Prévisions à fin 2030
HA	2 700	4 000	5 300
MA-VL	40 000	45 000	49 000
FA-VL	87 000	89 000	133 000
FMA-VC	830 000	1 000 000	1 200 000
TFA	360 000	762 000	1 300 000
Déchets sans filière	3 600		
Total général	~ 1 320 000	~ 1 900 000	~ 2 700 000

Radioactive waste: stocks at end 2010 and forecasts for end 2020 and end 2030 for each category

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

At the European level, the council directive of 19th July 2011 established a community framework for the safe and responsible management of spent fuel and radioactive waste. It reaffirms the responsibility of each State for the management of its radioactive waste. This directive, in particular, requires that the Member states set up a national programme for management of spent fuel and radioactive waste, as is already the case in France, with the drafting of the PNGMDR and the National Inventory.

The national framework for the management of radioactive materials and waste is defined by the Programme Act 2006-739 of 28th June 2006, concerning the sustainable management of radioactive materials and waste and dealing with the definition of a management policy for radioactive materials and waste, for improving transparency and for financing and economic support. The Act specifies that the management of radioactive materials and waste must comply with the following fundamental principles:

- protection of the individual health and the environment;
- reduction in the quantity and harmfulness of radioactive waste;
- prevention or mitigation of the burden borne by future generations;
- the polluter-pays principle, which applies in environmental law.

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

- reducing the quantity and harmfulness of the waste, in particular by reprocessing spent fuels and processing and packaging radioactive waste;
- storage as a preliminary step, in particular with a view to fuel and waste reprocessing, or to disposal of the waste;
- after storage, deep geological disposal as a permanent solution for ultimate waste that cannot be disposed of on the surface or at shallow depth, for nuclear safety or radiation protection reasons.

In the field of transparency, the Act in particular gives the National Assessment Commission the task of assessing research into the management of radioactive materials and waste. It also makes provision for regular information and consultation by the French High Committee for Transparency and Information on Nuclear Security (HCTISN). Finally, it requires that the PNGMDR be transmitted to Parliament, which refers the assessment to the Parliamentary Office for the Evaluation of Scientific and Technical Choices, and be made public.

KEY FIGURES

2 kg of radioactive waste produced per year and per inhabitant in France

About **1** Olympic sized swimming pool of high level waste produced in France between the beginning of nuclear energy use and the end of 2010

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 assessment of all the research conducted pursuant to the 1991 Act

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

Future milestones

2013 : public debate on the reversible deep geological repository

2015 : submission by Andra of the creation authorisation application for the reversible deep geological repository

2016 time-frame: Act specifying the reversibility conditions for the deep repository

2025 : beginning of operation of the reversible deep geological repository

The social dimension and preservation of memory

§1.4

The social dimension of the various waste management projects means that research in the fields of human and social sciences must be included. Management of the most highly radioactive waste raises complex issues concerning the need to anticipate and make provision for events over very long time-scales. Advance provision must also be made to deal with the question of the long-term preservation and transmission of memory, well after closure of the disposal repositories.

Specialists equipped with dedicated suits in order to deal with radioactive waste contaminated with plutonium.

How is waste management financed?

§1.5

Under the control of the State, radioactive waste management is financed by the nuclear licensees, in accordance with the polluter-pays principle.

An arrangement to ring-fence secure financing of long-term nuclear costs, instituted by the 28th June 2006 Act and codified in the Environment Code, provides for the creation of a portfolio of dedicated assets by the nuclear licensees during the period of operation. To do this, 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 costs by creating dedicated assets with a high level of security.

The Bugey site in particular houses a gas cooled reactor currently being decommissioned.

These operations are closely monitored by the State, through an administrative authority formed by the Ministers responsible for the economy and for energy. Therefore, in order to carry out its oversight duties, the administrative authority receives a three-yearly report from the licensees assessing the long-term costs, the methods and choices made for management of the dedicated assets and a quarterly inventory of these dedicated assets. In addition, an extra-Parliamentary commission, the National Assessment Commission for financing the cost of decommissioning of Basic Nuclear Installations and of managing spent fuels and radioactive waste (CNEF), assesses the oversight performance of the administrative authority and submits a three-yearly report on its assessments to Parliament, as well as to the High Committee for Transparency and Information on Nuclear Safety (HCTISN).

Improving existing management modes

This section provides an overview of the existing management routes as at the end of 2012. It underlines the areas for improvement and the recommendations of the PNGMDR for management of radioactive materials and waste, in order to deal with:
- legacy situations;
- radioactive materials;
- radioactive waste (processing, disposal).

Management of legacy situations

§2.1

Certain radioactive waste may, in the past, have been managed in ways that have since changed, for example disposal within or close to the production sites. In certain cases, it may also have been used as backfill, or handled in routes intended specifically for the management of conventional waste. The term legacy disposal sites is used to describe those places (except for mining residue and waste rock repositories) where radioactive waste is disposed of and is not under the responsibility of Andra and for which, at the time of disposal, the producers or those in possession of the waste did not envisage resorting to existing or planned external routes dedicated to the management of radioactive waste. This concerns:
- thirteen conventional waste disposal facilities which had received VLL waste from the conventional or nuclear industries;
- waste disposed of within or near civil or military Basic Nuclear Installations;
- 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 classified installations regulations.

Port of La Pallice in La Rochelle (17) where production residues (VLL type waste) from the Solvay plant (formerly Rhodia) were used as backfill in the construction of the port.

What the plan recommends

By the end of 2014, Areva, CEA and EDF will be required to continue investigations to search for legacy disposal sites within or near the perimeter of nuclear facilities and present the management strategies envisaged for those sites identified.

Comurhex plant in Malvési.

Moreover, the initial nuclear fuel cycle operations led to the storage of 600,000 m3 of waste (uranium conversion residues) in settling ponds on the site of the Comurhex conversion plants in Malvési. Some of the ponds containing these sludges are currently the subject of an administrative modification with a view to classifying a part of the site as a Basic Nuclear Installation.

DEFINITIONS

Mining residues
Mining residues are very low level or low level type waste generated by ore processing operations.

Mining waste rock
Mining waste rock is the material (soil, rock, etc.) excavated to access the uranium deposits to be worked. It has not undergone any special mechanical or chemical treatment.

Radon
Radon is a radioactive gas of natural origin. It comes in particular from granite and volcanic sub-soils and is one of the decay products of uranium. This is why it is present on former uranium mining sites.

Former Treviels mining site before remediation.

Former Treviels mining site after remediation.

What the plan recommends

By the end of 2013, Comurhex shall submit the feasibility options studies for the disposal of the waste already produced. With regard to management of the waste that will be produced between now and 2050, Andra and Comurhex shall present an interim report specifying the proposed options and the optimised routes, by the end of 2013.

Management of mining processing residues and waste rock

§ 2.2

In France, the uranium mines were exploited from 1948 to 2001. The exploration, extraction and processing activities concerned about 250 sites in 25 French départements. Ore was processed in eight plants. Exploration uranium mine workings generated:

- **processing residues** consisting of products remaining after processing to extract the uranium;
- **waste rock** consisting of soil and rock excavated to access economically useful ore.

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

The studies conducted by Areva mean that it is now possible to assess some of the long-term impacts of the processing residues disposal sites. Those included in the 2010-2012 PNGMDR in particular led to:

- acquisition of the basic knowledge needed to assess the stability of the retention embankments around the treatment residue disposal sites and to define new associated requirement levels;
- improved knowledge concerning modelling of radon for scenarios involving the construction of housing on the disposal site and, more generally, confirming the pertinence of the assessments made following modelling, by comparing its results with surveillance measurements.

In the case of water treatment and the impact of discharges from the former mining sites, the studies enabled the impacts associated with the various substances discharged to be assessed. The consideration of chemical and radiological impacts on man and the environment show the need to look for processing solutions which would limit discharges of uranium and barium.

What the plan recommends

Areva will need to carry out the studies already underway, to complete the long-term assessment of the exposure risks for the population and the strength of the embankments and will examine the possibility of upgrading or shutting down the treatment stations for the water collected from the former mining sites and in the end propose concrete steps to mitigate the risks and the impacts on the various sites. A summary of the results of these studies is to be submitted by 30th November 2014.

For the mining waste rock, Areva is continuing its work started in 2009, to identify where it has been reused in the public domain, in order to define any incompatibilities between the presence of this waste rock and the public use of those locations. Additionally, the long-term dose impact of the waste rock heaps has been reassessed to take greater account of the radon concentrations.

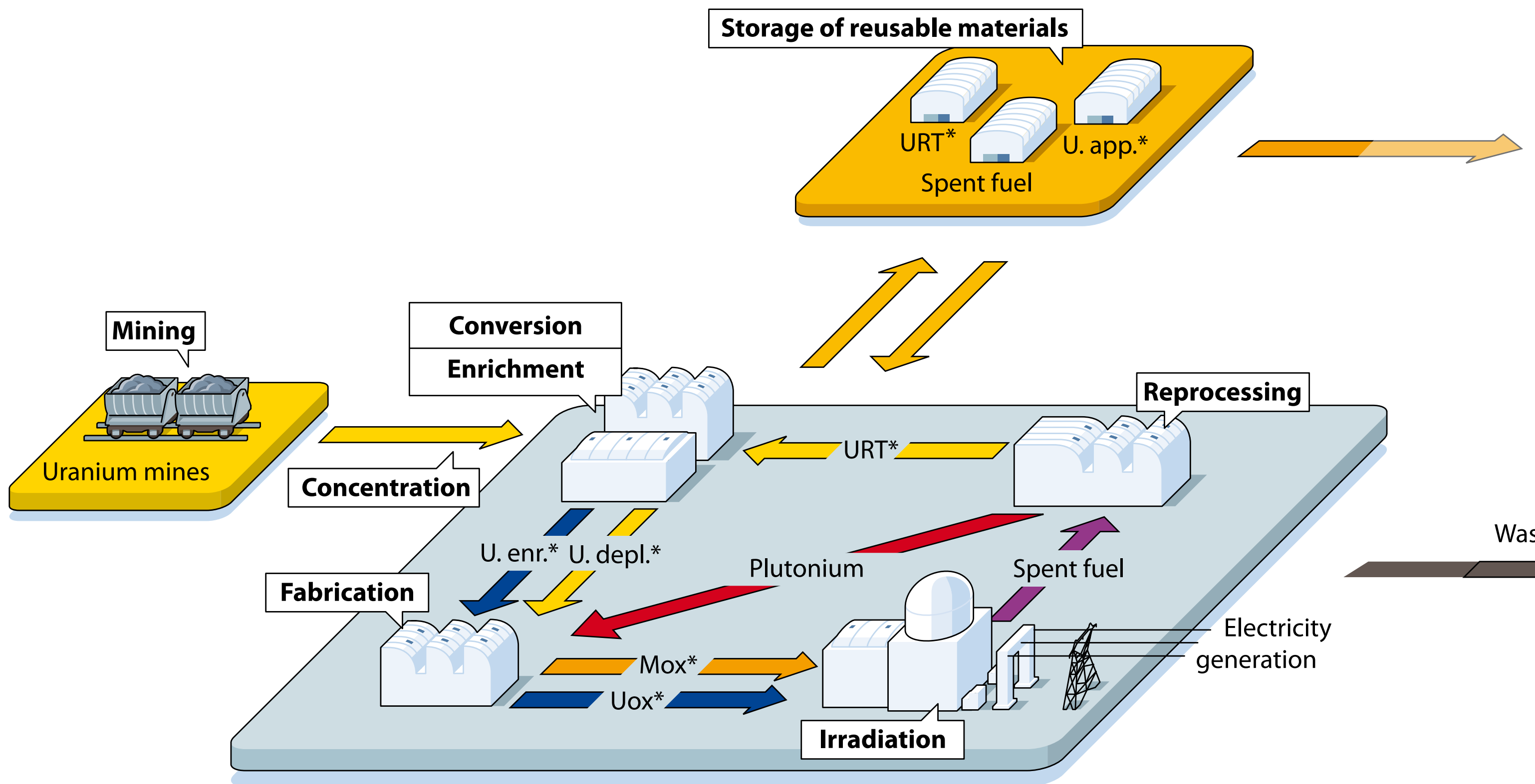
What the plan recommends

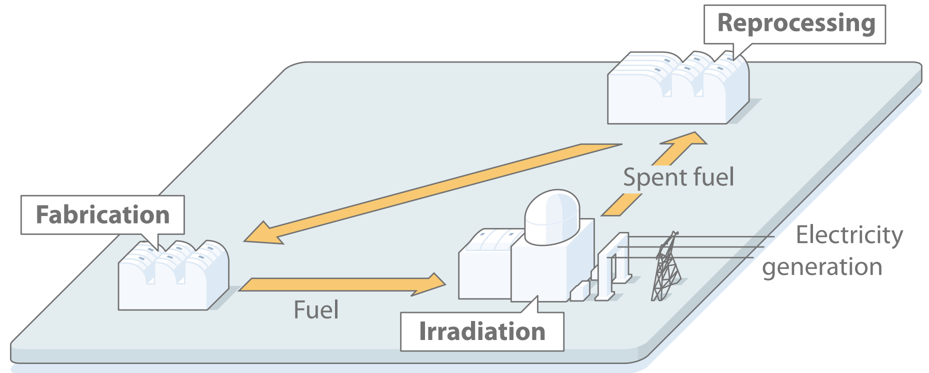
By 30th November 2014, Areva will present a summary of the results of the management of the dose impact associated with the presence of mining waste rock.

FOCUS

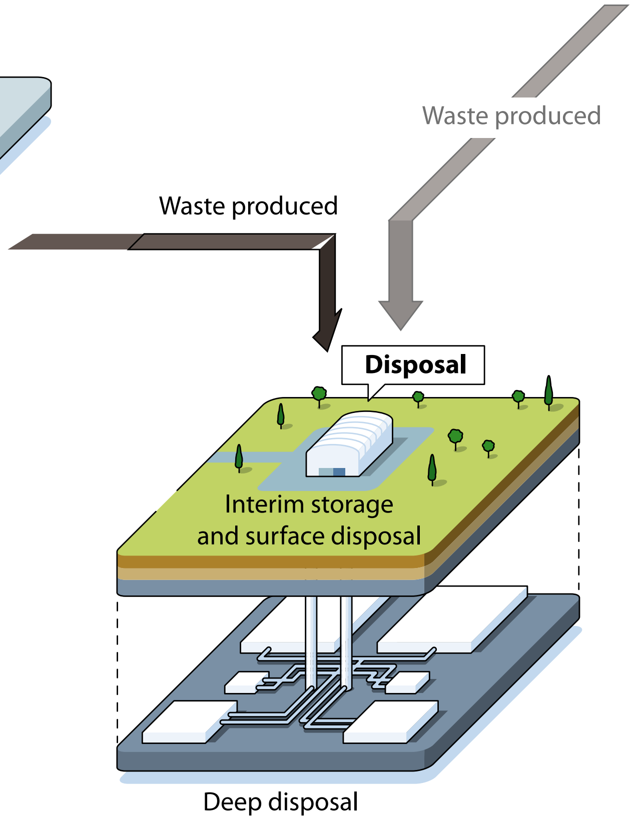
The Limousin pluralistic experts group (GEP Limousin) was set up in 2006 by the Ministries responsible for ecology and health and ASN, in order to intensify dialogue and consultation concerning the forming uranium mining sites. On 15th September 2010 the GEP issued a report and recommendations for management of the former uranium mining sites in France for the short, medium and long terms. The GEP's work can be consulted on the website www.gep-nucleaire.org

General diagram of the nuclear fuel cycle stage





Envisaged future cycle
dependent on development of generation IV



Cycle today

* U. depl. = depleted uranium
* U. enr. = enriched uranium
* URT = reprocessed uranium
* UOX = Uranium Oxide (nuclear fuel consisting of uranium oxide)
* MOX = Mixture of Oxides (nuclear fuel fabricated from plutonium and depleted uranium).

Illustration: Lorenzo Timon

FOCUS

To be able to be used, in a nuclear reactor, radioactive materials must enter a fuel cycle comprising several steps, before and after irradiation in the reactor.

Current fuel cycle

• *Before irradiation*
The mined uranium ore must first be concentrated and then chemically converted. It must then be enriched to increase its uranium 235 content, which is too low in natural uranium. At the same time, this process also produces a flow of depleted uranium 235, which is stored pending subsequent utilisation.
The actual fuel can then be manufactured using the enriched uranium.

• *Irradiation*
In order to produce electricity, the fuel is then irradiated for three to four years in the reactor.

• *After irradiation*
Following this step, 95% of the fuel still has considerable energy potential (uranium and plutonium). 5% of the fuel can no longer be used and is thus considered to be waste (fission products and minor actinides).

Spent fuel reprocessing operations can then extract the reusable materials for recycling. Plutonium is recycled in the form of fuel known as MOX (a mixture of plutonium and depleted uranium), which can then be irradiated in the French reactors. The uranium resulting from reprocessing can be re-enriched for further irradiation in some French reactors.

The reprocessing operation also packages the waste from the spent fuels. This waste contains most of the radioactivity (other waste is produced at various steps in the fuel cycle). This waste is packaged in the form of extremely durable vitrified waste packages, with definitive disposal being the reference operation for their long-term management.

Future fuel cycle

Another fuel cycle, which is currently being researched, would make it possible, in the future, to use the large quantity of depleted uranium, recycled uranium from reprocessing and spent fuels currently stored pending a reuse solution. This cycle would, in particular, include 4th Generation fast neutron reactors. This cycle would also produce radioactive waste, but the separation-transmutation of the minor actinides would reduce its long-term radiotoxicity.

DEFINITION

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

After being used in the reactor, the spent fuels are stored in pools filled with water, so that they can cool down. The height of water provides protection against the radiation they emit.

Uranium concentrate (yellowcake), resulting from ore processing. It is then transported for subsequent enrichment operations.

KEY FIGURES

94 % of spent fuel, after irradiation in the nuclear reactors, consists of uranium which can be extracted in the form of recycled uranium for reuse.

Management of radioactive materials

§2.3

A radioactive material is defined as being a radioactive substance for which subsequent use is planned or envisaged, if necessary after processing. These materials can be used in France or abroad. The 2013-2015 PNGMDR presents the circulation and stocks of the materials produced at the various stages in the fuel cycle, as well as where these materials are reused.

Spent fuel

Most of the spent fuel present on French soil is intended to be reprocessed. The uranium (reprocessed) and the extracted plutonium can be reused.

Uranium

Natural uranium

Used by the enrichment plants to produce the two types of 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 utilised in some EDF reactors.
- Can be 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 reusable on a large scale in 4th Generation fast neutron reactors.

Recycled uranium from reprocessed spent fuel (URT)

Extracted from spent fuels, 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 utilised in some EDF reactors.

Thorium

Could be used in various types of reactors as a fuel in a thorium cycle, but not for several decades yet, given the amount of research and development work still necessary. Other applications are currently under development, in particular for the treatment of certain cancers.

As requested by the 2010-2012 PNGMDR, the radioactive material owners supplied studies on the management options in the eventuality of the materials being classified as waste at some time in the future. The depth of the repositories envisaged by the producers in these studies makes them vulnerable to human intrusion and to the natural phenomena liable to occur over the long term.

What the plan recommends

The owners of radioactive materials, together with Andra, must conduct further studies concerning options for their management in the eventuality of these materials being classified in the future as waste, considering the geological conditions most favourable to the confinement and isolation of the radionuclides in various development scenarios.

Waste management by radioactive decay

§2.4

Waste management by radioactive decay is for waste in which the radionuclides have a half-life of less than 100 days, originating mainly from nuclear medicine departments and research laboratories. After storage for radioactive decay, they are sent to management routes dedicated to conventional waste.

This is also an intermediate step in the management of certain radioactive waste produced in the basic nuclear installations, in particular waste containing tritium. This management method requires the construction of appropriate storage facilities.

Reusing radioactive waste

§2.5

Recycling reusable materials extracted from waste is an area for particular focus, pursuant to the fundamental principles laid down in Article L.541-1 of the Environment Code. In France, there are two recycling alternatives for reusing radioactive waste in the nuclear facilities, commissioned in the 2000s:

- Centraco smelting facility for recycling ferrous metal waste in the form of radiation shielding materials integrated into concrete containers for the fabrication of radioactive waste packages;
- the lead recycling route which, after decontamination, enables the lead to be made into shielding material.

KEY FIGURES

In France, the MOX fuel used by EDF in 22 reactors (as at end of 2012), contributes to about **10 %** of the nuclear electricity generated.

About **10** tons of plutonium are thus recycled annually, or the entirety of the stream from the EDF fuels reprocessed in the La Hague plant by Areva.

Of the 1000 tons separated annually, up to **650** tons of URT are re-enriched in place of natural uranium, which enables the supply to 4 reactors on the Cruas site.

Tanks containing daily waste from iodine 131 treatment, stored in a refrigerated room during decay, nuclear medicine department, Brabois hospital for adults, Nancy university hospital.

FOCUS

Storage
The storage of radioactive substances consists in temporarily placing them in a facility for holding, grouping, monitoring or observation, before retrieval.

Disposal
The disposal of radioactive waste consists in placing these substances in a specially designed facility, without the intention of retrieval.

The Centraco incineration furnace.

SPOTLIGHT

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

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

However, there are questions over the future operation of these solutions: the Centraco smelting facility has been stopped since the 12th September 2011 accident and closure of the lead recycling unit is scheduled for 2013.

The studies required by the 2010-2012 PNGMDR identified two reuse options, one for recycling VLL waste as infill material for the VLLW disposal facility at the industrial centre for collection, storage and disposal (Cires), the other for recycling of VLL ferrous metal waste to construct cast iron radioactive waste packages. However, the industrial feasibility of this was not confirmed by the studies conducted, in particular with regard to the recycling of ferrous metal waste.

What the plan recommends

Given the rising VLL waste management needs created by the forthcoming decommissioning and post-operational clean-out operations, Andra, Areva, CEA and EDF will, by the end of 2014, submit a summary of the studies concerning the implementation of reuse and recycling solutions, in order to preserve scarce disposal site resources.

Incinerating radioactive waste

§2.6

Waste incineration provides a real answer to the management of a broad spectrum of VLL and LL-SL radioactive waste. It is for example, a way of preserving disposal site resources by reducing the volume of ultimate radioactive waste by a factor of 10 to 20. The Centraco incinerator, which entered service in 1999, can thus process solid waste (gloves, overshoes, plastics, etc.) and aqueous and organic liquid waste, in particular oils and solvents, resulting from the day to day operation of nuclear facilities or from small producers of waste outside the nuclear power generating sector (hospitals, etc.).

Incineration is an important aspect of radioactive waste management. The shutdown of the Centraco incinerator for nearly a year, in 2011-2012, revealed the vulnerability of this management route.

What the plan recommends

The licensees of nuclear facilities must analyse the operating experience feedback concerning the problems linked to the shutdown of the incinerator and take steps to secure the management options for incinerable radioactive waste.

Disposal of very low level (VLL) waste

§2.7

The management policy for the VLL waste produced by nuclear facilities in France is not based on clearance levels, in other words a level below which a material is no longer subject to the regulations and can be considered as conventional. It is dependent on the origin of the waste within the facility. All contaminated or activated waste, or waste that is liable to be so, is considered to be radioactive waste and must follow specific, rigorous management, including disposal in a facility dedicated to radioactive waste. 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 2011, the total volume placed in the Cires was about 203,000 m³, or 31% of the authorised regulation capacity (650,000 m³) and the latest production estimates indicate that needs will approximately double the inventory of waste to that originally identified to be disposed of in this facility.

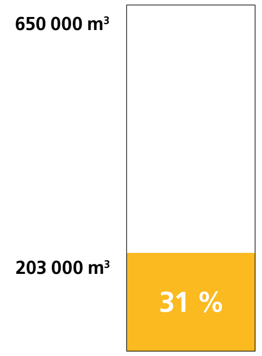
In order to preserve scarce disposal site resources, solutions to reduce the flow of ultimate radioactive waste, such as waste compaction or reuse, were studied and the efforts made must be continued. However, the facility should reach full capacity within 20 to 25 years, instead of the 30 years initially anticipated, requiring the construction of another disposal facility or extension of the authorised capacity of the current facility in around 2025.

What the plan recommends

Andra, together with Areva, CEA and EDF, will draw up a forecast schedule for filling the VLL waste repository at the industrial centre for collection, storage and disposal (Cires) in Morvilliers and will propose an overall industrial system to meet the need for new disposal capacity for VLL waste.
Overall optimisation must be sought, in particular for the decommissioning operations producing large quantities of VLL waste. The producers will be required to work with various public stakeholders, Andra in particular, in order to establish experience feedback concerning the management of this waste.

Forecast date for saturation of the Cires repository

KEY FIGURE



Utilisation of the volume capacity of the Cires repository (data as at 31/12/11)

Emplacement of VLL waste in a disposal cell excavated at a depth of several metres in clayey rock.

KEY FIGURES

3 disposal repositories.

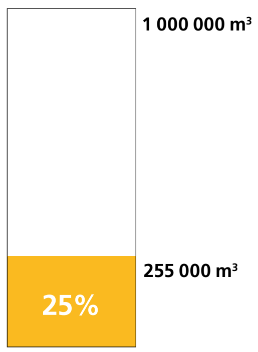
2 in the Aube département: the industrial centre for grouping, storage and disposal (Cires) and the Aube waste disposal facility (CSA).

1 in the Manche département: the Manche waste disposal facility (CSM).

Aerial view of the Manche repository (CSM) at Digulleville).

Surface repository for LLW/ILW (low/ intermediate level waste) at Soulaines-Dhuys (in the Aube département).

KEY FIGURE



Utilisation of the disposal volume capacity of the Cires (data as at 31/12/11)

Disposal of low and intermediate level, short lived waste (LL/ILW-SL)

§ 2.8

"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.

Between 1969 and 1994, the Manche waste disposal facility received 527,000 m3 of waste packages and entered the surveillance phase in 2003. 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 records and memory of the facility and the waste emplaced in it are kept for future generations.

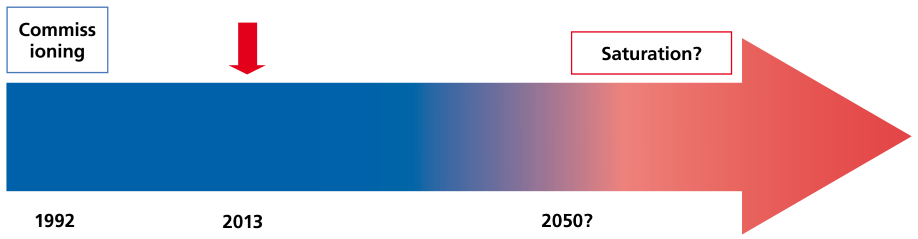
What the plan recommends

Andra will present the steps taken to ensure that records and memory of the Manche waste disposal facility are maintained.

At the end of 2011, the total volume of packages emplaced in the Aube waste disposal facility (CSA) was about 255,000 m3, or 25% of the authorised regulation capacity (1,000,000 m3). Efforts made at source to reduce the amount of LL/ILW-SL waste produced, and the commissioning of a VLL waste repository in the Cires, plus the smelting and incineration routes, have enabled the lifetime of the repository to be extended.

What the plan recommends

Together with Areva, CEA and EDF, Andra will produce a forecast for filling of the Aube waste disposal facility (CSA), in particular presenting the anticipated evolution in the occupation of the repository's radiological capacity.



Forecast date for saturation of the CSA

Management of waste containing enhanced natural radioactivity

§ 2.9

Waste containing enhanced natural radioactivity (TENORM) is waste created by the transformation of raw materials naturally containing radionuclides but which are not used for their radioactive properties. This is low level, or even very low level, long-lived waste.

TENORM waste is managed in situ, or is either disposed of in conventional waste disposal facilities (four facilities are authorised to receive TENORM), or is sent to Andra's disposal facilities dedicated to the management of radioactive waste, according to their radiological characteristics. Combustion ashes can also be reused in the production of cement, owing to their very low radiological activity when compared with the natural radioactivity already present in the concrete.

Improving the management of TENORM waste requires greater knowledge of the quantities concerned and improved traceability.

What the plan recommends

Examination of tighter regulatory provisions applicable to the management of TENORM waste is requested.

DEFINITION

Technologically enhanced naturally occurring radioactive materials
This is waste generated by the transformation of raw materials naturally containing radioactive elements but used for reasons other than their radioactive properties.

Residues from the rare earths extraction process (Solvay). This waste is referred to as TENORM.

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

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 numerous applications (medical, scientific or industrial). They concentrate their radioactivity in small volumes and are usually made of stainless metals with a long life.

Sealed source used in radiotherapy. (CIS Bio international).

FOCUS

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 for example comes from medical imaging examinations, experiments to develop certain drugs, or certain industrial welding inspections. Even if there are a large number of producers of this type of waste, the volume generated remains small.

This part presents the long-term management methods under development for certain waste categories which do not yet have a solution, in particular waste containing tritium, sealed radioactive sources, low level, long-lived waste (LLW-LL) and high and intermediate level, long-lived waste (HLW/ILW-LL). 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 makes provision for studies to define management solutions for this waste.

Waste management requiring specific work §3.1

Because of their properties, certain categories of radioactive waste require special management routes. This is, for example, 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 requires storage prior to disposal, to allow radioactive decay of the tritium. 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 its 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 not in the nuclear power generating sector.

What the plan recommends

Together with Areva, CEA and SOCODEI, Andra will submit a summary of the studies concerning the treatment of liquid and gaseous tritiated waste from the small producers outside the nuclear power generating sector.

Most used sealed sources are currently stored pending a final management solution and only a small part of the used sealed sources can be disposed of in the Aube waste disposal facility.

What the plan recommends

A working group headed by the Ministry for Ecology will be set up to define a management system for used sealed sources, by the end of 2014.

Finally, the handling of waste from the small producers outside the nuclear power generating sector needs to be optimised, given the nature and volumes of the waste to be dealt with.

What the plan recommends

By the end of 2013, Andra will identify the investments needed to guarantee the future of the management solutions for the waste generated by this sector.

Management of low level, long-lived (LLW-LL) §3.2

Low level, long-lived radioactive waste (LLW-LL) requires specific management, appropriate to its long lifetime, which rules out disposal in Andra's facilities in the Aube. This waste in particular comprises graphite waste from the operation and future decommissioning of EDF's graphite moderated, gas-cooled, natural uranium type reactors, radium-bearing waste, mainly from the processing of ores containing rare earths, some of the bitumen packages on the Marcoule nuclear site and uranium conversion residues from the Comurhex plant in Malvési. Pending their disposal, possibly following processing, the packages of LLW-LL waste are currently stored in facilities on the sites of the producers.

En 2008, the search for a disposal site capable of taking LLW-LL type waste was unsuccessful. Therefore, in order to learn the experience feedback lessons, working groups were set up, in particular in the HCTISN and within the framework of the Aarhus Convention. They submitted their recommendations in order improve preparations for the search for the future LLW-LL disposal site.

Two concepts are being envisaged for final disposal of LLW-LL waste: Reworked Cover Disposal (SCR) in an outcropping geological layer by excavation and then backfill, and Intact Cover Disposal (SCI), excavated underground in a layer of clay at a greater depth. Various scenarios are being studied for each type of LLW-LL waste. In particular, the possibility of processing and sorting of part of this waste (graphite waste and drums of bitumen packages) is being examined in order to optimise LLW-LL waste management.

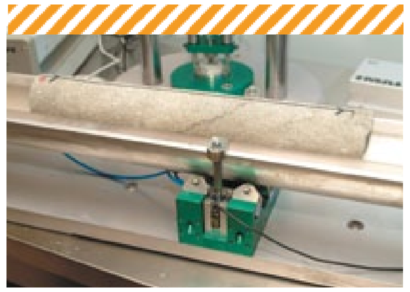
Handling of radioactive substances in a medical research laboratory (Nice Hospital).

FOCUS

The Aarhus convention
This is an international agreement signed in 1998 by 39 States. It aims to improve the environmental information produced by the public authorities, to promote public participation in decisions with an environmental impact and to broaden the conditions for access to justice in terms of environmental legislation and access to information.

LLW-LL type package – Cézus.

Up until the end of the 1990s, sealed sources containing radium or americium were added to certain lightning ro. Once dismantled, they must be collected and managed as LLW-LL type radioactive waste.



Characterisation of the mechanical properties of rock on a core sample.

FOCUS

The 2006 Act requires that the creation authorisation application file for the geological repository be available for review in 2015 and, subject to it being granted, the centre would be commissioned in 2025. The submission of this application will be preceded by a public debate planned for 2013 and an Act will specify the reversibility conditions of this repository.

2D seismic survey around the Meuse Haute Marne laboratory.

What the plan recommends

By mid-2015, Andra should be submitting a report on the feasibility of reworked cover disposal, specifying the associated waste perimeter and a summary of the management strategy for the lowest level graphite waste and bitumen encapsulated waste drums in Marcoule, using the work done during the siting search process and the possibility of sorting/reprocessing.

In the meantime, the Cigéo deep geological repository project inventory presented in 2012 with a view to submitting a creation authorisation application file, makes provision for possible reception of LLW-LL type bitumen packages and waste from sorting/processing of graphites.

Management of High and Intermediate Level, Long-lived waste (HLW/ILW-LL)

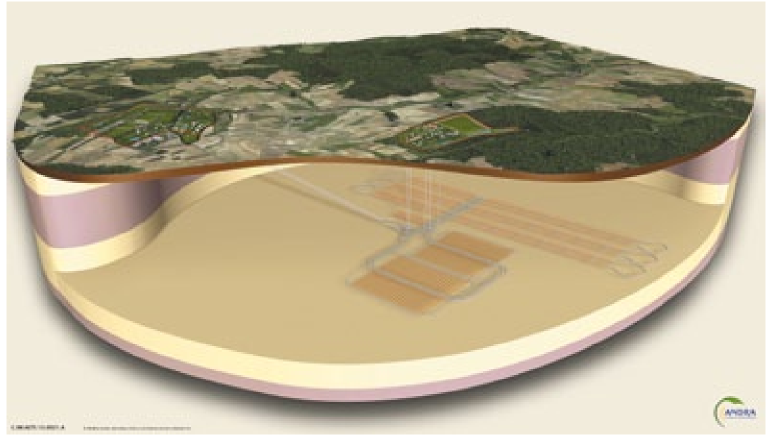
The management of HLW/ILW-LL waste is studied according to the three complementary focal points identified in the 28th June 2006 Act on the sustainable management of radioactive materials and waste, now codified in the Environment Code: reversible disposal in a deep geological layer, storage and the separation and transmutation of long-lived radionuclides. In addition, research is being carried out into the processing and packaging of the 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 28th June 2006 Act requires commissioning of a reversible deep geological disposal facility in 2025. The underground installations in the planned repository, called Cigéo (French acronym for industrial centre for geological disposal) would be located in a layer of clay, at a depth of about 500 m. The research being carried out by Andra in the underground laboratory in the Meuse and Haute Marne départements has produced significant results concerning the feasibility and safety of such a repository.

Storage allows the safe management of HLW/ILW-LL waste pending the opening of a long-term management facility. The waste packages are stored in facilities on the sites of the producers.

What the plan recommends

The storage capacities needed for HLW and ILW-LL packages must be analysed by Areva, CEA and EDF together with Andra, taking account of the schedule of shipments to the planned Cigéo repository and of the principle of reversibility.



General view of the Cigéo project installations – schematic layout.

The studies being carried out into separation-transmutation, coordinated by CEA, aim to assess the industrial feasibility of the solutions for separating certain radionuclides contained in the spent fuels and currently found in the ultimate waste. Even if the studies show that separation-transmutation can be considered as a potential means of improving waste management, there are nonetheless a certain number of drawbacks (difficulties with cycle operations, extra costs, etc.). Furthermore, it does not preclude the need for geological disposal.

What the plan recommends

The forthcoming studies will affect the decisions to be taken following submission by CEA in late 2012 of a study assessing the prospects for the separation-transmutation options.

FOCUS

Separation-transmutation

Transmutation is the transformation, following a nuclear reaction, of one element into another. Transmutation can be performed in a reactor or using a particle accelerator. This solution is being studied for elimination of certain radionuclides contained in spent fuels currently disposed of as ultimate radioactive waste. The aim is to reduce their harmfulness by transforming them into radionuclides with a shorter half-life. They must thus first be separated from various radionuclides in order to subject them to specific neutron fluxes; the process as a whole then being referred to as separation-transmutation.

Improving the overall consistency of radioactive materials and waste management

§3.4

In order to improve the overall management of radioactive waste, working groups were set up under the 2010-2012 PNGMDR in order, on the one hand, to propose solutions for optimisation between management routes and, on the other, to study the waste for which there is currently no disposal route.

Optimising the breakdown between the management routes is desirable. Thus, waste and package sorting has been identified as one of the main areas for the optimisation process. At the same time, possible processing hypotheses were examined for waste categories representing large volumes.

What the plan recommends

The licensees must continue with their work to characterise the waste and waste packages already produced, so that they can be sent to the most appropriate disposal solution. By the end of 2014, they will submit a report presenting more complete industrial scenarios, including the operations to be performed upstream of disposal.

On the basis of the 2009 edition of the National Inventory, it was revealed that about 0.1% of the volume of waste produced could not be sent to any existing or planned disposal solutions.

What the plan recommends

By late 2014, the licensees will submit a report on the progress of the on-going studies to determine the steps to be taken to ensure that the management of waste with no current disposal solution is compatible with the existing routes or those to be created.

Conclusion

The 2013-2015 PNGMDR continues on from and expands the measures initiated in the previous version. It stresses the need to develop overall industrial management systems and management methods for high-level and intermediate level, long-lived waste. It in particular proposes the following measures.

Developing new long-term management modes

The 2013-2015 PNGMDR requests that the following be continued:

- studies and research concerning high level and intermediate level waste and in particular those concerning the planned deep geological disposal repository, Cigéo, which will enter a new phase during the period 2013-2015 with the submission of the creation authorisation application in 2015, preceded by a public debate planned for 2013;
- studies on the packaging of intermediate level, long-lived waste in order to meet the 2030 target for the packaging of waste produced before 2015, set by article L.542-1-3 of the Environment Code.

With regard to low level, long-lived waste, the 2013-2015 PNGMDR requires the definition of management scenarios, in particular by continuing the studies into sorting, characterisation and processing of graphite waste and bitumen encapsulated waste, as well as feasibility studies concerning disposal options for the waste already produced by Comurhex Malvési.

Improving existing management modes

The 2013-2015 PNGMDR requests the following:

- improved monitoring of the volume and radiological capacities of the disposal facilities, thus anticipating any need for new capacity;
- development of reuse and recycling solutions for very low level waste, in order to preserve disposal site resources;
- continued studies on mining treatment residues, in order to propose concrete improvement measures, whether in terms of understanding the exposure risk for the general public, the long-term strength of the embankments or changes in water treatment techniques;
- continuation of the process to implement the circular from the Ministry responsible for Ecology and ASN, dated 22nd July 2009, in order to determine whether the sites on which mining waste rock is reused are compatible with the usages and to reduce their impact when necessary.

Taking account of significant events over the period 2010-2012

The 2013-2015 PNGMDR requests the following:

- identification of the investments required to guarantee the future of the management routes for the waste generated by small producers outside the nuclear power generating sector and, in particular, to continue with the studies concerning the treatment of liquid and gaseous tritiated waste produced by this sector;
- to continue with the work started to define a management system for used sealed sources;
- to establish experience feedback from the shutdown for several weeks of the Centraco incineration plant and to propose measures to secure the incinerable radioactive waste management solutions.

Annexes

The main stakeholders in radioactive materials and waste management

In France the main stakeholders are:

- 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 storage facilities and the 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 providing public information;
- 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 Ecology, Sustainable Development and Energy (MEDDE), 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 French Nuclear Safety Authority (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;
- the National Assessment Commission for financing the cost of decommissioning of basic nuclear installations and of managing spent fuels and radioactive waste (CNEF). It assesses the control made by the administrative authority to ensure that the updated provisions are able to meet the gross costs, as evaluated by the licensees, along with management of the dedicated assets;
- 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 authority
ASND : Defence nuclear safety authority
Bq : Becquerel
BNI: Basic Nuclear Installation
Cigéo : Industrial centre for geological disposal
Cires : Industrial centre for collection, storage and disposal
CLIS : Local Information and Monitoring Committee
CNE : National Assessment Commission
CNEF : National Assessment Commission for financing the cost of decommissioning of basic nuclear installations and of managing spent fuels and radioactive waste
CNRS : French National Centre for Scientific Research
CSA : Aube waste disposal facility
CSM: Manche waste disposal facility
HLW: High level Waste
HCTISN: High Committee for Transparency and Information on Nuclear Security
ILW-LL: Intermediate Level Waste, Long-lived
IRSN: French Institute for Radiation Protection and Nuclear Safety
LLW-LL: Low Level Waste, Long-lived
LLW/ILW-SL: Low Level and Intermediate Level Waste, Short-lived
MOX: Plutonium and uranium oxides based fuel
OPECST: Parliamentary Office for the Evaluation of Scientific and Technical Choices
PNGMDR: National Radioactive Materials and Waste Management Plan
SCI: Intact cover disposal
SCR: Reworked cover disposal
TENORM: Technologically enhanced naturally occurring radioactive materials
URE: Enriched Reprocessed Uranium
URT: Reprocessed Uranium
VLLW: Very low level waste

Useful links

www.developpement-durable.gouv.fr
- headings: Énergies, Air et Climat - Énergies - Nucléaire
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Ministry for Ecology, Sustainable Development and Energy

Head of editorial project: SG/DICOM/DIE/M. Watine - **Editorial committee:** DGEC and ASN - **GraphiC Design:** SG/DICOM/DIE/C. Cazeau
Publication: SG/DICOM/DIE/C. Fedecki - **Printing:** SG/SPSSI/ATL2 - **Réf. :** DICOM-DGEC/PLA/13030-GB - August 2013

Brochure printed on European ecolabel certified paper - www.eco-label.com

Photo credits

Cover: (from left to right): Andra (x2) - P. Demail/Andra **Inside pages** (from top to bottom) **Page 4:** Andra **Page 5:** Andra - P. Demail/Andra (x2) - F. Dano/ACD Systems **Page 8:** C. Jandaurek/Cadam/CEA - EDF - **Page 9:** Andra - Areva **Page 10:** J.-M. Taillat/Areva **Page 14:** J.-M. Taillat/Areva - P. Lesage/Areva **Page 15:** P. Luchez/ASN - ASN **Page 16:** Socodei - P. Bourguigon/DeclicÉditions **Page 17:** Andra **Page 18:** Zorilla-Production - P. Bourguigon/DeclicÉditions **Page 19:** Andra **Page 20:** P. Demail/Andra **Page 21:** P. Demail/Andra (x2) - P. Maurein/Andra **Page 22:** P. Demail/Andra - A. Rezzoug/Andra

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