

RADIOACTIVE WASTE MANAGEMENT AND DECOMMISSIONING IN FRANCE

1. NATIONAL FRAMEWORK FOR MANAGEMENT AND REGULATION OF RADIOACTIVE WASTE AND DECOMMISSIONING

1.1 National framework

1.1.1 Overview of national policy

The French nuclear activities produce solid, liquid or gaseous waste, some of which is radioactive. The national policy on radioactive waste is that reliable, transparent and stringent management of this waste must ensure the protection of individuals, preservation of the environment and limitation of undue burdens imposed on future generations.

The preferred decommissioning strategy shall be immediate dismantling after the operating period of nuclear installations. Installations (NPPs, nuclear plants, research installations, etc.) have to remain at all times in a satisfactory safety condition, even when they have ceased to be operated, taking into account the specific nature of the dismantling operations. Dismantling operations produce radioactive waste which has to be managed with the same principle as the above-mentioned one.

In this respect two important acts were promulgated in 2006:

- the “Transparency and Security in the nuclear field” Act (June 13th 2006), sometimes called “TSN Act” and available in English at <http://www.french-nuclear-safety.fr/index.php/English-version/Asn-s-publications>
- the Planning Act on the sustainable management of radioactive materials and waste (June 28th 2006). . This Act is available in English at http://www.andra.fr/index.php?id=edition_1_5_2&recherche_thematique=all&global_id_item=387. Articles of this 2006 Planning Act have been integrated in the Environmental Code¹.

1.1.1.1 Radioactive waste management:

The general principles of radioactive waste management have been set initially by the December 30th 1991 Waste Act (called as well “Loi Bataille”) and later modified by the above-mentioned 2006 Planning Act on the sustainable management of radioactive materials and waste, and are the following:

- sustainable management of radioactive materials and waste of whatever nature, resulting in particular from the operation or dismantling of installations using radioactive sources or materials, with due regard for the protection of personnel health, safety, and the environment,
- in order to avert or limit the burden that will be borne by future generations, research is undertaken and the necessary means for the definitive securing of radioactive waste shall be implemented,

¹ <http://www.legifrance.gouv.fr/affichCode.do?cidTexte=LEGITEXT000006074220&dateTexte=20110209>

- producers of spent fuel and radioactive waste are responsible for those substances, without prejudice to the responsibility their holders have as nuclear activity operators.

The National Plan for the management of radioactive materials and waste (PNGMDR²) prescribed by the 2006 Planning Act is an important tool to improve radioactive waste management. It is issued by the Nuclear Safety Authority (ASN³) and the General Directorate for Energy and Climate (DGEC⁴) with the participation of a pluralistic steering committee and is updated every three years (third edition issued in 2012).

1.1.1.2 Decommissioning / dismantling:

Upon completion of their operating period, the so-called Basic Nuclear Installations (INB) undergo a series of clean-up operations followed by dismantling up to the defined end-state.

The scenario for each nuclear installation is selected by the operator on a case by case basis, generally in the light of comparative studies. The operator is asked to justify that the strategy proposed is the best one in terms of safety, radiation protection and waste management. The operator is also asked to justify the selected end-state of the considered installation.

The Nuclear Safety Authority (ASN) considers that immediate and complete dismantling shall be retained, for various reasons. At present all operators endeavour to apply this policy.

The technical provisions applicable to installations to be decommissioned must obviously be in compliance with general safety, radiation protection and waste management rules, notably regarding worker external and internal exposure to ionising radiation, criticality, radioactive waste treatment, discharges to the environment of radioactive effluents or measures designed to limit accident hazards and mitigate their consequences.

Waste originating from dismantling work is managed in the same way as waste originating from nuclear installations in operation. Although Directive 2013/59/Euratom so allows, French regulations have not adopted the notion of “clearance level”, i.e. the generic levels of radioactivity below which waste from nuclear activity can be disposed of as current waste without specific radioactive supervision. This policy is based on a “waste zoning” that divides facilities into zones generating nuclear waste and zones generating conventional waste. In other words, there is no release from regulatory controls of materials from zones likely to generate nuclear waste.

Moreover, there is also no release criteria for buildings and site after decommissioning, the release of a site is stated on a case by case study contemplating scenarios and future land use. The Nuclear Safety Authority (ASN) recommends that the remediation is conducted as far as possible. However there may be cases leading to restricted uses.

² French 2013 issue of the PNGMDR (report in English) : <http://www.french-nuclear-safety.fr/Information/Publications/Others-ASN-reports/French-National-Plan-for-the-Management-of-Radioactive-Materials-and-Waste-2013-2015>

³ <http://www.french-nuclear-safety.fr/>

⁴ <http://www.developpement-durable.gouv.fr/-Energie-Air-et-Climat-.html>

1.1.1.3 International Conventions:

In order to share the experience of other countries, France signed the “Joint convention on the safety of spent fuel management and on the safety of radioactive waste management” on 29 September 1997. The joint convention was ratified on 22 February 2000.

France also signed other conventions, such as:

- the convention on early notification of a nuclear accident,
- the convention on assistance in the case of nuclear accident or radiological emergency,
- the London convention.

1.1.1.4 Scope of facilities or activities covered by the present document:

The scope of facilities or activities covered by the present document is large. It includes nuclear power plants (NPPs), nuclear fuel cycle facilities, research centres (including hot laboratories, research reactors), National Defence activities, medical activities and industrial activities.

1.1.2 Overview of relevant institutions

1.1.2.1 Energy policy

The institutions in charge of energy policy are the Parliament, the Government and more specifically the DGEC (General Directorate for Energy and Climate) on behalf of the ministry for Ecology⁵ and Energy.

1.1.2.2 Regulatory framework

The “Transparency and Security in the nuclear field” Act of 13 June 2006 (or TSN Act) creates a nuclear safety authority as an independent administrative body. This has been implemented in 2006. It is composed of an independent college of 5 commissioners, a General Directorate, eight Directorates and eleven decentralized offices.

Whenever it deems it necessary, ASN calls upon its technical support organisations, primarily the IRSN. For major issues (such as license application), ASN requests the opinion of the competent advisory expert group (GPE) to which the IRSN presents its analyses; for other secondary matters, safety analyses are the subject of an opinion to be sent directly to ASN by the IRSN.

As for license application, a government decree finalises, based on ASN and other organisations advices the licensing process.

Nuclear facilities which are not considered as Basic Nuclear Installations (INB) because they deal with a amount of radioactive material at an activity level below the INB threshold are required to comply with :

- the environmental protection provisions specified in the Act 76-663 of 19 July 1976, insofar as they belong to the category of facilities classified on

⁵ <http://www.developpement-durable.gouv.fr/>

environmental protection grounds (ICPE). They are controlled at the local level by a regional directorate (DREAL).

- or when the quantity of radioactivity dealt with is lower than the thresholds for classifying them under the ICPE regime, they are regulated under the Public Health Code, with respect to radiation protection, ASN is involved in the control of the radiation protection aspects of these facilities.

Nuclear installations connected to National Defence activity are under the control of the *Autorité de sûreté nucléaire défense* (ASND).

Disposal of mining and milling residues⁶ is classified on environmental protection grounds. An inventory of these sites has been performed by the IRSN (MIMAUSA database⁷).

The IRSN (see 1.1.2.6) is an independent technical safety organisation. One important activity is to support the ASN and ASND in the technical review of Safety Cases.

1.1.2.3 *Andra, the National Radioactive Waste Management Agency*

A specific public agency since the 1991 Waste Act, Andra⁸, has the responsibility for the long-term management of radioactive waste produced in France (but excluding foreign waste or waste originating from foreign spent fuel processing). This agency operates waste repositories, defines the acceptance criteria for waste packages in these repositories and controls the quality of their production. The agency is also in charge of designing, siting, and constructing new disposal facilities. It keeps up to date the National inventory of radioactive waste and recoverable materials in France⁹ (this inventory includes the so-called “committed” or forecast waste with projection over the coming years with contrasting scenarios) with an edition issued on a three-year basis (the last one issued in 2012 and considering inventories at end 2010).

1.1.2.4 *CEA, the Alternative Energies and Atomic Energy Commission*

The CEA¹⁰ was created by Ministerial Order 45-2563 of October 18 1945 to carry out R&D for the implementation of civilian nuclear activities (energy, industry, research and health) and to provide the necessary support to the development of National Defence activities (Nuclear deterrent forces). Following the December 1991 Waste Act, CEA was entrusted with the R&D concerning high-level and long-lived intermediate-level radioactive waste management:

- Partitioning and transmutation,
- Long-term storage and waste conditioning (which has been tasked in 2006 to Andra).

Since the 2006 Planning Act, CEA still carries out R&D either as an actor of this 2006 Planning Act on the feasibility of partitioning and transmutation or as support to Andra programme for some specific topics (on the basis of bilateral agreements).

⁶ These residues are not considered as ultimate waste according to the French regulatory framework.

⁷ http://www.irsn.fr/FR/base_de_connaissances/Environnement/surveillance-environnement/sites-miniers-uranium/Pages/4-bdd.aspx

⁸ <http://www.andra.fr>

⁹ http://www.andra.fr/international/index.php?id=edition_1_5_2&recherche_thematique=6&global_id_item=387

¹⁰ <http://www.cea.fr>

1.1.2.5 CNE, the National Assessment Board

The December 1991 Waste Act has prescribed the creation of an expert assessment committee, the CNE (National Assessment Board¹¹), to evaluate and review the various programmes carried out for the management of high-level and long-lived intermediate-level radioactive waste.

The CNE is neither a regulator nor an operator but its role has been essential¹² to the progress of the geological disposal of high-level and long-lived intermediate-level radioactive waste project.

Moreover, the 2006 Planning Act has extended the mission of the National Assessment Board, now called CNE2¹³, to reviewing of all radioactive waste management R&D programmes mentioned in the PNGMDR.

Its reports are issued on a yearly basis for the government. The annual report shall be transmitted by the government to Parliament, which in turn forwards it to the Parliamentary Office for the Evaluation of Scientific and Technological Choices (OPECST¹⁴), before being made public.

1.1.2.6 IRSN, the National Institute for Radiation Protection and Nuclear Safety

IRSN¹⁵ (*Institut de radioprotection et de sûreté nucléaire*) is the public body in charge of the scientific assessment of nuclear and radiation hazards. For that purpose it especially develops technical expertise methods. It is mandated for advising the public authorities and contributing to public policies, for developing the research activities necessary to support its expertise function and for delivering services to industry and other organisations.

The key fields of research relate to safety of nuclear installations and waste, to severe accidents in nuclear reactors and emergency preparedness, to radioactivity and ecosystems and to radiation protection. National and international partnerships are preferred to develop scientific knowledge.

IRSN support to public policies and regulation concerns mainly radiation protection, reactors, plants, laboratories, transport and waste safety, protection and control of nuclear and sensitive materials. IRSN also develops a specific organisation devoted to management of emergencies due to a nuclear crisis and radiological emergency (Emergency Response Centre commissioned at Fontenay-aux-Roses near Paris, radiological response, crisis mobile resources and analysis laboratories).

¹¹ <http://www.cne2.fr/>

¹² It is worth mentioning that the URL Local Information and Oversight Committee can call upon the CNE for scientific expertise on specific topics according to the provision established by the 1991 Waste Act and now integrated in the Environment Code.

¹³ to distinguish it from the former CNE established by the December 1991 Waste Act.

¹⁴ <http://www.assemblee-nationale.fr/commissions/opecest-index.asp>.

¹⁵ <http://www.irsn.fr>

1.2.2.7 *High Committee for Transparency and Information in Nuclear Safety (HCTISN)*

This independent committee¹⁶ was created by the 2006 TSN Act and is an information, dialogue and debate institution in the field of hazards and impact of nuclear activities on health, environment and nuclear safety.

Its composition is quite wide with 4 Members of Parliaments, 6 representatives in the following categories: local information commissions, environmental societies, trade unions, Authorities (State, ASN, IRSN), the nuclear industry, qualified personalities. It is currently chaired by a former Senator (and former member of the OPECST).

As such and in this field, this committee can i) issue opinions on any topic related to nuclear safety & security ii) and as well take up any issue concerning access to information and propose provisions to guaranty or improve transparency. Ministers in charge of nuclear safety, parliamentary commission and OPECST chairs, local information committee chairs and nuclear operators can as well refer to this HCTISN.

1.2 **National, technical regulatory organization**

1.2.1 *Regulatory function of the ASN*

The missions of the ASN essentially relate to:

- regulation
- control
- information of the public,

in the field of nuclear safety (INBs during all their lifetime from creation to de-licensing, radioactive waste management, spent fuel management, sources, contaminated sites by radioactive material,...) and radiation protection, to protect workers, patients, the public, and the environment.

A clear distinction between the respective competence of the government and the ASN is defined by the “transparency and security in the nuclear field” Act. This Act defines clearly which decisions are to be made by the government and what is left to the ASN. ASN contributes to the preparation of regulations which will be signed by ministers. It gives its opinion and advice to the government about decrees and ministerial orders and takes regulatory decisions from a technical point of view. ASN verifies that operators actually comply with regulations and specific requirements related to their installations or activities. It also contributes to the information of the public, including in case of emergency situation. Besides, in case of emergency situation, it assists technically the Government.

In the framework of its regulatory functions concerning INB safety, the ASN issues decision and guidance defining the safety objectives to be achieved and describing accepted practices deemed compatible with these objectives (in the past, ASN issued basic safety rules so-called “RFS” some of which are still valid, and other under revision) .

INB licensing is granted within the framework of the decree of decree of 2 November 2007 in application of the “transparency and security in the nuclear field” Act (TSN Act). It provides for an authorisation procedure including licences issued at key points in plant lifetime: creation license (authorisation decree), license for start-up of normal operation (commissioning license), shut-down and decommissioning licenses, end of licences.

¹⁶ <http://www.hctisn.fr>

The decree of 2 November 2007 establishes the documents which are needed at each license application. For instance, a creation decree requires a decommissioning plan since the inception of the project

Before the authorisation decree is signed, the facility has to provide a safety analysis report and an environmental impact study. In case of operating licences, and, most of the time for decommissioning / dismantling of a nuclear installation, the reports are subjected to public debate in the framework of a public inquiry. A technical instruction procedure is followed implying a peer review by the competent Advisory Committee (see § 1.2.2.3).

1.2.2 Organisation and resources

1.2.2.1 Organisation of the ASN

It is composed of a college of five commissioners (including the chairman), an executive committee, a central office comprising eight directorates, a general secretariat (for administration and finance) and an expertise & QA service, and eleven regional directorates. Concerning the eight centralized directorates, they are respectively in charge of: NPPs, nuclear pressure equipment, transport and sources, R&D installations, fuel cycle facilities, decommissioning and waste, ionising radiation and health, environment and emergency, international relation, communication and public information.

Since 2000, each INB pays an annual tax to the State and ASN receives financial resources from the national budget. The budget of the ASN for 2010 amounts to €145,9M and the ASN benefits from the expertise of its technical support organisation IRSN (see § 1.2.2.2 below). The total staff of the ASN, by end 2012, was 471 persons (including the regional services).

1.2.2.2 Technical support of the French Nuclear Safety Authority

The main technical support organisation of the ASN is the *Institut de radioprotection et de sûreté nucléaire* (IRSN), created in February 2002. IRSN is constituted by the former Institute for Nuclear Safety and Protection (IPSN) and by part of the former Office for Radiation Protection (OPRI). It employs 1 718 persons and is an independent public agency with a budget of € 282M (figures by end 2011).

In the fields of radioactive waste safety, IRSN support to the French nuclear safety authority relates to scientific assessment of technical reports related to waste treatment facilities or conditioning processes for HLW (with respect to transportation, storage and their disposal) and to safety reports related to existing or foreseen disposal facilities. IRSN participates to national and international working groups (development of national guidance, policy, development and harmonisation of safety practices under the auspice of IAEA...) and advises the ASN on the work developed by various implementers in the framework of the PNGMDR.

IRSN assesses safety issues concerning the evolution of the existing CSM (Centre de stockage de la Manche) and CSA (Centre de stockage de l'Aube) disposal facilities, the development of considered or foreseen repositories and assesses also the research activities developed by Andra in the framework of the Planning Act of 28 June 2006 on the sustainable management of radioactive materials and waste. IRSN in particular assesses the adequacy of the proposed conditioning of waste.

IRSN also assesses the safety of installations under decommissioning of EDF, CEA and other research laboratories.

1.2.2.3 Advisory Committees (experts groups)

Seven Advisory Committees (sometimes called as well Standing Groups of experts - Groupes Permanents in French) comprising national and foreign experts and as well representatives of the Administration were created to assist the ASN by ministerial decisions of 27 March 1975 and 1 December 1998:

- the Advisory Committee for radioactive waste,
- the Advisory Committee for laboratories and plants,
- the Advisory Committee for nuclear reactors,
- the Advisory Committee for transport.
- the Advisory Committee for radiation protection in medicine applications
- The Advisory Committee for radiation protection in industrial activities
- the Advisory Committee for nuclear pressurized vessels

The Advisory Committees are consulted on the important aspects regarding the safety of the facilities and activities within their sphere of competence.

In particular, they examine the safety analysis reports produced by the operator for each INB during all its lifetime and also general matters (basic safety rules, consequences of new management of nuclear fuel, policy and strategy of the main producers of radioactive waste,...). They are provided with a report presenting the results of the assessment conducted by the IRSN, and issue an opinion with a number of recommendations.

1.3 National implementing organisations

1.3.1 Scope of responsibility

1.3.1.1 Andra, the National Radioactive Waste Management Agency

The main implementing organisation is Andra, the National Radioactive Waste Management Agency. Created in 1979 within the CEA, it was established by the December 1991 Waste Act as a public body in charge of the long-term management of all radioactive waste, under the supervision of the ministries for Environment, Energy and Research. Its 3 basic missions were extended and their funding secured through the 2006 Planning Act:

- a R&D mission to propose safe long-term solution for radioactive waste without current disposal system; this mission includes long-term storage, since the 2006 Planning Act, in order to propose interim solutions while final ones are being studied (until 2006, the long-term storage issue was initially entrusted to the CEA according to the December 1991 Waste Act),
- an industrial mission concerning on one hand waste acceptance criteria and control and on the other hand, siting, construction, operation, closure and monitoring of repositories. This mission includes as well a public service mission in terms of i) collection of waste of the “small-scale nuclear activities” producers or owners

(including the so-called “household” radioactive waste, ie waste owned by private individuals) and ii) clean-up and rehabilitation of orphan polluted sites,

- an information mission, notably through the regular publication of the National Inventory of radioactive waste and recoverable materials. This mission includes as well an active policy of dialogue with stakeholders both at national and local level (for instance through the activities of the various local information and oversight committees established for every INB or the underground research laboratory).

1.3.1.2 CEA (Alternative Energies and Atomic Energy Commission)

As requested in the 2006 Planning Act, CEA is in charge of conducting R&D on the feasibility of partitioning and transmutation.

A comprehensive report has been issued by the CEA in 2012, presenting the main results of CEA’s R&D in the field of partitioning and transmutation, and also giving the rationale and the main guidelines for the design of the ASTRID sodium-cooled fast reactor prototype, which could be operated, if decided, from around 2025. The main R&D goals for the period 2013-2015 are the following:

- Basic design of the ASTRID prototype, and related research and development;
- Multirecycle of plutonium in fast neutron reactors (optimizing reprocessing and recycling of Pu-bearing fuels)
- Partitioning and transmutation studies, with a focus on americium

1.3.2 Organisation and resources

1.3.2.1 Andra, the National radioactive waste management agency

By the end of 2013, Andra staff was 606 employees spread on different sites (excluding students carrying a thesis granted by Andra). Its total budget for 2013 was €188M.

Andra organisation is composed as detailed below:

- headquarters sited near Paris with specific divisions relevant to Andra’s missions as the R&D division, the programme division, the engineering and Cigeo¹⁷ project division, the industrial division (in charge as well of the public service mission), the risk management division (in charge notably of safety & quality and environment issues and of the National Inventory of radioactive waste and recoverable materials) and support divisions as General secretariat (administration, purchase and contract, accounting and control, legal and insurance), human resources division, communication and international division,
- the industrial division runs as well, with on-site staff :
 - the CSM surface repository under post-closure monitoring phase since 1994 (end of disposal operation) and located in the Manche district near the AREVA La Hague facility,
 - the CSA surface repository dealing with low- and intermediate-level short-lived radioactive waste located in the Aube district;
 - and the near-by CIRES facility with :

¹⁷ Cigeo stands for Industrial Centre for geological disposal

- a surface repository dealing with very-low-level radioactive waste,
 - a facility for grouping and sorting of waste produced by small-scale nuclear activities (non-electronuclear), with, when relevant, shipment to installations for incineration or treatment;
 - and finally a storage facility for radioactive waste produced by small-scale nuclear activities, when there is no available final solution.
- the Meuse/Haute-Marne Centre (CMHM) which includes the Meuse/Haute-Marne Underground Research Laboratory (LSMHM) and the Technological Exhibition Facility (ETe), respectively located in Bure (Meuse district) and Saudron (Haute-Marne district).

Apart from its statutory governing board, three advisory committees comprising French and foreign experts were created either by decree for the first one or by Andra itself for the two other ones, to assist Andra and/or review its work:

- the Scientific Council, established by Decree 92-1391 article 10 of 30 December 1992 to review Andra scientific policy and results,
- the Advisory Committee for the implementation of the information and consultation plan in eastern France (COESDIC) to site a geological repository, created in 2007 upon Andra CEO's decision and composed of experts in social sciences and public information. This Committee could as well be consulted in the siting of a low-level long-lived waste repository in the framework of the so-called FA-VL project concerning mainly radium-bearing and graphite waste,
- the Scientific Orientation Committee (COS) of the LSMHM, created just after the granting of LSMHM license and composed of experts in geosciences to provide advices on the experimental programme carried out at the LSMHM. This committee is chaired by a member of the Scientific Council.

1.3.2.2 CEA (Alternative Energies and Atomic Energy Commission)

The CEA, the French Alternative Energies and Atomic Energy Commission, is a public body leader in research, development and innovation in three main fields: energy, information and health technologies, and defense and national security. In each of these fields, the CEA maintains a cross-disciplinary culture of engineers and researchers, building on the synergies between fundamental and technological research.

In the field of energy, in a constant effort to improve energy resources and protect the environment, the CEA is optimising the existing fleet of nuclear power plants, developing R&D solutions for nuclear waste management, and generating ideas on future energy sources (hydrogen, solar, biomass, etc), that do not produce greenhouse gases.

The life sciences deal particularly with radiobiology, nuclear toxicology and new imaging methodologies.

There are also important developments in the field of information technologies (micro and nano, microelectronics and microsystems, sensors and signal processing) and health technologies developing imaging and medical research, genomics, large scale biology and protein engineering.

There are 52 joint research units (UMR) linking the CEA and its research partners and 27 correspondent research laboratories (LRC) associated with the CEA.

1.3.2.4 CNE, the National Assessment Board

As per the 2006 Planning Act, the National Assessment Board shall consist of the following members, appointed for a term of six years:

- 1° six qualified personalities, including at least two international experts designated in equal parts by the National Assembly and the Senate, on the proposal of the Parliamentary Office for the Evaluation of Scientific and Technological Options (OPECST),
- 2° two qualified personalities designated by the government on the proposal of the Academy of Moral and Political Sciences,
- 3° four scientific experts, including at least one international expert, designated by the government on the proposal of the Academy of Sciences.

The mandate of the members of the National Assessment Board shall be renewable for no more than one term. Half the membership shall be renewed every three years. For the initial constitution of the said Board, the mandate of six of its members, designated by draw, shall be set at three years.

The president of the National Assessment Board shall be elected by its members at each triennial renewal.

The members of the National Assessment Board shall exercise their functions in full impartiality. No member shall, whether directly or indirectly, exercise any other function within or receive fees from any assessed organisation and any company or establishment producing or holding radioactive waste.

2. LEGAL FRAMEWORK

2.1 Primary Legislation and General Regulation

Basic Nuclear Installations and organisation of their control and information

The TSN act about transparency and security in the nuclear field (13 June 2006), which:

- stipulates the main principles to be implemented with regard to nuclear activities (this includes requirements concerning conditions and procedures for final shut-down and decommissioning/dismantling of nuclear installations);
- creates the ASN, as an independent administrative authority (and defines its role as well as the role of government),
- organizes nuclear transparency,
- revises the administrative framework for nuclear facilities, clarifies and reinforces the system of controls and applicable penalties.

Decree 2007-1557 of November 2nd 2007. This decree concerns the licensing and control procedure for basic nuclear installations (INB) including nuclear waste processing plants, storage facilities and nuclear waste disposal facilities such as surface disposal facilities of short-lived low- and intermediate-level waste. It also concerns the final shutdown and decommissioning/dismantling of INBs (licensing procedures). This decree supersedes the

decree of 11 December 1963 taking into account of the provisions laid down in Act 2006-686 about transparency and security in the nuclear field (13 June 2006) and the ASN's note of 27 February 2003.

The Ministerial Order of 7 February 2012 that sets generic technical rules for operations of INBs.

Installations classified on environmental protection grounds

Code of Environment, articles L511, L512 (law 2003-699 of 30 July 2003), L513 to L516, and decrees.

Code of Public Health, article L1333-11 and R1333-13 concerning NORM (naturally occurring radioactive materials) and TENORM (technically enhanced naturally occurring radioactive materials).

Ministerial order of 25 May 2005 concerning activities handling naturally occurring radioactive materials, not used for their radioactive properties (including the list of such activities).

Installations working for National Defence

Decree 2001-592 of 5 July 2001 concerning safety and radiation protection in nuclear activities for National Defence purposes (INBS).

Waste management

Code of Environment articles L541-1 and following, concerning treatment, disposal and elimination of waste and the information of the public on environmental impact. They apply to all types of waste conventional (i.e. non-radioactive) or radioactive (excepted if other provisions are made by regulations specific to radioactive waste).

The 2006 Planning Act on the sustainable management of radioactive materials and waste (Act 2006-739 of 28 June 2006) which defines:

- the national policy for the management of radioactive materials and waste (see details in § 3.2 below),
- the organization and funding of the management of radioactive materials and waste, and
- controls and sanctions.

Ministerial Order of 7 February 2012. This Ministerial Order defines the general technical regulations for prevention and limitation of pollution and external hazards due to INB operations. It contains provisions concerning waste management (both conventional waste and radioactive waste): identification and description, by the operator, of zones producing conventional (non-radioactive) waste and zones producing radioactive waste, provisions on storage of waste, generalization of waste surveys in the form of documents submitted to ASN's approval, etc.

The ASN decision n°2008-DC-0095 published on July 23rd 2008 defines the technical rules for radioactive waste management and releases of facilities authorized under the Public Health Code regulations. It requires in particular that each establishment shall establish an internal radioactive waste management plan.

Decree of 30 May 2005 (traceability of waste).

Decommissioning

The French regulatory framework on decommissioning has been updated with the promulgation of the “TSN Act” about transparency and security in the nuclear field (“TSN” Act 2006-686 promulgated 13 June 2006) and decree 2007-1557 of November 2nd 2007, as above mentioned.

It is required that the final shut-down and decommissioning of a basic nuclear installation are subject to prior licence. The licence application comprises the provisions concerning the shut-down conditions, the decommissioning and waste management procedures, the target end-state and also the surveillance and subsequent maintenance of the installation site.

Information and participation of the public, including environmental impact assessments

Code of Environment articles L121 and R121 to R125, and decrees.

Other regulations, notably concerning the Public Debate National Commission, Public Health Code, Labour Code...

See also TSN Act 2006-686 about transparency and security in the nuclear field (13 June 2006).

Although the LSMHM underground laboratory located at Bure (Meuse district) is not an INB, a similar information scheme to the INB Local Information Commission (CLI) has been established at its licensing according to the provisions of the December 1991 Waste Act, with the creation of a Local Information and Oversight Committee (CLIS). This prescription was renewed in 2006 with some changes in the CLIS composition according to the 2006 Planning Act.

2.2 Regulations concerning specific activities or facilities

2.2.1 Radioactive waste management

There are several decrees and ministerial orders, particularly as regards:

The National Radioactive Waste Management Agency (Andra),

- Decree for entering the post-closure monitoring phase (10 January 2003) of the CSM waste disposal facility (surface repository located in the Manche district),

- Licensing of the CSA waste disposal facility (surface repository for short-lived low- and intermediate-level waste located in the Aube district) by Ministerial letter of 24 December 1991 and definitive operating license on 2 September 1999,

- Licensing of the very-low-level waste disposal facility, located also in the Aube District (Authorization order signed by the Aube Prefect on 26 June 2003, this installation being classified on environment protection grounds ICPE),

- Decree of 3 August 1999 authorising Andra to create and operate, until December 31 2006 at Bure (Meuse district), an underground laboratory in order to study the deep geological disposal of high-level and long-lived intermediate-level radioactive waste. This Decree was modified by the Decree of December 23 2006 which extended the underground laboratory operation license until December 31 2011. The licence was renewed after file application by Andra and the current administrative procedures, including a public inquiry and a consultation of the local communities involves, by a Decree issued on December 22 2011 and extending the underground laboratory operation licence until December 31 2030.

- Securing sufficient funds for radioactive waste management and decommissioning with the modified decree n°2007-243 of February 23 2007 and the Ministerial Order of March 21 2007.

- The ASN decision n° 2008-DC-0095 de of 29 January 2008, describes the rules for waste management in installations which are authorized under the Public Health Code.

2.2.2 Decommissioning/dismantling

Decommissioning/dismantling operations are covered by the decree n° 1557 of 2 November 2007. It requires that the final shutdown and the decommissioning shall be licensed by a specific decree. A public inquiry systematically takes place.

The decree n°1557 requires an update of the decommissioning plan at least three years before the date foreseen for the final shutdown including:

- the description of the preparatory activities for the final shutdown,
- the systems and components important for decommissioning,
- the elimination routes for the waste.

The decree requires an application to be filed at least one year before the date foreseen for the final shutdown. This file application must include the following documents:

- the description of the nuclear facility before shutdown,
- an updated decommissioning plan,
- an environmental impact assessment,
- a preliminary safety analysis report,
- a risk analysis,
- the operating rules,
- if appropriate, the restricted use foreseen after the dismantling operations.

After completion of the decommissioning/dismantling operations and the clean-up of the site, the operator can apply for the license termination of the facility according to a procedure described in the decree n° 2007-1557. The license termination is effective after a decision issued by ASN and approved by the ministry of safety. Prior to such a decision, in case all hazardous substances could not have been removed, the former nuclear site may be still covered by some restrictions of use, after a public inquiry.

2.3 Guidance on implementation

2.3.1 Radioactive waste management

RFS I.2 (19 June 1984): Safety objectives and design basis for surface disposal of short lived, low and intermediate level radioactive waste.

RFS III.2.a (24 September 1982): General safety measures for production, control, treatment, conditioning and storage of reprocessing waste.

RFS III.2.b (12 November 1982): Particular safety measures for production, control, treatment, conditioning and storage of high-level waste from reprocessing to be conditioned in glass matrix.

RFS III.2.c (5 April 1984): Particular safety measures for production, control, treatment, conditioning and storage of low- or intermediate-level waste from reprocessing to be conditioned in bitumen matrix.

RFS III.2.d (1 February 1985): Particular safety measures for production, control, treatment, conditioning and storage of waste from reprocessing to be conditioned in concrete matrix.

RFS III.2.e (31 October 1986 revised 29 May 1995): Conditions prior to acceptance of solid waste in surface repositories.

Guidelines for the deep geological disposal of radioactive waste (2 February 2008). It supersedes the former RFS III.2.f (10 June 1991)

Guidelines for low-level long-lived waste management: in the view of a selection of a site for a new disposal of LL-LLW, ASN has published a guidance entitled “General safety guidelines for site selection for the disposal of long-lived low-specific-activity waste” that defines the main principles and requirements for the siting, design and closure of a disposal. This guidance has been established by a working group composed by ASN, IRSN and Andra.

2.3.2 Decommissioning / dismantling

Two main periods are considered in a facility lifetime, each being subject to licensing:

- the operational period,
- the final shutdown and decommissioning/dismantling period.

The ASN guide n°6 published on 18 June 2010 on decommissioning and its associated appendix gives details on the expected content of the documents to be provided by the operator in view of the authorization (decree) for final shutdown and decommissioning/dismantling of the installation. The exhaustive list of these documents is contained in the decree n°2007-1557 (article 37) among which:

- an update of the decommissioning plan,
- the preliminary safety analysis report,
- the environmental impact assessment,
- the operating rules.

It is clearly up to the nuclear operator to present to the regulator the decommissioning schedule for the facility as the regulator does not prescribe any timetable. Nevertheless, and in agreement with the regulator recommendation, many of the current schedules so far implemented aim at a quick dismantling without waiting for long decay period, in order to take advantage of the facility knowledge by the current operating staff. A deferred dismantling schedule, of 50 years or so, may mean a safer reduced-radioactivity environment, but as drawback, the loss of the facility memory since the operating staff would not be anymore involved and the aging of the installation.

ASN regularly conduct technical visits throughout the decommissioning process. In regulatory terms, decommissioning of nuclear facilities requires several major phases:

Phases under the licensing of operation of the facility (decree of creation of the INB):

- the decision to stop the normal operation of the facility. An information by the licensee is due, including the schedule foreseen,

- the preparatory operations prior to the final shutdown leading to the end of operation according to normal operating procedures. This phase includes the removal of all the fuel, of the waste produced during the operation phase and still present on site, treatment of fluids, clean-up and evacuation of hazardous material. Some modifications may require a declaration by the operator, prior starting these operations, based on a safety case. A completion report must be submitted to the ASN at the end of this phase,

Phases under the licensing of decommissioning of the facility (decree of decommissioning of the INB):

- the phase leading to the shutdown status of the facility. This phase consists in dismantling the pieces of equipment which are no longer required for surveillance and safety. The containment is reinforced. At the end of this phase, a complete inventory of the radioactivity is conducted,

- the final shutdown which could include preparatory operations for dismantling that cannot be done under normal operating rules. This phase includes additional clean-up and elimination of pieces of equipment, using new operation rules, different from - normal operation, that allow to decrease progressively the necessary monitoring of the facility and of its surroundings,

- the decommissioning/dismantling of the facility with the objective to reach an end-state enabling license termination,

The ASN's guide n°14 published the 26 June 2010 sets recommendations for methodologies concerning complete clean-up of contaminated or activated structures (notably concrete structures) in INBs. This guide is applicable whatever the situation of the nuclear facility is, under decommissioning or under operation. The purpose is to provide recommendations on the modification of the waste zoning of the nuclear facilities, where decommissioning addresses the modification of all the nuclear zones to non nuclear zones to allow the implementation of the termination of the license process.

The operator has to define and justify clean-up objectives for the facility and site and demonstrate that the residual radiological impact of the facility/site is as low as reasonably achievable (ALARA principle) according to the best national and international practices.

License termination process:

This termination leads to change of the facility's administrative status and can lead to implementation of restrictions of use. The termination of the license follows an administrative process leading to a decision taken by the ASN on the basis of an application and a completion report sent by the operator and a thorough visit of the nuclear facility performed by the ASN in order to check that the end-state has been achieved.

3. WASTE MANAGEMENT STRATEGY AND CURRENT PRACTICE

3.1 Waste classification and quantities

The various types of radioactive waste produced in France vary considerably by their activity levels, their half-lives, their volumes and their contents (fission products, scrap metal, rubble, sludge, resins, etc.). The treatment and final disposal solution must be adapted to the type of waste involved, in order to manage it safely.

The radiological risk can be assessed on the basis of two main parameters: the activity level and the half-life. Therefore, the classification makes, on one hand, the distinction between very-short-lived waste, short-lived waste and long-lived waste, and on the other hand the distinction between very-low-, low-, intermediate- or high-level waste. The existing or expected management solutions (see 3.2) are notably based on these criteria.

Table 1. Existing or future disposal systems for the main solid waste and residues resulting from radioactive effluent treatment

Activity/period	Very-short-lived (Half-life < 100 days)	Short-lived (Half-life ≤ 31 years)	Long-lived (Half-life > 31 years)
Very-low-level	Management by <i>in situ</i> radioactive decay	CIRES waste surface disposal facility (Morvilliers in the Aube district) (*). Recycling channels (under investigation)	
Low-level		CSA waste surface disposal (Aube district)	Dedicated subsurface disposal facility designed for radium-bearing and graphite waste under study (see Planning Act 2006-739 of 28 June 2006)
Intermediate-level		Tritiated waste: under study (see Planning Act 2006-739 of 28 June 2006) Some used sealed sources	Waste management solutions under study in the framework of Planning Act 2006-739 of 28 June 2006
High-level		Waste management solutions under study in the framework of Planning Act 2006-739 of 28 June 2006	

(*) Waste residue from uranium ore processing has its own specific disposal facilities provided for in the vicinity of the production sites.

3.1.1 Very-short-lived waste:

Medical use of radioactivity for diagnosis or therapy implies the utilisation of very-short-lived radionuclides. They are managed by radioactive decay on the site it-self. The resulting waste is then considered as conventional and managed in the same way as other conventional waste.

3.1.2 Very-low-level (VLL) waste:

Today's very-low-level waste comes mainly from the dismantling of nuclear facilities or conventional industrial sites using slightly radioactive substances. The quantity involved will increase considerably when the time comes for the large scale complete dismantling of nuclear power reactors currently in operation. Radioactivity in these cases amounts to a few becquerels per gram.

3.1.3 Low-level long-lived (LL-LL) waste:

Long-lived low-level waste includes the particular category of waste containing a significant quantity of radium and producing radon. This type of waste was notably produced in the past by the rare-earth industry. Long-lived low-level waste also includes graphite waste originating from natural-uranium graphite-moderated gas-cooled reactors (UNGG) that have been since shut down. The activity of graphite waste is mainly of the beta-gamma type.

It includes as well some used sealed radioactive sources, containing small quantities of long-lived radio-nuclides.

3.1.4 Low- and intermediate-level short-lived (LIL-SL) waste:

The activity of short-lived low- and intermediate-level waste is mainly due to beta or gamma radiation emitting radio-nuclides, with a half-life of less than 30 years. Alpha particle emitters are strictly limited. This type of waste comes from nuclear reactors, fuel cycle facilities, research centres as well as university and hospital laboratories. They consist mainly of manufacturing waste, worn equipment, materials cleaning rags and protective clothing. This category also includes products from gaseous and liquid waste treatment at nuclear installations.

3.1.5 High-level (HL) waste and intermediate-level long-lived (IL-LL) waste:

These types of waste contain radio-nuclides with a long half-life, notably alpha emitters. They comprise both intermediate-level and high-level waste. The former mainly comes from spent fuel structures (cladding hulls and end caps) and maintenance operations. Within this category of waste, the alpha emitters can be found in significant quantities. The second category generally originates from fission and activation products contained in spent fuel and separated from recoverable materials by the reprocessing operations. Their activity is such that the heat release for each 150-liter container can reach 2.5 kW (at the date of fabrication). These high-activity types of waste could also include CEA (from research reactors) and EDF spent fuel which would not be reprocessed, should the case arise.

The table below presents, for each category of radioactive waste currently produced an estimation of the annual throughput and the total activity and volume foreseen in 2020. These data constitute simply an indication and can vary depending on the treatment options selected and the spent fuel management strategy adopted. However, they clearly show that the largest volumes concern very-low-level or short-lived low- and intermediate-level waste, representing only a minute fraction of the total activity. The high-level waste, representing a very small volume, comprises more than 96% of the total activity.

Further information on the state and localisation of radioactive waste on French territory, including National Defence installations, can be obtained from the National inventory of radioactive waste and recoverable material, issued in 2012.

Table 2. Annual quantities of waste produced by end 2010 and total quantity expected by 2020 and 2030 (sources: Andra National Inventory published in 2012¹⁸).

Note: These figures exclude waste from the reprocessing of foreign irradiated fuel which, in compliance with the French legislation, is to be returned to the owners.

¹⁸ The next issue of the National Inventory shall be published by mid-2015, with the status at end 2013

Waste volumes existing at the end of 2010

These volumes correspond to the waste after conditioning in 'primary packages' to be stored in readiness for transport to waste disposal facilities.

In some specific cases, such as deep disposal, for example, additional conditioning may be required before the waste can be placed into the repository.

** Waste identified as belonging to the DSF category (déchets sans filière), is that for which no management solution exists or is being studied, due in particular to its chemical and physical characteristics. The management of this waste is currently under examination.*

Category	Volume at end 2010 (m ³ equivalent conditioned)
HLW	2,700
ILW-LL	40,000
LLW-LL	87,000
LILW-SL	830,000
VLLW	360,000
DSF*	3,600
Grand total	~ 1,320,000

Waste volume forecasts for 2020 and 2030*

	For 2020	For 2030
HLW	4,000	5,300
ILW-LL	45,000	49,000
LLW-LL	89,000	133,000
LILW-SL	1,000,000	1,200,000
VLLW	762,000	1,300,000
Grand total	~ 1,900,000	~ 2,700,000

** As far as the nuclear power industry is concerned, the forecasts are based on the assumption that the operating life of the power plants will be extended to 50 years and that all spent fuel will be processed. The National Inventory takes account of the 58 current reactors and the Flamanville EPR under construction.*

3.2 Waste management strategies

For the ASN, the management strategy must cover all categories of radioactive waste. This involves setting up specific waste management systems, taking into account not only radiological risks, but also chemical, physical and sometimes biological hazards incurred by that waste.

Waste management begins with the nuclear plant design, proceeds during the operating life of the installation through concern for limitation of the volume of waste produced, of its noxiousness and of the quantity of residual radioactive materials contained. It ends with waste elimination (recycling or final disposal) via the intervening stages of identification, sorting, treatment, packaging, transport and storage. All operations associated with management of a category of waste, from production to disposal, constitute a waste management route, each of which must be adapted to the type of waste concerned.

The operations within each route are interlinked and all the routes are interdependent. These operations and routes form a system which has to be optimised in the context of an overall approach to radioactive waste management encompassing safety, traceability and volume reduction issues.

It is to be noted that long-term management solutions exist in France (repositories) for the categories of radioactive waste which represents the major volumes (but with a low

radioactive content): the low- and intermediate-level short-lived (LIL-SL) waste and the very-low-level (VLL) waste. The existing solutions are briefly described as follows:

- Very-low-level waste repository:

The CIRES very-low-level waste repository (located at Morvilliers in the Aube district) has been commissioned in August 2003. Its overall capacity is 650,000 m³. At the end of 2013, the volume of waste disposed of was about 251,761 m³ (39% of its total capacity).

Waste is disposed of in special vaults excavated in a clay formation and protected by a synthetic membrane and, in the future, by a clay capping.

This disposal facility is operated by Andra.

- Short-lived low- and intermediate-level waste repositories:

The technical solution adopted for the long-term management of this type of waste is disposal in a surface repository where adequate waste packages are placed in concrete structures.

In the past, this type of waste was disposed of at the former CSM waste disposal facility located in the Manche district, near the AREVA La Hague facility, and operated by Andra (527,000 m³). Waste reception has stopped in 1994 and this disposal facility has now entered the post-closure monitoring phase (decree of 10 January 2003).

Monitoring is under the responsibility of Andra. The technical requirements associated with the decree concern notably the monitoring of the protective cap, the maintenance of the facility and the long-term preservation of information. Short-lived low- and intermediate-level waste has been disposed of since 1992 at the CSA facility located in the Aube district and also operated by Andra. Since the beginning of its operation, this repository has disposed of about 280,171 m³ of waste (end of 2013) or about 28% of its total capacity. In 2004, the first pressure-vessel-head packages originating from nuclear power plants reactors were disposed of at this repository in specifically-designed vaults (by end 2013, 51 pressure-vessel-heads have been disposed of).

The overall capacity of the CSA waste disposal facility is 1,000,000 m³. Its lifetime was initially planned for 30 years but should be extended to about 50 years as the quantity of waste yearly received has decreased in the last years. Its definitive operating license was granted on 2 September 1999.

Concerning the reduction of waste volumes, the CENTRACO facility (run by SOCODEI, an EdF subsidiary company) has been designed to deal with short-lived low- and intermediate-level waste either thru incineration or, in case of metal scrap, thru melting. Following the accident of September 12th 2011, all activities were stopped. Incineration activities have been authorized since July 2012 by the regulator, but melting is still stopped.

- Other types of waste:

With regard to the other categories of radioactive waste, the strategy is defined in the 2006 Planning Act on the sustainable management of radioactive materials and waste (Act 2006-739 of 28 June 2006). This Act is a consequence of the Waste Act n° 91-1381 of 30 December 1991 which stipulated that, in 2006 at the latest, the government shall submit to Parliament an overall assessment of the research concerning high-level, long-lived waste, with a bill authorizing, if appropriate, the creation of a disposal facility for these categories of radioactive waste. At the same time, the 2006 Planning Act widens the field of action initially aimed at by the December 1991 Waste Act.

The 2006 Planning Act stipulates that for high-level waste and long-lived intermediate-level waste the research and studies have to be pursued according to three complementary venues (see § 3.3 for more details), which were already mentioned as R&D venues in the December 1991 Waste Act:

- partitioning and transmutation of long-lived elements, so that an assessment can be made in 2012 of the industrial prospects of reactors allowing transmutation and a prototype installation set in operation before 31 December 2020;
- reversible disposal in deep geological formations, in order that a license application can be filed in 2015, and, subject to such an authorization, the repository can be commissioned in 2025;
- storage, in order, at least in 2015, to create new storage installations or modify existing ones to meet the needs.

The 2006 Planning Act defines as well, with some milestones, the programme for the other types of radioactive waste which do not have a final solution (radium-bearing and graphite waste, tritium-containing waste, sealed sources) and for the long-term impact of the disposal sites of uranium mining waste and implementation of a strengthened radiological surveillance plan at these sites.

It stipulates that a National Plan for the management of radioactive materials and waste shall be drawn up before 31 December 2006 and, afterwards, shall be updated every three years. A third version of the National Plan was thus published in February 2013.

There are also articles concerning various topics (no disposal in France of foreign radioactive waste, rules concerning the introduction in France of spent fuel and its reprocessing, a National Assessment Board in charge with evaluating, annually, the progress of research and studies with reference to the above-mentioned National Plan).

A specific issue concerns the very large quantities of very-low-level mining and milling residues produced in the past during operation of uranium mines in France and sited nearby. This category of residues contains a very small quantity of long-lived radionuclides, notably radium. Since moving the millions of tonnes concerned is obviously ruled out, it is planned to appraise the long-term impact of the sites (considered as disposal sites) and determine actions from this appraisal if any.

3.3 Waste management issues at national level

3.3.1 Low-level long-lived (LL-LL) waste:

The management of LL-LLW (especially radium-bearing waste with some 70,000 m³ and graphite waste with some 100,000 m³) is currently the subject of studies performed by Andra. Other waste such as disused sealed sources or bituminous waste could be added to this inventory, meaning some 30,000 to 40,000 m³ more. The disposal concepts are based on shallow disposal within a low-permeability clay host-formation at a depth varying from some 15 meters excavated from surface if the formation is outcropping or down to 200 meters through an underground installation if the formation is deeper.

A call for expression of interest has been launched by mid-2008 to identify volunteering municipalities among some 3000 ones with a potentially suitable geology for shallow disposal; by the deadline of end October 2008, some 40 municipalities did show an interest.

According to the provisions of the 2006 Planning Act on the sustainable management of radioactive materials and waste and the 2008-357 Decree of April 16 2008, Andra has submitted, by end 2008 to Ministry of Ecology, Energy, Sustainable Development and the Sea, a report assessing the suitability of possible sites to host such a disposal facility which should be commissioned by 2013. Following the withdrawal of the two selected municipalities to host such a facility and the HCTSIN report on this topic, the socio-political process has been reviewed. The National Plan for radioactive waste and materials management however required Andra to submit by mid-2015 a report on the different technical solutions contemplated for managing the radium bearing waste as well as the graphite waste. Different sites were identified as potential ones. More specifically, local contacts with the group of municipalities where both CIRES and CSA (Aube department) are located, expressed an interest for this project. Preliminary geological investigations (eg boreholes) have been launched in 2013.

3.3.2 Low- and intermediate-level short-lived (LIL-SL) waste

Low- and intermediate-level short-lived waste includes certain categories which have characteristics making them unsuitable for acceptance at the CSA waste disposal facility. This comment includes tritiated waste, mainly originating from National Defence activities, and such waste are stored at the Valduc CEA facility for the time being. Tritium is a very mobile radioelement and therefore difficult to confine. It appears that this type of waste, even conditioned in specifically designed containers, cannot be disposed of at the CSA waste disposal facility. Solution to manage this type of waste is still under study. The 2006 Planning Act on the sustainable management of radioactive materials and waste requires development of a storage concept allowing a reduction of their radioactivity before any surface or shallow-depth (subsurface) disposal.

3.3.3 High-level (HL) waste and intermediate-level long-lived (IL-LL) waste

As above-mentioned (§ 3.2), the 2006 Planning Act on the sustainable management of radioactive materials and waste stipulates that the research and studies on this waste shall be pursued according to the three following complementary venues:

- Partitioning and transmutation of long-lived radioactive elements. The corresponding studies and research shall be conducted in relation with those performed on the new generations of nuclear reactors mentioned in Article 5 of the Programme Act n° 2005-781 of 13 July 2005 fixing the guidelines of the energy policy and those performed on accelerator-driven reactors devoted to waste transmutation, so that an assessment can be made in 2012 of the industrial prospects of these reactor types and a prototype installation set in operation before 31 December 2020. This specific R&D venue is entrusted to the French Alternative Energies and Atomic Energy Commission (CEA),

- Reversible disposal in deep geological formations. The corresponding studies and research shall be performed in order to choose a site and design a disposal facility (Cigeo project) so that, on the basis of the results of the studies undertaken, an application for its authorization can be filed in 2015 pursuant to Article L542-10-1 of the Environmental Code and, subject to said authorization, the facility can be set in operation in 2025. This specific venue is entrusted to Andra,

- Storage. The corresponding studies and research shall be performed in order, at the latest in 2015, to create new storage installations or modify existing ones to meet the needs, in particular in terms of capacity and lifespan. This specific venue is entrusted to Andra.

The specific “retrievability/reversibility” issue :

This issue which was not considered in the 80’s has been an important criterion in the siting process failure carried out at this period for the geological disposal of high-level and long-lived intermediate-level radioactive waste. It was then introduced by the Parliament, following the hearings carried out by MP Bataille in 1990, in the 30 December 1991 Waste Act in terms of retrievability option for the studies to be carried out.

In 1998, when the government took the political decision of authorising the creation and operation of an underground research laboratory at Bure (Meuse district), retrievability rationale was made compulsory in the R&D programme. This decision was the consequence of the various opinions voted by the local municipality and district councils during the 1997 public inquiry associated to the underground research laboratory license application filed by Andra.

The various conceptual studies and works, carried out then in France but as well abroad, have led to the “reversibility” concept, which is wider than the “retrievability” one in the sense that it allows for an operational stepwise disposal process driven by a political and safety-related decision-making process. Apart from the mere possibility of retrieving waste packages from their disposal cells (which is the definition of “retrievability”), “reversibility” provides flexibility in the repository construction and operation with the possibility of design evolution at all steps and notably includes the option of going backwards one or more steps, during the whole process of construction and operation. This reversibility concept was developed by Andra in its “Dossier 2005 Argile”.

Following the various inputs from evaluators, the public debate and still ongoing discussions with stakeholders (eg NEA Conference in December 2010), the reversibility approach may evolve and Andra is expected to present it when filing the repository licence application.

In 2013, the Cigéo licencing process can be considered as launched with the mandatory national public debate to be held before any file application and which was carried out from May 15th until December 15th. Following the boycott through perturbations by opponents during the first public meetings, such meetings were cancelled by the Organizing Commission and the debate initially planned to end by September 15th (precisely May 15th until July 31st, then a break in August and from September 1st until October 15th) was extended until mid-December. The conclusion report which was issued by the Commission in February 2014 will be an important input document for the project file application.

By beginning of May, through a unanimous decision by its Board of Administrators, Andra decided to take account of the opinions and expectations expressed during the debate and to maintain the stepwise approach initiated by the 1991 Act. The Agency has decided to continue the Cigéo project, implementing four new developments, clarifying its proposals on reversibility and making a number of commitments for the future. This was presented in a press release on May 6th 2014: http://www.andra.fr/download/andra-international-en/document/press_release/press-release-on-the-cigro-public-debate-follow-up.pdf.

This repository license application will be reviewed in all its aspects, including the

reversibility approach, by the regulator¹⁹ (ASN) and its technical support (IRSN), and the CNE.

The 2006 Planning Act on the sustainable management of radioactive materials and waste (Act 2006-739 of 28 June 2006) has notably prescribed in terms of reversibility the following:

- geological disposal shall be reversible and the reversibility period shall last at least 100-year,
- Vote by Parliament of a “Reversibility” Act before granting the repository license, in order for the Parliament to validate the reversibility approach and its decision-making process,
- Vote by Parliament of a “Closure” Act before granting the repository closure license.

3.3.4 *Other issues*

According to the 2006 Planning Act on the sustainable management of radioactive materials and waste (Act 2006-739 of 28 June 2006), further work shall be performed on:

- Processes allowing the disposal of spent sealed sources at existing or to-be-built centres,
- Short and long term management solutions for waste with enhanced natural radioactivity,
- The long term impact of the disposal sites of uranium mining waste and implementation of a strengthened radiological surveillance plan at these sites.

These studies were issued in due time by the organisations in charge of producing them according to the responsibilities described in the decrees of 16 April 2008, 23 April 2012 and 27 December 2013 with respect to the National Plan for Materials and Radioactive waste management. They were reviewed by ASN who gave its stance to the government. The ASN advice was an input for issuing the third version of the National Plan as well as the regulatory requirements related to this plan.

As well, in the framework of its mission of collecting and taking-over of radioactive waste produced by non-electronuclear activities, Andra has commissioned by end 2012 two installations near the VLL waste disposal facility at Morvilliers (Aube district), making up the CIRES facility :

- an installation for grouping, sorting, treating and conditioning of waste produced by small-scale nuclear activities (non-electronuclear), with, when relevant, shipment to installations for incineration or treatment;
- and a storage installation for radioactive waste produced by small-scale nuclear activities, when there is no available final solution.

Solutions for the *management of legacy waste* are also a challenge for several reasons:

- ASN has to make sure that temporary solutions do not become definitive as a result of lack of action. In this respect, the CEA and AREVA have started a clean-up of their installations where legacy waste is temporarily stored,

¹⁹ According to ASN guidelines concerning HL & IL-LL geological disposal, reversibility must not be achieved at the expense of safety.

- Legacy waste often needs to be characterized more precisely and conditioning processes need to be adapted to their specificity. This often needs a stepwise approach and takes a long time,

- Therefore, safety of the storage facilities has to be periodically reassessed and sometimes measures aiming at improving safety of the storage have to be considered and implemented,

- Dismantling of an old installation is often dependent on removal of legacy waste stored in it. This can lead to delay deconstruction of equipment and structures, which may be a safety issue in itself.

3.4 Research and Development

3.4.1 Research infrastructure

Concerning radioactive waste management an extensive research and development programme is conducted by Andra and the CEA on their respective venues as prescribed by the 2006 Planning Act on the sustainable management of radioactive materials and waste:

- *Andra:*

Andra's major research facility is the LSMHM Underground Research Laboratory sited at Bure in the Meuse district and aiming at studying the feasibility of the reversible geological disposal of high-level and long-lived intermediate-level radioactive waste in the Callovo-Oxfordian clay formation. This facility was licensed on August 3rd 1999 and its construction as such (access shafts, basic drift network with underground ventilation) has been achieved in 2006. Nevertheless, more drifts and niches are due to be excavated for the on-going geological survey and experimental programme or the engineering technological demonstrations. Apart from this underground research laboratory, Andra works on the technological and engineering feasibility of geological disposal and has built at Saudron in 2007, in the Haute-Marne district near the LSMHM, a Technological Exhibition Facility (ETe), in order to design and operate prototypes and demonstrators. This ETe is open to the public since mid-2008.

Andra had also created a long-term environmental research monitoring and testing system, the Ecotheque²⁰. With its main building sited in Bure, it is planned to perform monitoring & testing during at least a century and over some 900 km² around the planned Cigeo site.

After a dialogue phase with local stakeholder and the approval by the government in 2010, Andra has also focussed, within the 250 km² transposition zone identified in the Dossier 2005, on a 30 km² area (ZIRA) for more detailed investigations in order to site the underground installations of the Cigeo repository. The Cigéo Public Debate was launched and completed in 2013 to collect public opinions about the project in general, the possible sites of the various surface and underground installations and its governance, notably for the reversibility. The whole project concerning the feasibility of the reversible geological disposal of high-level and long-lived intermediate-level radioactive waste in the Callovo-Oxfordian clay formation (2nd venue of the 2006 Planning Act) means an average annual budget of €126.7 M to be compared with Andra total annual budget of €199.6M (2012 figures).

²⁰ <http://www.andra.fr/ope/index.php?lang=en>

Andra, although running the LSMHM research facility, is not *stricto sensu* an R&D organisation but rather a programme agency. As such, it does sub-contract and organise research according to a scientific policy which mainly relies on:

- Research groups, notably with the French National centre for scientific research (CNRS) on specific topics as modelling, geosciences,
- Cooperation schemes with Universities (e.g. Nancy and Troyes), R&D and waste management organisations (in France and abroad),
- Participation to the Euratom R&D Framework Programme,
- Thesis and post-doctorate support through grants.

It is worth mentioning that Andra is working as well in the field of social and human sciences, as the Cigeo project (but the other ones too) does not concern only scientific and technological matters.

- *CEA:*

CEA is implementing R&D activities in order to develop advance fuel cycle processes. The goal has been reached in 2012 with a comprehensive view of actinides separation processes, actinides loaded fuel fabrication processes, and transmutation data.

As to advanced partitioning, the strategy is to assess two different processes. On one hand to develop a process that should be considered as an add-on of the current PUREX process and on the other hand a GEN IV process R&D activity is also under way.

As to fuel fabrication, CEA activity is structured by the implementation of two projects which aim to achieve detailed design of a GEN IV core production facility and of a minor actinide loaded fuel assembly fabrication facility (2012). Both facilities would be built on the La Hague site and the schedule is decided in order to meet the GEN IV reactor prototypes schedule facility which means that they should be operable by 2017 since the targeted capacity of the core production facility is 10t/year for a 30t heavy metal core. The actinides loaded fuel capacity would be an assembly/year in the homogeneous way (6 kg minor actinides). Along with these facilities design, R&D program are under way both in Marcoule and Cadarache facilities.

- *IRSN:*

In order to develop and maintain its expertise function in the field of nuclear waste safety, the IRSN carries out studies and experiments in either its own facilities or through international cooperation and partnership.

Those works are performed by the mean of IRSN surface laboratories, *in situ* experiments in the IRSN Tournemire underground research laboratory in the south-east of France (a former railway tunnel) or in the experimental platform in Tchernobyl operated by IRSN.

Numerical computer tools are developed, sometimes in partnership, to simulate rock mechanics, geochemistry, gas transfer, groundwater movements and biosphere contamination. In complement, IRSN develops its own integrated computer code MELODIE aiming at simulating the transfer of radioactivity from the packages to the surface.

Because of the complexity and large scope of issues to be addressed, IRSN promotes a multi-disciplinary approach integrating experimentalists, modellers and experts of safety who work together on each of the topics of interest for safety. This synergy between research engineers and experts in safety assessment is a valuable tool to ensure consistency and quality

of technical assessment. Scientific partnerships with research facilities and universities is the preferred strategy of IRSN in order to be able to take benefit of high level scientific skills in different specialities and for a duration compatible with the planned time frames of the assessment process (several decades). All research activities are organised in an internal research plan annually updated and periodically reviewed by a scientific committee.

Part of IRSN research programme is integrated in the EURATOM Framework Programme related to radioactive waste management research. IRSN is involved in the 6th and 7th Framework Programmes which offer a valuable framework for achieving results and for sharing experience among countries involved in waste safety. IRSN supports also international research programmes as the Mont Terri project as well as bilateral cooperation with homologous organisations in foreign countries.

3.4.2 Content of R&D plans

3.4.2.1 Andra

As indicated in §3.4.1, the major R&D programme for Andra is the one concerning the geological disposal of high-level and long-lived intermediate-level radioactive waste (the Cigeo Project). Cigeo priorities with a annual budget of around €126.7M in 2012 are the following:

- Identifying and characterisation of a specific area (30km² ZIRA) within the so-called 250 km² transposition zone of the LSMHM, to site underground installations, for the geological repository, notably through geological surveys, boreholes and seismic campaign;
- identifying possible sites for the various surface installations;
- Pursuing the LSMHM scientific experimental programme and complete it with technological demonstrations (underground or at surface, notably at the ETe),
- Optimising the repository concepts from the proposed ones in the “Dossier 2005 Argile” and carrying out engineering studies in view of the future file application,
- Conducting a consultation and information programme for the local populations, through the introduction of social sciences in the Cigeo siting process,
- Working on long-term memory conservation (sites and waste inventory).

The storage venue, which is entrusted to Andra according to the 2006 Planning Act, does not need R&D as storage concepts have already been implemented, for instance at the AREVA La Hague facility. It must be considered as an industrial implementation, taking into account and organising future waste or spent fuel throughputs.

The other major programme, although of a quite smaller order of magnitude if compared to the above one, is the radium-bearing and graphite waste with an increasing annual budget of €2.7M for 2012 when compared to 2011 as the siting process has been restarted in 2013 with preliminary geological investigation in the Aube department.

Of course, the various surface disposal facilities do need as well R&D work in order to optimise current design or operation (CSA and CIRES operations, acceptance at the CSA of new types of waste such as recently the pressure-vessel-heads of NPP reactors or the Chooz-A steam generators at the CIRES or CSM cap overhauling). Nevertheless these budgets are not comparable to the ones concerning the 2 above projects.

3.4.2.2 CEA

Considering the “add-on” process of the current PUREX process, a comprehensive test of such a process (DIAMEX-SANEX) has already been conducted in the CEA Atalante facility (located in Marcoule) in 2005 and the current development activity focuses on simplification and consolidation of the process.

The main feature of the GEN IV process is to separate the main part of uranium in a first step followed by an “all actinides separation” process as a second step (GANEX = Global ActiNide EXtraction process). This second process is not adaptable to current PUREX facilities and is consistent with homogeneous recycling whereas DIAMEX-SANEX can meet both heterogeneous and homogeneous recycling strategies. Considering R&D, an integrated test of GANEX will be performed by the end of 2008 in the CEA Atalante facility.

In the field of nuclear fuel fabrication, the R&D plan aim to achieve detailed design of a GEN IV core production facility and of a minor actinide loaded fuel assembly fabrication facility (2012).

3.4.2.3 IRSN

To support its scientific skills in safety assessment, IRSN develops a multi-annual research programme in the fields of reactors, plants and waste safety. Regarding waste safety in particular, the IRSN research programme was initially launched to support IRSN assessment of the feasibility of reversible geological disposal in clay. Considering the elements that justify IRSN R&D programme, 4 categories of major questions are addressed: the adequacy between experimental methods and data foreseen, the knowledge of complex coupled phenomena, the identification and confidence in components performances and the ability of the components to practically meet in-situ the level of performances required. Addressing these questions requires the research programme to be developed along the following lines:

- test the adequacy of experimental methods for which feedback is not sufficient. The assessment of their validity allows addressing the consistency and degree of confidence of the data produced,
- develop basic scientific knowledge in the fields where there is a need for better understanding the complex phenomena and interactions occurring all along the life of the repository and their influence on nuclear safety, so as to preserve an independent evaluation capability in these matters,
- develop and use numerical modelling tools to support studies on complex phenomena and interactions so as to allow IRSN assessing orders of magnitudes of components performances and physico-chemical perturbations but independently than specified and estimated by implementers,
- perform specific experimental tests aiming at assessing the key parameters that may warrant the performances of the different components of the repository. Such experiments are designed in particular to simulate the behaviour of components in altered conditions and allow IRSN delivering appraisal on the specifications of construction that are to be proposed by implementers.

These studies are carried out by the mean of experiments performed either in IRSN surface laboratories, or in the Tournemire Experimental Station (TES) operated by IRSN in the south-east of France.

3.5 Financing of Radioactive Waste Management

3.5.1 Framework and responsibilities

In France, operators are responsible for financing the management of their waste and the decommissioning of their nuclear installations.

It is important that financial resources (funds) will be sufficient and available when needed, notably to ensure a satisfactory safety level of the future operations. Several actions were also launched by the European Union (Commission, Council, and Parliament) and the French administration participates in them. In January 2005, the French Court of Accounts issued a specific report entitled “the decommissioning of nuclear installations and management of radioactive waste”. This report acknowledges the progress made for several years in the field of financing but includes a number of recommendations to improve the existing situation. The annual report (2006) of the Court contains a follow-up of its 2005 specific report.

The 2006 Planning Act has precised the role of the various stakeholders and established an evaluation commission:

- An administrative authority (Ministries for Economy and Energy) is in charge of controlling every 3 years the status report of waste producers, with of long-term liabilities, the methodology and choices to manage these liabilities together with an inventory of the dedicated assets in terms of provision. Such assets must comply with liquidity and security criteria and are “ring-fenced”;
- Moreover, an extra-parliamentary Commission (CNEF) is in charge of assessing the control carried out by the Ministries and provides every 3 years to the Parliament and to the HCTSIN.

More precisely, the 2006 Planning Act on the sustainable management of radioactive materials and waste stipulates the following, in its article 20:

- operators of INBs shall assess prudently the costs of dismantling their installations and management of their spent fuel and radioactive waste,
- operators of INBs shall establish financial provisions to cover the above-mentioned costs and earmark the necessary assets for the exclusive coverage of these costs. They shall account separately for these assets which shall present a sufficient degree of security and liquidity to meet their purpose,
- except where the State wields its powers to get the operators to respect their obligations to dismantle their installations and manage their spent fuels and radioactive waste, nobody can claim to have a right over the assets, even on the basis of the Commercial Code,
- operators shall transmit every three years to the administrative authority a report describing the assessment of the costs, the methods applied for the calculation of these costs and the choices adopted with regard to the composition and management of the assets earmarked to cover the reserves. The report shall include a plan for constituting the assets. Every year operators shall transmit to the administrative authority a note updating this report and inform it without delay of any event likely to modify its content.
- if the administrative authority finds insufficiencies or adequacies, it can, after hearing the operator, the necessary measures for the operator to regularise his situation, and, if need be, the administrative authority can order, on pain of a penalty payment, the constitution of the necessary assets,

- a national financial evaluation commission (CNEF) is created to assess the funding of the costs in dismantling INBs and managing spent fuel and radioactive waste. This commission has issued a report in July 2012. It has been made available to the public²¹.

The decree of 23 February 2007 (modified by the decree of 30 December 2010) and the ministerial order of 21 March 2007 define the categories of operations (decommissioning activities and management of radioactive waste) that are covered by the provisions of the 2006 Planning Act.

The last version of the PNGMDR (2013-2015) includes a specific chapter on this financing issue and the below figure provides a synthesis of the current status at December 2011 :

En milliards d'euros, et au 31.12.2011		Charges brutes, aux conditions économiques 2011	Provisions Actualisées	Assiette des provisions à couvrir par des actifs dédiés ²¹	Valeur du portefeuille d'actifs de couverture	Taux de couverture
EDF	Démantèlement	21	11	11	-	-
	Combustibles	15	9	-		
	Déchets	25	7	7		
	TOTAL	61	27	18		
CEA	Démantèlement	9	6	6	-	-
	Combustibles	1	1	1		
	RCD*	3	2	2		
	Déchets	3	1	1		
	TOTAL	16	10	10		
AREVA et filiales	Démantèlement	8	4	4	-	-
	RCD*	2	1	1		
	Déchets	2	1	1		
	TOTAL	12	6	6		
Total Exploitants	Démantèlement	38	21	21	-	-
	Combustibles	16	10	1		
	RCD*	5	3	3		
	Déchets	30	9	9		
	TOTAL	89	43	34		

Actifs dédiés des exploitants AREVA, EDF et CEA au 31 décembre 2011²².

** RCD : reprise et conditionnement des déchets anciens*

Starting 1st January 2014, the Cigéo project already financed according the 2006 Planning Act provisions for its R&D through an additional INB tax, called Research Tax paid by waste producers, shall be also financed specifically for its design studies by the so-called “conception” fund (financed from the long-term provisions carried out by the waste producers).

A similar scheme than the previous one with two another additional INB taxes (one dedicated to the local outreach scheme and the other one to local technological diffusion), has been implemented, as prescribed by the 2006 Planning Act, to fund the economic development scheme of the local municipalities and districts concerned by the project of geological repository for high-level and long-lived intermediate-level radioactive waste, through their respective Public Interest Group (GIP).

Specific public funding has also been implemented in the framework of the 2006 Planning Act to participate, if necessary, to the collection and management of waste from the

²¹ http://www.developpement-durable.gouv.fr/IMG/pdf/1207_10_Rapport_de_la_CNEF-2.pdf

“small-scale nuclear” activities, including “household” waste (owned by private individuals) and as well to address the issue of clean-up and rehabilitation of orphan polluted sites (usually from former industries).

3.5.2 Status of financing scheme

The above schemes are being currently implemented starting in 2007.

4. DECOMMISSIONING STRATEGY AND CURRENT PRACTICE

4.1 Decommissioning strategy

The various provisions chosen for each stage in dismantling of a nuclear installation are chosen by the operator on a case by case basis, generally in the light of comparative studies. The operator is asked to justify that the strategy proposed is the best one in terms of safety, radiation protection, waste management, and final status of the installation.

As above-mentioned in § 1.1.1, immediate decommissioning is the strategy recommended by the ASN for various reasons such as loss of familiarity with the design and operation of the installation, the minimal advantage gained from radioactive decay, or the risk of equipment obsolescence.

At present all operators in charge of a current dismantling operation endeavour to apply this policy. Besides the ASN asked EDF to make a study aiming at defining the future strategy for dismantling of NPPs which are still in operation, taking account of the number of NPPs, their standardization, and dates of shutdown.

From a regulatory point of view, to avoid splitting up the dismantling projects and to improve overall consistency, the ASN asks that as of final shutdown of an installation, a file be submitted, explicitly presenting the various steps of works envisaged from final shutdown to attainment of the target end-state, and demonstrating at each step the nature and scale of the risk presented by the installation and the steps taken to control it.

The ASN considers that the current dismantling operations should be exemplary. They are an opportunity for the operators to define and implement a decommissioning strategy on the one hand (level of dismantling to be performed, schedule of operations) and a management policy for the large quantity of radioactive waste generated (in particular very low level waste), on the other. If seen through to completion, they should also be demonstrations of the technical and financial feasibility of complete dismantling.

4.2 Status of decommissioning project

The majority of decommissioning activities in France is occurring in two sectors : the civilian nuclear facilities and the deterrent nuclear facilities.

In France there are three major operators concerned with decommissioning activities: EDF, AREVA and CEA. Andra is in charge of disposal of radioactive waste, including those originating from dismantling operations (existing repositories and research/studies for new repositories).

The main installations which are at a decommissioning stage are the following:

- all UNGG reactors (Bugey 1, Chinon A1, A2, A3, Saint-Laurent-des-Eaux A1 and A2), one pressurized water reactor (Chooz A), one fast neutron reactor (Superphenix), one heavy water reactor prototype moderated with carbon dioxide cooling (EL4/Brennilis), i.e. 9 reactors all together,
- several nuclear installations of the CEA civilian research centres (ATPU, ATUe, all the facilities of Grenoble and Fontenay-aux-Roses, etc.),
- some nuclear installation of the AREVA facilities (Reprocessing plant UP2-400, SICN),
- various installations linked to the Nuclear Deterrent force: Marcoule reprocessing plant, reactors located at Marcoule, “low, intermediate, high and very high plants” at Pierrelatte.

4.3 Decommissioning issues at national level

Current issues are linked to the risks due to the dismantling operations themselves and the waste management. Those risks require a lot of attention. Indeed the rapidly changing nature of the installation is a non-negligible risk factor in that it is harder than for an operating installation to guarantee that all potential risks have been consistently and exhaustively taken into account.

The first steps lead to removal of the fuel or nuclear materials present in the installation, which already helps reduce the risk from the nuclear safety viewpoint. This is then replaced by risks linked to radiation protection of persons and conventional safety owing to operations close to residual nuclear material.

As dismantling proceeds, the risks identified during operation of the installation, primarily linked to the radioactive nature of the materials handled, are gradually replaced by risks more linked to radiation protection and conventional safety (dismantling requires that the workers go into areas they were not used to visiting during operation), risks linked to the numerous waste removal handling operations generated by dismantling and risks linked to the technologies used for dismantling and cutting the structures (often involving hot points with the concurrent risk of fire or explosion). The risks linked to the problem of the stability of partially dismantled structures must also be taken into account, along with those linked to the obsolescence of the equipment (in particular concerning the possibility of fires breaking out in ageing electrical installations).

For complex nuclear installations, dismantling work often lasts more than a decade, frequently coming after several decades of operation. There is thus a considerable risk linked to loss of familiarity with the design and operation of the installation, especially when the former operators have left the installation, and it is vital to be able to collect and record the recollections of the persons involved in these phases, all the more so as the traceability of the design and operation of old installations is frequently less than rigorous.

With each subsequent phase in dismantling, arises the question of the surveillance of the installation being at all times appropriate to its state and the risks entailed. It is often necessary to replace the in-service means of surveillance with other (radiological, fire) more appropriate means, either temporarily or more permanently. As it is hard to constantly check that surveillance is appropriate to the constantly changing state of the installation, there is a risk of failure to detect an incipient hazardous situation.

The final state of the installation on completion of its decommissioning, including the soils, must be detailed and justified in the decommissioning plan transmitted to support

the final shutdown and decommissioning application. The shutdown and decommissioning decree usually requests that a remediation strategy for soils is submitted when the state of the installation allows for an exhaustive characterisation. Similarly to the civil engineering structures, ASN recommends that total clean-up should be the prime objective in order to avoid coming back in the future and that any other strategy shall be justified.

In regard of those issues and problems, the following arrangements have been made:

. as above-mentioned (§ 2.3.2), the ASN guide n°6 on decommissioning describes the general principles and regulatory procedures concerning decommissioning/dismantling of INBs, the issue of authorizations has been clarified:

. firstly, when dismantling an installation is expected to last many years, or even several decades, the implementation of a phased approach is recommended. The main phases are defined in the decree which authorizes the shutdown and dismantling of the installation. As well as defining the main phases, the application filed by the operator for the decree explains the works which will be carried out and details those planned in the next few years (typically five years after the decree authorizing the dismantling of the installation). For the subsequent phases of works, the decree mentions the main obligations, and states that specific authorizations are needed before starting the next phases and certain works deemed as crucial: authorizations are given on the basis of detailed safety cases to be provided by the operator and accepted by the ASN after review,

. secondly, besides the “major” authorizations to proceed from one phase to the other (given by the ASN, see above), “minor” authorizations for works may be necessary during each phase. Because of the continuous evolution of the installation, adapted procedures are necessary. The regulation allows systems of internal authorizations to be put in place for minor operations. Such internal authorizations are limited to evolutions which do not impair the safety demonstration presented in the safety case. They must be scheduled (schedule transmitted to the ASN), assessed by an entity different from the operator of dismantling, and declared to the ASN. Such systems provide flexibility, give an increased sense of responsibility to the company, and give the ASN more time to deal with the most important safety issues.

The need became apparent for conservation of a trace of the past existence of a INB on a site, along with any utilisation restrictions appropriate to the condition of the site. A conventional constraint on behalf of the State can be established by the ASN, together with the local State representatives concerned, and proposed to the owner of the land. This constraint is recorded in the mortgage register to guarantee its permanence.

The risks linked to waste management (radioactive waste disposed of inappropriately in a conventional channel, etc.) are present throughout all dismantling phases. Waste management relies on the concept of zoning as explained in § 2.1 (Ministerial order of 31 December 1999 updated in 2006 replaced by Ministerial order of 7 February 2012). Dismantling produces large quantities and a wide variety of radioactive waste. However the radioactive waste produced (or expected to be produced) by existing and future dismantling activities is mainly very-low-level waste or low- and intermediate-level short-lived waste.

The nuclear waste generated by dismantling (i.e. coming from a nuclear zone) has the same disposal routes as the waste originating from INB in operation:

- the existing CIRES very-low-level waste repository,
- the existing CSA low-and intermediate-level short-lived waste repository.

For graphite waste (low-level long-lived waste) and intermediate-level long-lived waste, produced in operation or during dismantling phases, long term management solutions are under study. The ASN requires the operators to provide alternatives for the management of dismantling waste that have currently no disposal routes in order not to delay the decommissioning. For example it has been asked to EDF to provide alternatives for the management of graphite waste generated by the dismantling of the graphite cores of the gas-cooled reactors until the LL-LL waste disposal facility is available.

The need became apparent for conservation of a trace of the past existence of a INB on a site. A conventional constraint on behalf of the State can be established by the ASN, together with the local State representatives concerned, and proposed to the owner of the land. This constraint is recorded in the mortgage register to guarantee its permanence. In the case where residual pollution remains, having a significant long-term impact on the site or its environment, utilisation restrictions appropriate to the condition of the site are established through an order taken by the local State representative after a public enquiry. These acts are prerequisites before ASN makes its decision for license termination on the request of the operator.

4.4 Research and Development

4.4.1 Research Infrastructure

There is no specific research infrastructure. EDF is in a learning process with the decommissioning/dismantling operation of various reactors (UNGG plants for instance) and the same applies to CEA (Marcoule).

4.4.2 Contents of R&D plans

As indicated previously, there is no specific large-scale R&D plans apart from the current learning processes by nuclear operators.

4.5 Financing

4.4.1 Framework and responsibilities

See § 3.5.1

4.4.2 Status of financing scheme

See § 3.5.2

ACRONYMS AND ABBREVIATIONS

ANDRA: Agence Nationale pour la Gestion des Déchets Radioactifs (French National Radioactive Waste Management Agency).

AREVA: name of former COGEMA group holding, which now includes all COGEMA activities and subsidiaries (fuel cycle and reactor construction).

ASN: Autorité de Sûreté Nucléaire (French Nuclear Safety Authority).

ASND: Autorité de Sûreté Nucléaire de Défense (Nuclear safety authority for defence – reports to both French Ministry for Defence and for Ecology, Energy and Sustainable Development).

CEA: Commissariat à l'Energie Atomique et aux Energies Alternatives (French Alternative Energies and Atomic Energy Commission).

CENTRACO: waste volume reduction facility operated by SOCODEI (an EDF group company, located in south-eastern France) with INB status.

Cigeo: Centre industriel de stockage géologique (Industrial Centre for Geological Disposal). For the time being, it stands as a project of geological disposal facility to be sited in Eastern France near the LSMHM URL with a licence application to be filed by 2015 and a commissioning expected by 2025.

CIRES: Centre Industriel de Regroupement, d'Entreposage et de Stockage (Grouping, Storage and Very-low-level radioactive waste surface disposal facility). This facility, run by Andra, is located in the eastern part of the Aube district, very close to the CSA.

CLI: Commission Locale d'Information (Local Information Commission). It concerns INBs and other industrial facilities.

CLIS: Comité Local d'Information de Suivi (Local Information and Oversight Committee). It is specific to the LSMHM underground laboratory located at Bure (Meuse district).

CMHM : Meuse/Haute-Marne Centre. New entity created by Andra in 2008 and including the LSMHM URL and the ETe.

CNDP: Commission Nationale du Débat Public (Public Debate National Commission).

CNRS: Centre National de la Recherche Scientifique (French National Centre for Scientific Research).

CSA: Centre de Stockage pour les déchets de Faible et Moyenne Activité (Short-lived low- and intermediate-level radioactive waste disposal facility). This surface-disposal facility, run by Andra, is located in the eastern part of the Aube district.

DGEC: Direction Générale de l’Energie et du Climat (General Directorate for Energy and Climate).

DREAL: Direction Régionale de l’Environnement, de l’Aménagement et du Logement (Regional Directorate for Environment, Territorial Planning and Housing). Located in each region in France, they report to the Ministry for Ecology, Sustainable Development, Transport and Housing.

EDF: Electricité de France (Electricity of France).

ETe : Technological Exhibition Facility, built by Andra in Saudron (Haute-Marne district) near the URL site to display prototypes and demonstrators of disposal operations.

GEN IV: international project aiming at designing the IVth generation of nuclear reactors.

GIP: Groupement d’Intérêt Public (Public Interest Group).

INB: Basic Nuclear Installation (installations containing radioactive materials over a certain level of radioactivity). Examples: NPP, reprocessing plant, civilian CEA centre, etc.

INBS: Secret Basic Nuclear Installation (National Defence).

ICPE: Facilities Classified on Environmental Protection Grounds (quantity of radioactive materials below the threshold of an INB).

IRSN: Institut de Radioprotection et de Sûreté Nucléaire (French Institute for Radiation Protection and Nuclear Safety).

LSMHM: Laboratoire Souterrain de Recherche de Meuse/Haute-Marne (Underground research laboratory located at Bure in the Meuse district near the Haute-Marne district).

NPP: Nuclear Power Plant.

OPECST: Parliamentary Office for the Evaluation of Scientific and Technological Choices. It is composed of both senators and congress members.

PNGMDR: Plan National de Gestion des Matières et Déchets Radioactifs (French National Plan for the management of radioactive materials and waste).

PWR: Pressurised Water Reactor.

RFS: Règle Fondamentale de Sûreté (Basic Safety Rule).

UNGG (reactor): (réacteur) Uranium Naturel Gaz Graphite (Natural-uranium graphite-moderated gas-cooled reactor). The first generation of French power reactors was UNGG type and was designed by CEA. The fuel is natural uranium; it is gas-cooled and moderated with graphite. The 2nd generation of French reactors is PWR type.

URL: Underground Research Laboratory. The Andra URL is located in Bure (Meuse district, eastern France at the border of the Haute-Marne district) and its acronym in French is

LSMHM, meaning Laboratoire Souterrain de Meuse/Haute-Marne (Meuse and Haute-Marne being the two districts candidate for its siting in 1993).