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.

After their operating period, nuclear installations need to be decommissioned and dismantled in due time. Installations (NPPs, nuclear plants, research installations, etc.) have to remain at all times in a satisfactory safety condition, even 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. The articles of this 2006 Planning Act have been integrated in the Environmental Code[1].

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.

A National Plan for the management of radioactive materials and waste (PNGMDR[2]) is considered as an important tool to improve radioactive waste management. The first plan has been issued at the beginning of 2007 by the Nuclear Safety Authority (ASN[3]) and the General Directorate for Energy and Climate (DGEC[4]) and updated in 2010. It is notably based on the National Inventory of radioactive waste and recoverable materials, issued by the National Radioactive Waste Management Agency (Andra[5]).

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 Nuclear Safety Authority (ASN) fosters a return to the public sector (for uses which may or may not be restricted), subject to possible restricted use.

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 have applied or plan 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 96/29/Euratom so allows, French regulations have not adopted the notion of “clearance threshold”, i.e. the generic levels of radioactivity below which the effluents and 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 (or radioactive) waste and zones generating conventional waste. In other words, there is no release from regulatory controls of materials from zones generating nuclear waste.

Moreover, there is also no release criteria for buildings and site after decommissioning, the release of as site is stated on a case by case study contemplating scenarios and future land use.

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[2] French 2010 issue of the PNGMDR: http://www.asn.fr/index.php/S-informer/Dossiers/La-gestion-des-dechets-radioactifs/Le-cadre-reglementaire/Le-Plan-national-de-gestion-des-matieres-et-des-dechets-radioactifs-PNGMDR
[3] http://www.asn.fr/sections/the-french-nuclear-safety-authority
[4] http://www.developpement-durable.gouv.fr/energie/sommaire.htm
[5] http://www.andra.fr

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, 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 ministries for Ecology[6] and Energy[7].

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 and eight decentralized divisions.

Whenever it deems it necessary, ASN calls upon its technical support organisations, primarily the IRSN, for advice as well as. 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 environmental protection grounds (ICPE). They are controlled at the local level by a regional directorate (DREAL).

[6] http://www.developpement-durable.gouv.fr
[7] http://www.industrie.gouv.fr

- or when the quantity of radioactivity dealt with is lower that 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 *Délégué à la sûreté nucléaire et à la radioprotection pour les activités et installations concernant la défense* (DSND).

Disposal of mining and milling residues[8] is classified on environmental protection grounds. An inventory of these sites has been performed by the IRSN (MIMAUSA database[9]).

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

1.1.2.3 Andra, the National Radioactive Waste Management Agency

A specific public agency, Andra[10], 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 France[11] (this inventory includes the so-called “committed” or forecast waste) on a three-year basis.

1.1.2.4 CEA, the Atomic Energy Commission

The CEA[12] 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 2 venues 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).

1.1.2.5 CNE, the National Assessment Board

In addition of an already existing regulator (ASN, see above), the December 1991 Waste Act has prescribed the creation of an expert assessment committee, the CNE (National

[8] These residues are not considered as ultimate waste according to the French regulatory framework.
[9] http://www.irsn.fr/FR/base_de_connaissances/Environnement/surveillance-environnement/sites-miniers-uranium/Pages/4-bdd.aspx
[10] http://www.andra.fr
[11] http://www.andra.fr/index.php?id=edition_1_5_2&recherche_thematique=all&global_id_item=387
[12] http://www.cea.fr

Assessment Board), to evaluate and review the various programmes carried out for the management of high-level and long-lived intermediate-level radioactive waste.

Although the CNE is not to be considered formally as a regulator as it cannot grant any license nor as an implementer, its role since its inception has been essential[13] 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 CNE2[14], 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 (OPECTS[15]), before being made public.

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

IRSN[16] (*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).

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

This independent committee[17] 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 MPs, 6 representatives in the following categories: local information commissions, environmental societies, trade unions, Authorities

[13] 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 of the 1991 Waste Act.
[14] to distinguish it from the former CNE established by the December 1991 Waste Act.
[15] http://www.assemblee-nationale.fr/commissions/opecst-index.asp.
[16] http://www.irsn.fr
[17] http://www.hctisn.fr

(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 issue 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 dismantling, 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 new 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 new ASN. The new 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. The new 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 the government technically.

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) .

Up to now INB licensing was granted within the framework of the decree of 11 December 1963 which provides for an authorisation decree procedure followed by a series of licenses issued at key points in plant lifetime: provisional license for start-up of normal operation (commissioning license), final license after several years of operation, decommissioning licenses.

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). Consultations of the different ministries concerned are set up.

The decree of 2 November 2007 in application of the “transparency and security in the nuclear field” Act (TSN Act) has been promulgated. It updates, and thus replaces, the above-mentioned decree of 11 December 1963. The decree of 2 November 2007 establishes the documents which are needed in the license application. For instance, the decree requires a decommissioning plan since the inception of the project.

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: INBs, pressure vessel control, industrial activities and transport, R&D installations and waste, radiation protection and health, environment and emergency situations, international affairs, 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 2010, was 451 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 1 786 persons and is an independent public agency with a budget of € 301M (figures by end 2009).

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 CSFMA (Centre de stockage des déchets de faible et moyenne activité) 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 Ecology, 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 (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.

Studies are conducted with those concerning the new generations of nuclear reactors in order to provide by 2012 an assessment of the industrial prospects of these system.

1.3.2 Organisation and resources

1.3.2.1 Andra, the National radioactive waste management agency

By the end of 2010, Andra staff was 500 employees spread on different sites (excluding students carrying a thesis granted by Andra). It total budget for 2010 was €165M.

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 Cigeo[18] 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 affair 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 CSFMA surface repository dealing with low- and intermediate-level short-lived radioactive waste and the near-by CSTFA surface repository dealing with very-low-level radioactive waste, both operating in the Aube district,
- 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:

[18] Cigeo stands for Industrial Centre for geological disposal

- 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 (Atomic Energy Commission)

The CEA, the French 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 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.

In 2009, the total CEA workforce consisted of 15,718 employees and its budget was €3,900M. The civilian programs of the CEA received about 50 % of their funding from the French government, and 40 % from external sources (partner companies and the European Union). The remaining 10 % was provided from a fund dedicated to the decommissioning/dismantling and clean-up of civilian nuclear plants. The military programs are mainly funded directly by the French Ministry for Defense.

There are 65 joint research units (UMR) linking the CEA and its research partners and 65 correspondent research laboratories (LRC) associated with the CEA.

1.3.2.4 CNE, the National Review Board

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

1º 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,

2º two qualified personalities designated by the government on the proposal of the Academy of Moral and Political Sciences, 3º 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 Review Board shall be renewable for no more than one term. Half the membership of the National Review Board shall be renewed every three years. For the initial constitution of the said Review Board, the mandate of six of its members, designated by draw, shall be set at three years.

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

The members of the National Review 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

Act 2006-686 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 definition, the licensing and control of 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.

Ministerial Order of 10 August 1984. This Ministerial Order defines the principles and rules to which each INB operator must comply in order to assure quality of design, construction, and operation of INBs. This Ministerial Order is under revision and ASN has issued a New Order for consultation in 2010. Consultation is now closed and ASN is proceeding in an update of the initial version to be finalized in 2011.

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 related to the Act 75-633 of 15 July 1975, modified in 1992, 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 31 December 1999. 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, generalization of waste surveys in the form of documents submitted to ASN's approval, etc. This Ministerial Order, already updated in 2006, is under revision together with the one of 10 August 1984.

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 authorisation. The authorisation application comprises the provisions concerning the shut-down conditions, the decommissioning and waste management procedures, and also concerning 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 CSFMA 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.

- Securing sufficient funds for radioactive waste management and decommissioning with the decree n°2010-1673 of 29 December 2010 modifying decree n°2007-243 of 23 February 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 takes place now systematically if the licensee has submitted its application after the 3 November 2007.

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 that a safety case must be sent with the application for decree at least one year before the date foreseen for the final shutdown. This safety case 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 (public inquiry),
- the operating rules,
- the restricted use foreseen after the dismantling operations.

After completion of the decommissioning/dismantling operations and the clean-up of the site, 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

The ASN guide n°6 published the 18 June 2010 on decommissioning and its associated appendix gives the lists the documents to be provided by the operator in view of the authorization for final shutdown and decommissioning/dismantling of its installation (decree).

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

- the operational period,

- the final shutdown and decommissioning/dismantling period.

The guide n°6 defines the structure and content of the main documents to be provided by the licensee:

the decommissioning plan including the provisions dealing with the creation of any new nuclear facility,

the periodic safety review,

the preliminary safety analysis report,

the environmental impact assessment,

the operating rules,

the waste survey.

The ASN’s note SD3-EDF-01 of February 2004 describes procedures relative to authorizations during the dismantling operations of NPP installations (EDF) and the corresponding documentation.

The ASN’s decision n°2010-DC-0178 of 16 March 2010 sets requirements concerning internal authorization procedures inside CEA organization.

It is clearly up to the nuclear operator to present to the regulator its dismantling plan for the concerned decommissioned facility as the regulator does not prescribe any timetable. Nevertheless, and in agreement with the regulator recommendation, the current plans 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, would obviously mean a safer reduced-radioactivity environment, but as drawback, the loss of the facility memory since the operating staff would not be anymore involved.

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 a projected schedule,

- 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, removal of the waste produced during the operation phase and still present on site, treatment of fluids, clean-up and evacuation of hazardous material. The operator must inform the ASN, prior starting these operations, and submit a safety case. The ASN formally acknowledges the end of this phase on the basis of a completion report and after a thorough visit,

- Phases under a new authorization decree (decree for final shutdown and decommissioning):

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,

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.

The ASN's guide n°14 published the 26 June 2010 sets recommendations for methodologies of 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.

It is recommended that the operator defines and justifies clean-up objectives for the facility and site and demonstrates that the residual radiological impact of the facitly/site is acceptable according to the best national and international practices.

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

<table>
<tr><th>Activity/period</th><th>Very-short-lived
(Half-life < 100 days)</th><th>Short-lived
(Half-life ≤ 31 years)</th><th>Long-lived
(Half-life > 31 years)</th></tr>
<tr><td>Very-low-level</td><td rowspan="4">Management by in situ radioactive decay</td><td colspan="2">CSTFA waste disposal facility (Morvilliers in the Aube district) (*). Recycling channels (under investigation)</td></tr>
<tr><td>Low-level</td><td rowspan="2">Surface disposal at the CSFMA waste disposal facility (Aube district)

Tritiated waste: under study (see Planning Act 2006-739 of 28 June 2006)</td><td>Dedicated subsurface disposal facility designed for radium-bearing and graphite waste under study (see Planning Act 2006-739 of 28 June 2006)</td></tr>
<tr><td>Intermediate-level</td><td>Waste management solutions under study in the framework of Planning Act 2006-739 of 28 June 2006</td></tr>
<tr><td>High-level</td><td colspan="2">Waste management solutions under study in the framework of Planning Act 2006-739 of 28 June 2006</td></tr>
</table>

(*) 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:

Very large quantities of very-low-level waste were produced in the past during operation of the French uranium mines. This category of waste 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.

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 fuel, irradiated in 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 2009.

Table 2. **Annual quantities of waste produced by end 2007 and total quantity expected by 2020 and 2030 (sources: Andra National Inventory published in 2009).**

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 after a storage period.

Volumes of radioactive waste, in storage or disposal facilities, at the end of 2007, in equivalent conditioned m^3:

	Volumes (m^3)
VLLW	231,688 (of which 89,331 is in repositories)
LILW-SL	792,695 (of which 735,278 is in repositories)
LLW-LL	82,536
ILW-LL	41,757
HLW	2,293 (of which 74 is spent fuel)
Management solution to be defined*	1,564
Total	1,152,533 (of which 824,609 m^3 is in repositories)

Forecast quantities of stocks of radioactive waste by the end of 2020 and 2030 including all sectors of activity:

	2020 Volumes: in disposal or storage facilities	2030 Volumes: in disposal or storage facilities
VLLW	629,217	869,311
LILW-SL	1,009,675	1,174,193
LLW-LL	114,592	151,876
ILW-LL	46,979	51,009
HLW	3,679 of which 74 is spent fuel	5,060 of which 74 is spent fuel
Total	1,804,142	2,251,449

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 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 CSTFA very-low-level waste repository (located at Morvilliers in the Aube district) has been commissioned in August 2003. Its overall capacity is 650,000 m^3. At the end of 2009, the volume of waste disposed of was about 142,900 m^3.

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 cover.

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 m^3). 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 CSFMA facility located in the Aube district and also operated by Andra. Since the beginning of its operation, this repository has disposed of about 231,046 m^3 of waste (end of 2009). In 2004, the first pressure-vessel-head packages originating from nuclear power plants reactors were disposed of at this repository in specifically-designed vaults.

The overall capacity of the CSFMA waste disposal facility is 1,000,000 m^3. Its lifetime was 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.

In 1995, ASN defined, in the basic safety rule RFS III.2.e, revised requirements for radioactive waste package acceptance for disposal in a surface repository. The respective responsibilities of Andra and the waste producers are stated in the rule. ASN carries out inspections to check that the acceptance procedures comply with the requirements of RFS III.2.e and are correctly implemented. RFS III.2.E is under revision and will be replaced by an ASN decision.

Concerning the reduction of waste volumes, the CENTRACO facility receives short-lived low- and intermediate-level waste either for incineration or, in case of metal scrap, for melting.

- *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 second version of the National Plan was thus issued end of 2009.

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 Review Board in charge with evaluating, annually, the progress of research and studies with reference to the above-mentioned National Plan).

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 m^3 and graphite waste with some 100,000 m^3) 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 m^3 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 (radium-bearing waste) or down to 200 meters through an underground installation if the formation is deeper (graphite waste).

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 (This is part of the National Plan for the management of radioactive materials and waste). On the basis of this Andra report and its review and opinion provided by respectively the regulator (ASN) and the CNE, the final selection with 2 municipalities was approved in June 2009. But this agenda is now delayed as, by July-August 2009, the 2 selected municipalities decided to withdraw. In the meantime, waste remains in the existing storage facilities and a new siting process will be necessary.

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

Regarding the CSM waste disposal facility (located in the Manche district near the AREVA La Hague reprocessing facility), now in the post-closure monitoring phase, ASN asked Andra to begin to look at the future of its cap. This should be the subject of a report into the benefits to be gained from installing a new and more durable cap, to be submitted no longer than 2009. Is must be reminded that the inventory of this disposal facility, which was operated without the nowadays quality assurance procedures, is not so-well known and that it includes some long-lived radio-elements, which means an at least 500-year monitoring period longer than the 300-year institutional period (conclusion of the so-called Turpin commission report issued July 1996 – report available in French on Andra website at http://www.andra.fr/andra-manche/pages/fr/menu7/le-centre-de-stockage/un-centre-qui-ne-recoit-plus-de-dechets-depuis-1994-1070.html)

Low- and intermediate-level short-lived waste includes certain categories which have characteristics making them unsuitable for acceptance at the CSFMA waste disposal facility (located in the Aube district). 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 CSFMA 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 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 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 (by 2015).

Similarly to the Dossier 2005, this repository license application will be reviewed in all its aspects, including the reversibility approach, by the regulator[19] (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:

- A reversibility period of at least 100-year long,

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

- 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):

- Processes allowing the disposal of spent sealed sources at existing or to-be-built centres shall be finalized by 2008,

- Short and long term management solutions for waste with enhanced natural radioactivity, proposing new solutions, if applicable, shall be appraised in 2009,

- The long term impact of the disposal sites of uranium mining waste and implementation of a strengthened radiological surveillance plan at these sites shall be appraised in 2008.

These studies were issued in due time by the organisations in charge of producing them according to the responsibilities described in the decree of 16 April 2008 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 second version of the National Plan as well as the regulatory requirements related to this plan.

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,

- 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 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 build 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.

After a dialogue phase with local stakeholder and the approval by the government in 2010, Andra has also focussed, within the 250 km^2 transposition zone identified in the Dossier 2005, on a 30 km^2 area (ZIRA) for more detailed investigations in order to site the underground installations of the Cigeo repository. A similar process, within the future public debate, should as well precise the sites of the various surface installations.

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 €90 M to be compared with Andra total annual budget of roughly €160M.

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 is to reach the 2012 milestone 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*:

To support its scientific appraisal 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 €75M in 2009 are the following:

- Identifying a specific area (30km^2 ZIRA) within the so-called 250 km^2 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”,

- 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 annual budget of the order of less than €2M for 2011. The siting process has been stopped in 2009 as the 2 selected municipalities withdraw.

Of course, the various surface disposal facilities do need as well R&D work in order to optimise current design or operation (CSFMA and CSTFA operations, acceptance at the CSFMA of new types of waste such recently the pressure-vessel-heads of NPP reactors, 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 appraisal of nuclear safety, 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 reports were published in France in 2005 on this subject. 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.

A working group was set up by the Ministry of Industry to review the cost of a geological disposal. This working group determined a range of costs, depending on various hypotheses, in the first semester of 2005.

The total amount of future expenses (liabilities) for decommissioning and radioactive waste management, for the three major nuclear operators (EDF, AREVA, CEA), has been estimated by them at about 65 billions Euros (2004 value, i.e. undiscounted) corresponding to a discounted value of about 37 billions Euros (3% discounted rate).

Each nuclear operator (EDF, AREVA, CEA) manages its fund which stays inside the company. However, the situation differs from one company to the other. AREVA has already earmarked assets corresponding to the total anticipated expenses estimated by this operator. Answering a remark of French Court of Accounts, EDF decided in September 2005 to accelerate the rythm of assets collection in the next years in order to reach, in 2010, the necessary level of provisions estimated by EDF. CEA manages two funds (one for its civilian centres and the other for centres linked to the deterrent force) which will need to be developed in the future.

The ASN pointed out the following principles in its annual report published in early 2006:

- identification of all liabilities which are relevant, regarding the necessary financial provisions,
- the bases for liabilities estimate (scenarios, hypotheses, methods including uncertainties, international comparisons…),
- discounted rate(s),
- nature of the funds, identification (earmarking), mechanism securing the funds (wise management of the funds, use for what the funds have been created, protection against creditors…),
- pace of assets collection,
- future withdrawals of sums to cover expenses,
- information / transparency.

At the time the ASN stated that a framework (law, decrees, guidelines) is necessary and a supervision system should be put in place.

Finally 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. The first reports were issued mid 2007. The second reports were issued mid 2010 and are currently being reviewed by the administrative authority (DGEC). ASN gave a stance, beginning of 2011 to DGEC on the technical part of this report.

- 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 is created to assess the funding of the costs in dismantling INBs and managing spent fuel and radioactive waste. This commission will issue a report which will be made available to the public.

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 authority in charge of the compliance of the Article 20 of this Planning Act is the General Directorate for Energy and Climate (DGEC). The new regulation requires an assessment by ASN of the reports on the cost of the future decommissioning/dismantling operations and the management of radioactive waste. This regulation requires also that the assets of the licensees to cover the future costs must be selected in a panel of particular secure financial products with a sufficient degree of liquidity. The prescriptions of the 2006 Planning Act concerning these matters are notably based on the previous recommendations of the ASN.

Apart from this scheme which concerns only long-term liability of waste producers both in terms of dismantling and waste management cost, the necessary R&D (notably Andra Cigeo project) is financed through an additional INB tax, which is transferred to a fund, as prescribed by the 2006 Planning Act.

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 “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 sited (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

As above-mentioned in § 1.1.1, the dismantling scenario (immediate or deferred) is selected by the operator on a case by case basis, generally in the light of comparative studies.

Similarly, the various provisions chosen for each stage in dismantling of a nuclear installation are chosen by the operator. 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.

Although the regulations do not stipulate dismantling as soon as reasonably feasible, the ASN is in favour of immediate dismantling 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 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 attained, 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 A1D, A2D, A3D, Saint-Laurent-des-Eaux A1 and A2), one pressurized water reactor (Chooz AD), 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 (SICN, Reprocessing plant UP2-400),
- various installations linked to the Nuclear Deterrent force: Marcoule reprocessing plant, reactors located at Marcoule, “low, intermediate, high and very high plants” at Pierrelatte.

In the past, the generic strategy chosen by EDF was that deferred decommissioning strategy (known as immediate level 2 decommissioning according to former international standards) of its stopped power reactors, the complete dismantling (referred to as level 3) being envisaged after several decades of containment (safe-store period).

After an initial evaluation submitted to the ASN in November 1999, EDF decided to revise its strategy for the EL4/Brennilis reactor, by undertaking to finish dismantling of the reactor rapidly, after completion of the partial dismantling currently in progress.

In January 2001, EDF chose to adopt a new immediate decommissioning strategy for all its nuclear facilities which have been finally shut down (Brennilis, Bugey 1, Saint-Laurent A, Chinon A, Chooz A and Superphénix). This new strategy provides for complete dismantling of the 9 reactors by the year 2036. In March 2004, the relevant Advisory Committee examined the strategy and concluded that there was no technical hindrance to the implementation of this programme.

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 and the numerous waste removal handling operations generated by dismantling.

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) or 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 leave 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.

Once the final installation state is reached, there is still the risk of pollution being inadequately or not at all identified or poorly characterised, having a significant long-term impact on the site or its environment. From an administrative point of view, it seems necessary, in most cases, that there be a means of preserving the memory of the past existence of a basic nuclear installation on a site, along with any utilisation restrictions corresponding to the condition of the site.

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 safety case submitted by the operator for the decree details the works which will be carried out in the next few years (typically five years after the decree authorizing the dismantling of the installation). Therefore the decree is detailed with regard to this period. 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 authorizations to proceed from one phase to the other (given by the ASN, see above), authorizations for works are necessary during each phase. Because of the continuous evolution of the installation, adapted procedures are necessary. For example, the ASN's note SD3-EDF-01 (2004) defines the types of authorizations which can be given by EDF and the corresponding practical details. Indeed the ASN authorized EDF to put in place a system of internal authorizations for dismantling operations of its installations. 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. EDF has to maintain the set of safety analysis and documents updated and the ASN conducts inspections *a posteriori*. This system is currently under revision. This system of internal authorizations improves the process: it provides flexibility, gives an increased sense of responsibility to the company, and gives 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 explains in § 2.1 (Ministerial order of 31 December 1999 updated in 2006). 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 CSTFA very-low-level waste repository,
- the existing CSFMA 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.

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).

CEA: Commissariat à l'Energie Atomique (French Atomic Energy Commission).

CENTRACO: waste volume reduction facility operated by SOCODEI (a common subsidiary of EDF and AREVA, 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.

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).

CSFMA: 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 is located in the eastern part of the Aube district.

CSTFA: Centre de Stockage pour les déchets de Trés Faible Activité (Very-low-level radioactive waste disposal facility). This surface-disposal facility is located in the eastern part of the Aube district, very close to the CSFMA.

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

DGSNR: Direction Général de la Sûreté Nucléaire et de la Radioprotection (General Directorate for Nuclear Safety and Radiation Protection – ASN centralized structure).

DSND: Délégué à la Sûreté Nucléaire et à la Radioprotection pour les activités et installations intéressant la Défense (Delegate for Nuclear Safety and Radiation Protection for National Defence Installations and Activities – reports to both French Ministry for Defence and for Ecology, Energy, Sustainable Development and the Sea).

DREAL: Direction Régionale de l'Environnement, de l'Aménagement et du Logement (Regional Directorate for Environnent, 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 IV^{th} 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 2^{nd} 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).