Kingdom of Belgium

National Programme for the Management of Spent Fuel and Radioactive Waste

Document drafted by the National Programme Committee pursuant to the Law of 3 June 2014 transposing European Directive 2011/70/Euratom of 19 July 2011

Courtesy translation

First edition, October 2015

The National Programme for the Management of Spent Fuel and Radioactive Waste was drafted by the National Programme Committee created by Article 6 of the Law of 3 June 2014 amending Article 179 of the Law of 8 August 1980 on the budgetary proposals for 1979–1980 for the purposes of transposing Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste (hereafter the "Law of 3 June 2014") into domestic law. In accordance with the law, this committee is comprised of representatives from the Federal Public Service responsible for Energy, the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) and Synatom, the company which is responsible for the fuel cycle for Belgian nuclear power plants, with the exception of activities assigned to ONDRAF/NIRAS, and is the owner of this fuel.

Courtesy translation: This text is a courtesy translation. Unlike the French and Dutch versions of the Belgian national programme, the English version of the national programme is not an official document of the Kingdom of Belgium.

Contact: ONDRAF/NIRAS, Secretariat of the National Programme Committee, Avenue des Arts 14, 1210 Brussels, Belgium

Publisher: Alberto Fernandez Fernandez, FPS Economy, S.M.E.s, Self-employed and Energy, Directorate General for Energy, Nuclear Energy Division, North Gate III, Boulevard du Roi Albert II 16, 1000 Brussels, Belgium

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Preamble

The National Programme Committee has decided to limit the first edition of the national programme to a description of the existing situation at 31 December 2014 in terms of national policies for the management of spent fuel and radioactive waste, the implementation of these policies and the national framework for this implementation, without new normative content.

The policies have been defined in accordance with the legal and regulatory provisions, particularly in terms of environment and public information, in effect at the time when they were introduced.

Institutional route of the national programme

In accordance with Article 6 of the Law of 3 June 2014, a draft version of the first edition of the national programme, dated 10 April 2015, was submitted on 5 May 2015 by the Directorate General for Energy of the Federal Public Service responsible for Energy, duly mandated by the ministers responsible for the Economy and Energy, to the competent regulatory authority, namely the Federal Agency for Nuclear Control (FANC), for its opinion. The National Programme Committee took note of FANC's opinion dated 7 May 2015 [FANC, 2015], drafted a response to this opinion in its session of 13 May 2015 [National Programme Committee, 2015] and adapted the national programme accordingly on that same day.

The new draft of the first edition of the national programme, dated June 2015,

- was submitted on 20 August 2015 by the Directorate General for Energy of the Federal Public Service responsible for Energy, at the request of the ministers responsible for the Economy and Energy, to the Belgian SEA Advisory Committee for its opinion as to the necessity to submit the first edition of the programme to a strategic environmental assessment (SEA) pursuant to Article 6, § 3, 2°, of the law of 13 February 2006 on the assessment of the effects of certain plans and programmes on the environment and on public participation in respect of the drawing up of certain plans and programmes relating to the environment. The SEA Advisory Committee acknowledged receipt of the request on 28 August 2015. In its opinion dated 11 September 2015 and transmitted on 24 September 2015, it confirmed that the first edition of the national programme does not have to be subjected to such an assessment: *"The current draft National Programme for the Management of Spent Fuel and Radioactive Waste must not be subjected to a strategic environmental impact assessment."* [translation] [SEA Advisory Committee, 2015];
- was notified by electronic mail to the European Commission on 21 August 2015 and was notified officially by the Kingdom of Belgium to the European Commission on 3 September 2015 [Kingdom of Belgium, 2015].

The first edition of the national programme was finalised after reception of the SEA Advisory Committee's opinion: it was left unchanged with respect to the June version, except for the addition of the present text relating to the institutional route of the programme and the addition of two references in the list of bibliographical references. Finally, its date – June 2015 – was changed to October 2015.

FANC's opinion on the draft version of the national programme dated 10 April 2015, the National Programme Committee's response to this opinion and the opinion of the SEA Advisory Committee as to whether or not the first edition of the national programme had to be subjected to a strategic environmental assessment can be found on www.cpnpc.be.

Part 1 Context and scope of the national programme

This first part introduces the national programme and establishes a set of contextual elements that are useful in understanding it.

- Chapter 1 sets out the objectives and scope of the national programme, considering the context in which it is drafted, specifies the approach and lists the existing national policies.
- Chapter 2 establishes the correlation between the subjects to be included in the national programme and its structure.
- Chapter 3 gives a brief overview of spent fuel and radioactive waste generation in Belgium.
- Chapter 4 introduces key elements of the national framework: the main actors in the management of spent fuel and radioactive waste and the main components of the federal legal and regulatory framework applicable to this management.

Throughout the document, the national programme adopts the following conventions:

- in accordance with Directive 2011/70/Euratom and the Law of 3 June 2014, the designation "spent fuel" [1] means nuclear fuel that has been permanently removed from a commercial or research reactor core, and which may either be considered as a usable resource that can be reused or reprocessed or be destined for disposal if regarded as radioactive waste;
- the designation "radioactive waste" encompasses non-reprocessed spent fuel considered as waste;
- the designation "owners of spent fuel" means the holders of the rights referred to in Article 87 of the Euratom Treaty;
- the translations of titles of official sources such as laws, royal decrees or resolutions as well as the translations of the quoted extracts are non-certified translations. Only the original texts in French and/or Dutch are authentic.

1 The national programme in a few words, including opening comments

The National Programme for the Management of Spent Fuel and Radioactive Waste (hereafter the "national programme") is the national programme referred to in Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste [EU, 2011]. This directive requires Member States to implement a national programme for the management of their spent fuel and radioactive waste, from generation to disposal, to inform the European Commission of this programme for the first time by 23 August

[1] Spent fuel is often called "irradiated or used fuel" in other contexts.

2015 and to notify it of any subsequent significant changes. It was transposed into Belgian law by the Law of 3 June 2014 amending Article 179 of the Law of 8 August 1980 on the budgetary proposals for 1979–1980 for the purposes of transposing Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste (hereafter the "Law of 3 June 2014") into domestic law [Belgian Official Journal, 2014c].

The national programme was drafted by the National Programme Committee created by Article 6 of the Law of 3 June 2014. In accordance with the law, this committee is comprised of representatives from the Federal Public Service responsible for Energy, which chairs the committee, the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) and the limited company Synatom *(Société belge des combustibles nucléaires)*, which is responsible for the fuel cycle for Belgian nuclear power plants, with the exception of activities assigned to ONDRAF/NIRAS, and is the owner of this fuel.

The National Programme Committee has decided to limit the first edition of the national programme to a description of the existing situation in terms of national policies, the implementation of these policies and the national framework for this implementation, without new normative content.

The national programme broadly describes the state of affairs at 31 December 2014 in terms of the management of spent fuel and radioactive waste and, wherever possible, refers to published documents for details. The reader may find it particularly useful to refer to the documents listed in inset 1. The figures (costs, waste volumes, etc.), however, are those which appear in published documents and therefore relate to earlier dates most of the time.

In practice, the national programme's structure is pragmatically based on the guidelines established by the NAPRO working group of the European Nuclear Energy Forum [ENEF, 2013] of the European Commission and, in particular, adopts an approach based on waste management routes, where the management routes are defined according to the final (planned or anticipated) destination of the waste. More specifically, the following main types of waste are considered [ONDRAF/NIRAS 2015]:

- very short-lived radioactive waste that can be cleared after decay;
- radioactive waste that after treatment and conditioning ends up in the category of:
  - short-lived, low-level and medium-level conditioned waste, also called category A waste (It corresponds to low-level waste in the IAEA 2009 classification [IAEA, 2009].); ONDRAF/NIRAS considers short-lived, very low-level waste that cannot be cleared to be category A waste;
  - long-lived, low-level and medium-level conditioned waste, also called category B waste (It corresponds to medium-level waste in the IAEA 2009 classification.);
  - high-level conditioned waste, also called category C waste, which includes non-reprocessed spent fuel from commercial nuclear power plants and from certain research reactors that would be declared as waste and vitrified waste from the reprocessing of spent fuel from commercial nuclear power plants (It corresponds to high-level waste in the IAEA 2009 classification.);
- radium-bearing waste that has radioactive waste status;
- radium-bearing waste likely to take on radioactive waste status, also called "potential" radium-bearing radioactive waste;
- NORM (naturally occurring radioactive materials) waste, i.e. waste from traditional industries using raw materials containing naturally occurring radioactive substances, without the radioactive

character being a desired property of these substances and which is likely to take on radioactive waste status, in which case it is called "potential" NORM radioactive waste.

At 31 December 2014, there were national policies for

- the management of very short-lived radioactive waste, namely *management by decay and subsequent clearance* [2] (section 6.2);
- the short-term and medium-term management of radioactive waste which, after treatment and conditioning, becomes category A, B or C waste, namely *centralised management at Mol–Dessel* (section 7.2.3);
- the long-term management of category A waste, namely *surface disposal on the territory of the municipality of Dessel* (section 7.4.1);
- the management of spent fuel from commercial nuclear power plants, namely the *safe storage of spent fuel followed by its reprocessing or disposal* (section 5.1);
- the management of spent fuel from the BR2 research reactor of the Belgian Nuclear Research Centre (SCK•CEN), namely *reprocessing* (section 5.2);
- the management of spent fuel from SCK•CEN's BR3 research reactor, namely the *safe storage of spent fuel* (section 5.2);
- the management of spent fuel from Ghent University's Thétis research reactor, namely its *declaration as radioactive waste* to ONDRAF/NIRAS (section 5.2).

These policies have been defined in accordance with the legal and regulatory provisions, particularly in terms of environment and public information, in effect at the time that they were introduced.

Pursuant to the provisions of Directive 2011/70/Euratom and the Law of 3 June 2014, the national programme does not cover the management of enriched fissile materials and plutonium-bearing materials which are not nuclear fuel and which have not been declared as radioactive waste. It does not specifically address the management of potential radioactive waste streams generated by radiological incidents or accidents, because these are managed on a case-by-case basis and, by definition, cannot be anticipated in a programme.

[2] Cleared waste: waste that is not subject to FANC's regulatory controls anymore.

Exempt waste: waste that does not need to be subjected to all or part of FANC's regulatory controls because the exposure (including potential exposure) that it generates is too low to justify the application of these controls.

The national programme is divided into four parts.

- The *first part* establishes a number of elements that are useful in understanding the national programme.
- The *second part* describes the state of affairs in terms of the management of spent fuel and radioactive waste from its generation up to and including the phase following the closure of repositories.
- The *third part* covers the special cases of radium-bearing radioactive waste, NORM radioactive waste and new types of future waste.
- The *fourth part* presents a synoptic view of the national programme, at 31 December 2014, in terms of performance indicators.

A list of acronyms and bibliographic references conclude the national programme.

Inset 1 – Selection of published documents that support the national programme which can be downloaded from www.cpnpc.be and a short description of their content in relation to the national programme.

EIG EURIDICE, Activity Report 2013, Doc. 14-107, 2014, 90 pages

A report that provides an overview of the works achieved in 2013 by EURIDICE, the Economic Interest Grouping responsible for managing and operating the HADES underground research laboratory dedicated to research, development and demonstration (RD&D) activities regarding the geological disposal of high-level and/or long-lived radioactive waste.

IAEA, Country Nuclear Power Profiles, Belgium, updated 2014, 64 pages

Summary report on the organisational and industrial aspects of the Belgian nuclear sector, including the national legal and regulatory framework and the international framework.

Kingdom of Belgium, Fifth meeting of the Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, National Report, October 2014, 164 pages

Report by Belgium drafted pursuant to Article 32 of the Joint Convention. This report contains in particular information on the actors in spent fuel and radioactive waste management and descriptions of the management facilities present in Belgium.

ONDRAF/NIRAS, The cAt project in Dessel — A long-term solution for Belgian category A waste, report NIROND 2010-02 E, March 2010, 140 pages

General description, for a wide audience, of the integrated project for surface disposal of category A waste according to all its components.

ONDRAF/NIRAS, Waste Plan for the long-term management of conditioned high-level and/or long-lived radioactive waste and overview of related issues, report NIROND 2011-02 E, September 2011, 262 pages

Strategic report designed to provide the government with the necessary elements to enable it to establish the bases for the national policy for the long-term management of high-level and/or long-lived radioactive waste (category B&C waste).

ONDRAF/NIRAS, Troisième rapport d'inventaire des passifs nucléaires de l'ONDRAF à sa tutelle (période 2008–2012) — Evaluation de l'existence, de la suffisance et de la disponibilité des provisions destinées à couvrir les coûts nucléaires estimés associés aux installations nucléaires et aux sites contenant des substances radioactives, hors coûts de gestion des déchets d'exploitation futurs, report NIROND 2012-02 F, janvier 2013, 288 pages // ONDRAF/NIRAS, Derde rapport over de inventaris van de nucleaire passiva van NIRAS aan haar voogdij (periode 2008–2012) — Evaluatie van het bestaan, de toereikendheid en de beschikbaarheid van de provisies bestemd om de geraamde nucleaire kosten te dekken met betrekking tot de nucleaire installaties en de sites die radioactieve stoffen bevatten, behalve de kosten van het beheer van het toekomstige exploitatieafval, rapport NIROND 2012-02 N, januari 2013, 288 bladzijden

Financial-type report containing in particular a detailed description and analysis of the legal and regulatory framework for covering management costs, an evaluation of the provisions made by the financially liable entities to cover their management costs and comprehensive recommendations as to the improvements to be made to the legal and regulatory framework.

ONDRAF/NIRAS, ONDRAF/NIRAS Research, Development and Demonstration (RD&D) Plan for the geological disposal of high-level and/or long-lived radioactive waste including irradiated fuel if considered as waste — State-of-the-art report as of December 2012, report NIROND-TR 2013-12 E, December 2013, 412 pages

Specialised scientific and technical report which reviews the state of the knowledge in terms of geological disposal of category B&C waste in poorly indurated clay and draws short-term and medium-term research priorities from it.

ONDRAF/NIRAS, Référentiel de gestion à long terme des déchets radioactifs — Approche unifiée d'identification de solutions de gestion à long terme, plus particulièrement pour les déchets radioactifs radifères et les déchets radioactifs NORM, et considérations relatives à l'établissement de plans stratégiques en vue de leur gestion, report NIROND 2015-01 F, février 2015, 72 pages // ONDRAF/NIRAS, Referentiekader voor het langetermijnbeheer van radioactief afval — Eenvormige aanpak voor het bepalen van oplossingen voor het langetermijnbeheer, in het bijzonder voor radioactief radiumhoudend afval en radioactief NORM-afval, en overwegingen inzake het opstellen van strategische plannen voor het beheer ervan, rapport NIROND 2015-01 N, februari 2015, 72 bladzijden

A strategic report which presents a unified view of the issue of identifying and developing solutions for the long-term management of all radioactive waste, including radium-bearing and NORM radioactive wastes, in preparation for the subsequent development of strategic plans for the long-term management of radium-bearing and NORM radioactive wastes.

SPF Economie, Informations générales sur le cycle du combustible nucléaire en Belgique *(in press)* // FOD Economie, Algemene informatie over de Belgische splijtstofcyclus *(in press)*

Document summarising the regulatory and technical elements needed to understand the problems surrounding the choice of a long-term management strategy for commercial nuclear fuel in Belgium.

SPF Economie, Etude préliminaire sur les stratégies de gestion du combustible nucléaire en Belgique *(in press)* // FOD Economie, Vergelijkende studie van de beheerstrategieën van de Belgische splijtstof *(in press)*

Preliminary study that considers six different management strategies for commercial nuclear fuel which could be applied in Belgium and their respective consequences. It presents a cross-cutting analysis of the chronology of the strategies studied.

2 Correlation between the subjects to be legally included in the national programme and its structure

The subjects to be included in the national programme are subjects (a) to (k) referred to in Article 12 of Directive 2011/70/Euratom and repeated practically word for word and with the same numbering in Article 6 of the Law of 3 June 2014 which transposes the directive into Belgian law, along with three additional subjects set out by Article 6 of the aforementioned law and numbered (l), (m) and (n). These 14 subjects are listed in table 1. A short identifier is associated with each one, which is then used throughout the document, along with the chapter or section number(s) which cover(s) the subject. The national programme's content referred to in paragraph 3 of Article 6 of the law is treated with subjects (a) to (n). The expertise and skills, referred to in Article 8 of the directive and Article 5 of the law, are treated with subject (f). The availability of financial resources and public participation, referred to in Articles 9 and 10 of the directive, are treated with subjects (i) and (j) respectively.

Table 1 – Subjects to be included in the national programme, as listed in Article 6 of the Law of 3 June 2014.

Subject to be included in the national programme	Identifier	Covered in
"a) the overall objectives of the national policies referred to in paragraph 6 of this article in respect of spent fuel and radioactive waste management;"	Objectives (a)	Sections 5.1, 5.2, 6.2, 7.2.3 and 7.4.1
"b) the significant milestones and clear timeframes for the achievement of those milestones in light of the overarching objectives of the national programme;"	Timeframes (b)	Sections 5.1, 7.4.1 and 7.4.2
"c) an inventory of all spent fuel and radioactive waste and estimates for future quantities, including those from decommissioning, clearly indicating the location and amount of the radioactive waste and spent fuel in accordance with appropriate classification of the radioactive waste and spent fuel;"	Inventory (c)	Sections 5.1, 5.2, 6.3, 7.4.1 and 7.4.2, chapter 11
"d) the concepts or plans and technical solutions for spent fuel and radioactive waste management from generation to disposal;"	Concepts / management plans (d)	Sections 5.1, 5.2, 7.4.1 and 7.4.2
"e) the concepts or plans for the post-closure period of a disposal facility's lifetime, including the period during which appropriate controls are retained and the means to be employed to preserve knowledge of that facility in the longer term;"	Post-closure concepts (e)	Sections 7.4.1 and 7.4.2
"f) the research, development and demonstration activities that are needed in order to implement solutions for the management of spent fuel and radioactive waste;"	RD&D (f)	Sections 5.1, 7.4.1 and 7.4.2, chapter 8
"g) the responsibility for the implementation of the national programme and the key performance indicators to monitor progress towards implementation;"	Responsibilities (g1); Indicators (g2)	g1: section 4.1 g2: part 4
"h) an assessment of the national programme costs and the underlying basis and hypotheses for that assessment, which must include a profile over time;"	Costs (h)	Sections 7.3, 7.4.1 and 7.4.2
"i) the financing scheme(s) in force;"	Financing (i)	Sections 5.1, 5.2 and 7.3, chapter 6
"j) a transparency policy or process;"	Transparency and participation (j)	Sections 5.1, 5.2, 7.4.1 and 7.4.2
"k) if any, the agreement(s) concluded with another country on management of spent fuel or radioactive waste, including on the use of disposal facilities;"	International agreements (k)	Chapter 9
"l) the identification of additional requirements arising from the interdependencies between the different management steps for each type of radioactive waste and spent fuel from generation to disposal in order to ensure proper linkage and overall consistency;"	Interdependencies (l)	Section 7.2.2, chapter 10
"m) information relating to any planned or anticipated modification to facilities and/or practices likely to have an impact on the management of radioactive waste and spent fuel;"	Modifications (m)	Chapter 12
"n) information about the historical situations and past or present work activities that generate or have generated substances likely to be qualified as radioactive waste as well as the basic principles for the management methods considered for this radioactive waste, in the event that it cannot be managed by existing management methods."	Historical situations and work activities (n)	Section 6.3, chapter 11

3 Spent fuel and radioactive waste generation in Belgium

Belgium is a country with a nuclear tradition and across its territory there has been and still is an extensive range of activities using radioactivity, including activities relating to the nuclear fuel cycle, to research or to medical and industrial applications of radioactivity (table 2). These activities generate spent nuclear fuel and radioactive waste with highly diverse characteristics, which must be managed safely (chapters 5, 6 and 7). Other activities — the historical radium and uranium production and the NORM industries — are moreover the source of radium-bearing and NORM wastes, some of which — that cannot currently be assessed — could take radioactive waste status in the future (chapter 11).

Table 2 – Principal activities generating spent fuel and radioactive waste and main associated facilities or main types of associated waste [IAEA, 2014; Kingdom of Belgium, 2014; ONDRAF/NIRAS, 2013a].

Principal activities	Main facilities or types of radioactive waste
Activities related to the nuclear fuel cycle	
Fuel reprocessing	
Eurochemic (1966–1974, Dessel, end of dismantling)	Pilot reprocessing plant (built as part of an OECD project)
Fuel fabrication	
FBFC International (1973–2015, Dessel, being dismantled)	Fabrication facilities for UO_2 fuel assemblies from enriched UO_2 and fuel assembly facilities for MOX from rods of MOX fuel
Belgonucleaire (1973–2006, Dessel, end of dismantling)	Fabrication facilities for rods of MOX fuel from UO_2 and PuO_2
Electricity production	
Electrabel (Doel and Tihange) (Synatom owns the fuel; Electrabel owns the Doel 1 and 2 reactors and shares ownership of the Tihange 1 reactor with EDF Belgium and ownership of the Doel 3 and 4 and Tihange 2 and 3 reactors with EDF Luminus)	7 reactors (net installed capacity, industrial commissioning date and operational end date stipulated by the law to phase out nuclear energy [Belgian Official Journal, 2003b]) Doel 1 (433 MWe): 15 February 1975 – 15 February 2015 Doel 2 (433 MWe): 1 December 1975 – 1 December 2015 Doel 3 (1006 MWe): 1 October 1982 – 1 October 2022 Doel 4 (1039 MWe): 1 July 1985 – 1 July 2025 Tihange 1 (962 MWe): 1 October 1975 – 1 October 2025 Tihange 2 (1008 MWe): 1 February 1983 – 1 February 2023 Tihange 3 (1046 MWe): 1 September 1985 – 1 September 2025 Treatment, conditioning and storage facilities, including storage facilities for spent fuel
Research	
Belgian Nuclear Research Centre (SCK•CEN, Mol)	6 reactors: BR1, BR2 and VENUS-F (operational), BR02 (dismantled), BR3 (being dismantled) and VENUS (changed into VENUS-F for GUINEVERE), laboratories
Institute for Reference Materials and Measurements (IRMM, Geel) of the Joint Research Centre of the European Commission	1 linear accelerator, laboratories
Ghent University (Ghent)	Thétis reactor (being dismantled), 1 cyclotron, 2 linear accelerators put out of service
Five other Belgian universities	8 cyclotrons (including 2 attached to university hospitals), 2 linear accelerators
Radioisotope production for medical and industrial use	
National Radioelements Institute (IRE, Fleurus)	Radioisotope production facilities
SCK•CEN (Mol)	Radioisotope production in the BR2 reactor
Private companies	7 cyclotrons (including 2 put out of service)
Radium and uranium production (from 1922 to 1977)	
Umicore (formerly Union Minière, Olen)	UMTRAP and Bankloop storage facilities, subject to nuclear licences and containing materials with radioactive waste status Contaminated industrial landfills and diffuse contamination, likely to require interventions generating radioactive waste
Activities of certain NORM industries	Radioactive waste from the operation and dismantling of the facilities of certain NORM industries Contaminated industrial landfills and diffuse contamination, likely to require interventions generating radioactive waste
Old domestic devices	Ionising smoke detectors, lightening conductors, etc.

4 Elements of the national framework for the responsible and safe management of spent fuel and radioactive waste

The main elements of the national framework necessary for understanding the national programme are the actors in the management of spent fuel and radioactive waste (section 4.1) and the components of the federal legal and regulatory framework relating to this management (section 4.2) (see also [IAEA, 2014; FPS Economy, 2015a]). The Federal State has indeed exclusive jurisdiction over the issues related to the nuclear sector, including the nuclear fuel cycle, radioactive waste management, radiation protection and research, development and demonstration (RD&D) in these fields. Protection of people and the environment, excluding aspects linked to ionising radiation, is a regional jurisdiction.

4.1 Main actors in the management of spent fuel and radioactive waste and responsibilities [subject (g1)]

In a simplified way, spent fuel and radioactive waste management may be seen as essentially involving four groups of actors (figure 1):

- the owners of the spent fuel (section 4.1.2);
- the radioactive waste producers (section 4.1.1);
- ONDRAF/NIRAS, the organisation responsible for the safe management of radioactive waste, and its subsidiary Belgoprocess (section 4.1.1);
- FANC, the agency responsible for protecting people and the environment against the risks of ionising radiation, and its subsidiary Bel V (section 4.1.3).

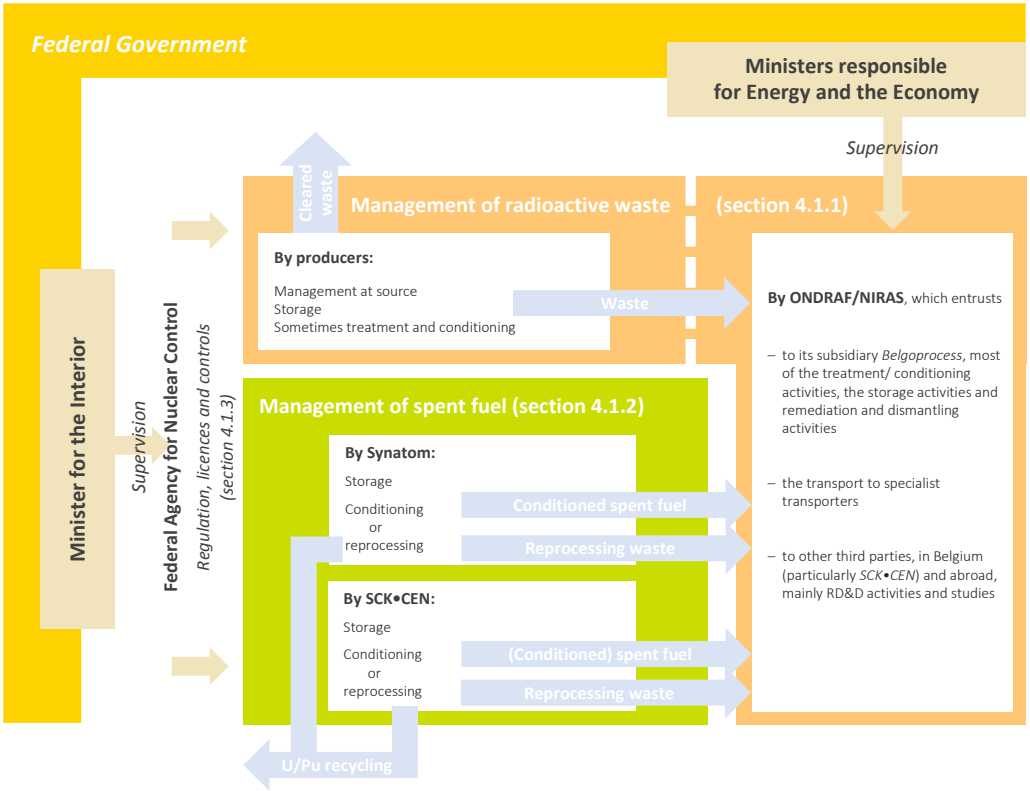

Figure 1 – Main actors in the management of spent fuel and radioactive waste in Belgium.

The organisation of spent fuel and radioactive waste management itself, including its financing, is described and discussed in chapters 5, 6 and 7.

ONDRAF/NIRAS' competences as the organisation responsible for managing radioactive waste and those of FANC are distinct yet complementary and the two parties carry out their tasks within their respective competences [Kingdom of Belgium, 2014]. A consultation agreement between them enables them to exchange views on, in particular, the strategic aspects of radioactive waste management and interdependencies, in a context separate from that of discussions relating to the nuclear licences requested by ONDRAF/NIRAS as a nuclear operator.

4.1.1 Radioactive waste management

ONDRAF/NIRAS, which was given responsibility for the management of radioactive waste by the legislature, is a public body with legal personality. Its missions and functioning rules are set out by Article 179, § 2, of the Law of 8 August 1980 and the Royal Decree of 30 March 1981 [Belgian Official Journal, 1980; Belgian Official Journal, 1981]. ONDRAF/NIRAS is supervised by the ministers responsible for Energy and the Economy. It presents an annual activity report to Parliament.

ONDRAF/NIRAS may conduct its radioactive waste management mission and its other missions (section 4.2.2) using its own resources or allow them to be carried out by third parties under its responsibility. In practice,

- it entrusts the transport of radioactive waste outside producer sites to specialist transport companies;
- it entrusts industrial activities to third parties, in particular to Belgoprocess SA, its industrial subsidiary based in Dessel: Belgoprocess conducts most of the treatment and conditioning activities for non-conditioned radioactive waste taken charge of [3] by ONDRAF/NIRAS, as well as the storage activities and remediation and dismantling activities;
- it entrusts the studies and RD&D activities to third parties; in particular, it entrusts many RD&D activities to SCK•CEN in Mol.

Furthermore, ONDRAF/NIRAS is the only actor appointed to ensure the long-term management of radioactive waste.

ONDRAF/NIRAS handles the general coordination of all the aforementioned industrial and RD&D activities and ensures the durability and integration of knowledge. Its role of radioactive waste manager is separate from its role of nuclear operator. When it acts as a nuclear operator, ONDRAF/NIRAS is controlled by FANC as any other nuclear operator.

In accordance with the provisions of the Law of 8 August 1980, ONDRAF/NIRAS must allocate its costs, estimated at cost price and in proportion to its services, between the beneficiaries of those services, namely the radioactive waste producers and financially liable institutional entities (Federal State, Walloon Region and European Commission) (section 7.3).

The radioactive waste producers are not required to ask ONDRAF/NIRAS to take charge of their waste immediately after its generation. They can treat, condition and (temporarily) store their waste on their site, subject to their facilities being licensed by FANC (section 4.1.3) and approved by

[3] Taking charge: *"set of technical and administrative operations necessary for the collection of radioactive waste or excess quantities from producer sites and their transfer to the facilities managed by the Organisation"* (Article 1 in [Belgian Official Journal, 1981]).

ONDRAF/NIRAS (section 7.2.2). These approvals must ensure that the generated waste will comply with ONDRAF/NIRAS' acceptance criteria for its future management. Furthermore, producers who wish to have their waste treated and conditioned abroad must ensure that the waste that returns to Belgium will comply with ONDRAF/NIRAS' acceptance criteria. In practice, Electrabel SA, which operates the seven Belgian commercial nuclear reactors, treats and conditions some of its own operational waste, several other producers have certain treatment and conditioning operations carried out abroad and hospitals and research laboratories store their very short-lived radioactive waste for clearance after decay, in accordance with the requirements of the general regulations for radiation protection. This waste is then managed as conventional industrial waste [Belgian Official Journal, 2003a].

4.1.2 Management of spent fuel from nuclear power plants and research reactors

Spent fuel from commercial nuclear power plants (section 4.1.2.1) and research reactors (section 4.1.2.2) is managed by the owners of the fuel.

4.1.2.1 Spent fuel from commercial nuclear power plants

Pursuant to Article 179, § 1, of the Law of 8 August 1980 [Belgian Official Journal, 1980], Synatom SA manages the spent fuel from commercial nuclear power plants, before ONDRAF/NIRAS takes charge of it in the form of reprocessing waste or as radioactive waste.

Synatom SA, a wholly owned subsidiary of Electrabel SA, owns the nuclear fuel throughout the entire fuel cycle, including while in the reactors of the nuclear power plants at Doel and Tihange. The Federal State has a golden share in Synatom giving it certain special rights within Synatom's Board of Directors and General Assembly.

Synatom can conduct its mission to manage spent fuel using its own resources or allow it to be carried out by third parties under its responsibility.

4.1.2.2 Spent fuel from research reactors

SCK•CEN, a foundation of public utility supervised by the Minister responsible for Energy, manages the spent fuel from its research reactors that it owns (section 5.2 and table 5 in section 7.4.2).

From 1967 to the end of 2003, Ghent University operated the Thétis research reactor, which has been subject to dismantling operations since 2013 (section 5.2 and table 5 in section 7.4.2).

4.1.3 Regulation, licences and controls

Created by the Law of 15 April 1994 [Belgian Official Journal, 1994b; Kingdom of Belgium, 2014], FANC is the public institution with legal personality responsible for protecting the population, workers and the environment in Belgium against the dangers arising from ionising radiation. Its missions and functioning rules are set out by the Law of 15 April 1994 and its implementing royal decrees. FANC is supervised by the Minister for the Interior. It presents an annual activity report to Parliament.

FANC is specifically responsible for proposing regulations in terms of radiation protection and safety (section 4.2.1), that comply with international recommendations and European directives, and to ensure their application. It grants construction and operation licences for nuclear facilities as well as dismantling licences, except for construction and operation licences and dismantling licences for class I facilities [4], which are issued by royal decree, on FANC's proposal to its supervisory authority, after a positive opinion from the FANC Scientific Council. FANC also grants nuclear transport licences to transport companies of radioactive materials. It inspects nuclear facilities, controls compliance with the licence provisions and, more generally, compliance with the provisions of the legal and regulatory framework for radiation protection, nuclear safety and nuclear security. If necessary, licences can be suspended or withdrawn by the authorities that have issued them. FANC also assesses notification files relating to work activities using naturally occurring sources of ionising radiation (NORM issue — chapter 11).

FANC's running costs are covered by taxes and fees that it charges to the beneficiaries of its services, primarily licence holders, in accordance with the conditions set out by the legal and regulatory framework.

On 7 September 2007, FANC created a subsidiary, called Bel V, in the form of a foundation of private law. Bel V, which constitutes FANC's technical support, is notably responsible for conducting inspections in the nuclear power plants and the other facilities subject to nuclear licences and evaluating safety cases submitted to FANC.

4.2 Federal legal and regulatory framework

The Federal State has exclusive jurisdiction over the management of spent fuel and radioactive waste. This management complies with a legal and regulatory framework comprised of elements such as laws, royal decrees and decisions by Parliament or the Council of Ministers.

For the management of spent fuel and radioactive waste, Belgium complies

- with the requirements of the international and European conventions, treaties and protocols to which it is a signatory and the requirements of European directives, regulations and decisions;
- with the requirements of the regional legal and regulatory framework, particularly for issues related to protection of the environment (other than aspects related to ionising radiation) and the management of cleared waste;
- with internationally recommended principles and standards.

[4] According to the general regulations for radiation protection [Belgian Official Journal, 2001], class I includes nuclear reactors used to produce electricity or for scientific research, facilities using or holding quantities of fissile substances (excluding natural and depleted uranium and natural thorium) greater than half the minimum critical mass (therefore, particularly all facilities where activities are part of the fuel cycle), radioactive waste treatment, conditioning and storage facilities, where such activities represent the company's core business, and repositories for radioactive waste.

Only the main elements of the *federal* legal and regulatory framework for the management of spent fuel and radioactive waste are considered hereafter. They are divided into six groups:

- radiation protection and safety (section 4.2.1);
- radioactive waste management (section 4.2.2);
- management of spent fuel from commercial nuclear power plants (section 4.2.3);
- management of spent fuel from research reactors (section 4.2.4);
- financing of the management (section 4.2.5);
- transparency and participation (section 4.2.6).

The consolidated versions of the laws and royal decrees quoted are available on http://www.ejustice.just.fgov.be/loi/loi.htm (in French) or http://www.ejustice.just.fgov.be/wet/wet.htm (in Dutch). The main international conventions and treaties in relation to the management of spent fuel and radioactive waste to which Belgium is a signatory are listed in section 4.1.1 of the ONDRAF/NIRAS B&C Waste Plan [ONDRAF/NIRAS, 2011a]. The regulations for regionalised issues are not included in the national programme.

4.2.1 Radiation protection and safety

Law of 15 April 1994 *on the protection of the population and the environment against the dangers arising from ionising radiation and on the Federal Agency for Nuclear Control* (hereafter the "FANC Law") [Belgian Official Journal, 1994b], which, in particular,

- establishes the Federal Agency for Nuclear Control and
- defines its missions, including that of proposing draft royal decrees implementing the FANC Law.

Royal Decree of 20 July 2001 *relating to the general regulations for the protection of the population, workers and the environment against the dangers arising from ionising radiation* (hereafter the "general regulations for radiation protection") [Belgian Official Journal, 2001], which, in particular,

- establishes the licensing system for class I treatment, conditioning and storage facilities for radioactive waste and establishes the general provisions for the licensing system for repositories (Article 6);
- establishes the basic standards regarding protection against exposure to ionising radiation (Chapter III, Section I);
- contains various articles relating to radioactive waste (Chapter III, Section IV);
- provides the possibility for operators to request authorisation from FANC for the discharge, disposal, recycling or reuse of liquid or solid radioactive waste (Article 18);
- describes the concept of "work activity", lists work activities and requires that these are declared to FANC (NORM issue).

The Royal Decree of 20 July 2001 will have to be brought into line with the new European radiation protection directive (Directive 2013/59/Euratom) by 6 February 2018 [EU, 2013].

Law of 2 August 2002 *containing assent to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, signed in Vienna on 5 September 1997* [Belgian Official Journal, 2002a].

Royal Decree of 24 March 2009 *regulating the import, transit and export of radioactive substances* [Belgian Official Journal, 2009].

Royal Decree of 30 November 2011 *on the safety requirements for nuclear facilities* [Belgian Official Journal, 2011].

4.2.2 Radioactive waste management

Article 179 of the Law of 8 August 1980 *on the budgetary proposals for 1979–1980* [Belgian Official Journal, 1980], which, in particular,

- creates ONDRAF/NIRAS (§ 2 — hereafter the "ONDRAF/NIRAS Law");
- assigns it various missions (in particular, the inventory and management of radioactive waste, including non-reprocessed spent fuel declared as waste, and missions relating to decommissioning) (§ 2);
- transposes Directive 2011/70/Euratom into Belgian law (§ 2 and § 5 to 11) and, in particular, stipulates that the King establishes and maintains national policies for the management of radioactive waste and spent fuel by decree debated in the Council of Ministers, on ONDRAF/NIRAS' proposal and after FANC's opinion.

Royal Decree of 30 March 1981 *determining the missions and setting out the functioning rules for the public body for the management of radioactive waste and enriched fissile materials* (hereafter the "ONDRAF/NIRAS Royal Decree") [Belgian Official Journal, 1981], which

- implements the ONDRAF/NIRAS Law.

Law of 20 December 1984 *approving the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, the Annexes, Addendum and Appendix, signed in London, Mexico, Moscow and Washington on 29 December 1972 and amended in London on 12 October 1978, 1 December 1978 and 1 December 1980* [Belgian Official Journal, 1984].

Royal Decree of 18 November 2002 *governing the approval of facilities for the storage, treatment and conditioning of radioactive waste* [Belgian Official Journal, 2002b], where

- this approval is given by ONDRAF/NIRAS and also concerns the facilities for radiological characterisation of radioactive waste.

Resolution 541/9 – 91/92 of the Chamber of Representatives of 22 December 1993 *on the use of fuels containing plutonium and uranium in Belgian nuclear power plants and the appropriateness of reprocessing fuel rods* [Chamber, 1993], which, in particular,

- *"orders the government: [...] 3) to prioritise research and development, including internationally, so as to be able eventually to carry out the direct disposal of irradiated fuel, without reducing the current research programme in the field of deep disposal of reprocessing waste".*

Decision of the Council of Ministers of 24 December 1993 [Council of Ministers, 1993], by which, in particular, the government

- fully accepts the mission entrusted to it two days earlier by the Chamber of Representatives.

Letter of 10 February 1999 from the Minister for the Interior approving the general rules for the acceptance of conditioned and non-conditioned radioactive waste drafted by ONDRAF/NIRAS pursuant to the ONDRAF/NIRAS Royal Decree [Van den Bossche, 1999].

Decision of the Council of Ministers of 16 January 1998 [Council of Ministers, 1998a], through which, in particular, it

- opts for a solution that is definitive or can become definitive, and one that is progressive, flexible and reversible, for the management of short-lived, low-level and medium-level waste (category A waste);
- orders ONDRAF/NIRAS' supervisory authority to give ONDRAF/NIRAS the mission to limit itself, in its exploratory activities, to existing nuclear zones and to sites where the local authorities show an interest.

Cooperation agreement of 17 October 2002 *between the Federal State and the Regions relating to the management of cleared waste* [Belgian Official Journal, 2003a].

Decision of the Council of Ministers of 23 June 2006 [Council of Ministers, 2006], through which, in particular, it

- decides that the long-term management method for category A waste will be surface disposal on the territory of the municipality of Dessel, as part of a project incorporating the technical and societal aspects and developed through a participative process.

4.2.3 Management of spent fuel from commercial nuclear power plants

Inset 2 in section 5.1 expands on the history of the legal and regulatory framework for the management of spent fuel from commercial nuclear power plants given below.

Article 179 of the Law of 8 August 1980 *on the budgetary proposals for 1979–1980* [Belgian Official Journal, 1980], which, in particular,

- orders Synatom to manage activities relating to the nuclear fuel cycle, with the exception of those assigned to ONDRAF/NIRAS (§ 1);
- stipulates that *"The reprocessing of fissile materials in Belgium may not start until after the legislative Chambers have decided on its principle."* (§ 4);
- transposes Directive 2011/70/Euratom into Belgian law (§ 2 and § 5 to 11) and, in particular, stipulates that national policies for the management of radioactive waste and spent fuel are based on at least six general principles, including the principle according to which the generation of radioactive waste shall be kept to the minimum which is reasonably practicable by means of various measures, including reprocessing, and provides that national policies contain the accepted hypotheses for the further use of the different types of spent fuel on the proposal of the holders of the spent fuel and after consultation with ONDRAF/NIRAS and FANC.

Resolution no. 7 of the Chamber of Representatives of 2 July 1982 *on the options in the field of nuclear energy* [Chamber, 1982], according to which

- Belgium must maximise the benefit of the investments made within its borders in terms of reprocessing, and therefore restart the Eurochemic plant, and have its excess fuel reprocessed abroad while awaiting new, more suitable infrastructures.

Resolution 541/9 – 91/92 of the Chamber of Representatives of 22 December 1993 *on the use of fuels containing plutonium and uranium in Belgian nuclear power plants and the appropriateness of reprocessing fuel rods* [Chamber, 1993], which, in particular, orders that the government

- *"1) in the future, no longer prioritises the reprocessing strategy compared with the conditioning and direct disposal strategy* (once through cycle). *The government can therefore no longer consider reprocessing as the obvious reference strategy. It must create the conditions to allow the conditioning and direct disposal strategy to be developed as an alternative;"*
- *"4) submits, to the Chamber, within 5 years, the elements for a new global evaluation of the situation [...];"*
- *"7) meanwhile, ensures that:*
  - *the electricity producers and Synatom provide safe temporary storage for irradiated fuel;*
  - *the electricity producers and Synatom conduct security studies (workers and population) and feasibility studies for the industrial conditioning of irradiated fuel;*
  - *all the costs, investments and various primary or additional charges which are related to nuclear electricity production and the nuclear fuel cycle are charged to the electricity producers. These costs cannot be imposed on third parties;".*

Decision of the Council of Ministers of 24 December 1993 [Council of Ministers, 1993], by which, in particular, the government

- fully accepts the mission entrusted to it two days earlier by the Chamber of Representatives.

Decision of the Council of Ministers of 4 December 1998 [Council of Ministers, 1998b], by which, in particular, the government asks Synatom

- to terminate, as soon as possible and at the latest by 23 December 1998, the reprocessing contract for 225 tonnes of fuel, agreed in 1991 with COGEMA;
- not to sign any new reprocessing contracts without its formal agreement.

4.2.4 Management of spent fuel from research reactors

Article 179 of the Law of 8 August 1980 *on the budgetary proposals for 1979–1980* [Belgian Official Journal, 1980], which, in particular,

- transposes Directive 2011/70/Euratom into Belgian law (§ 2 and § 5 to 11) and, in particular, stipulates that national policies for the management of radioactive waste and spent fuel are based on at least six general principles, including the principle according to which the generation of radioactive waste shall be kept to the minimum which is reasonably practicable by means of various measures, including reprocessing, and provides that national policies contain the accepted hypotheses for the further use of the different types of spent fuel on the proposal of the holders of the spent fuel and after consultation with ONDRAF/NIRAS and FANC.

Law of 5 May 2014 *containing assent to the Agreement between the Government of the Kingdom of Belgium and the Government of the French Republic on the treatment of Belgian spent fuel in la Hague, signed in Paris on 25 April 2013* [Belgian Official Journal, 2014b], which

- authorises SCK•CEN to have the spent fuel from the BR2 research reactor reprocessed by AREVA NC in la Hague and defines the obligations regarding the return of the generated waste.

4.2.5 Financing of the management

The legal and regulatory framework concerning the coverage of the costs of managing spent fuel and radioactive waste and the costs of decommissioning, referred to here using the generic term "management costs", is currently composed of different regulations as well as general elements of law (civil law, accounting law, administrative law, tax law, company law, etc.) and provisions relating to specific cases where various institutional entities have already been held financially liable.

The legal and regulatory framework concerning the coverage of the management costs is presented and discussed in detail in chapter 6 of ONDRAF/NIRAS' third inventory report on nuclear liabilities [ONDRAF/NIRAS, 2013a]. Only six texts are listed below.

Article 179, § 2, of the Law of 8 August 1980 (ONDRAF/NIRAS Law) [Belgian Official Journal, 1980], which, in particular,

- stipulates that the costs related to ONDRAF/NIRAS' activities, including RD&D costs, are charged to the beneficiaries of its services;
- allows ONDRAF/NIRAS to create a "long-term fund" to finance its long-term missions;
- allows ONDRAF/NIRAS to create a "medium-term fund" to cover the costs of integrating disposal projects into the local communities concerned;
- allows ONDRAF/NIRAS to create an "insolvency fund" to compensate for the potential bankruptcy or insolvency of some producers;
- gives ONDRAF/NIRAS the mission of evaluating the existence and sufficiency of the provisions established by nuclear facilities operators and the holders of radioactive substances to finance their decommissioning costs, including the costs of managing spent fuel and radioactive waste, and their remediation costs.

Royal Decree of 30 March 1981 (ONDRAF/NIRAS Royal Decree) [Belgian Official Journal, 1981], which

- implements the ONDRAF/NIRAS Law and, in particular, stipulates the obligation for radioactive waste producers to sign an agreement with ONDRAF/NIRAS focusing on, among other things, the financial terms for taking charge of their waste.

Royal Decree of 16 October 1991 *on the regulations for the control and method of subsidising the Belgian Nuclear Research Centre and amending the statutes of this centre* [Belgian Official Journal, 1991a], which, in particular,

- defines the technical (or nuclear) liabilities of SCK•CEN as being *"the obligations resulting from the decommissioning of facilities, as well as the treatment, conditioning, storage and discharge or disposal of radioactive waste arising from the decommissioning of facilities, related to the Centre's nuclear activities up to 31 December 1988"* and
- stipulates that the Federal State is responsible for financing this liability.

Royal Decree of 16 October 1991 *establishing the regulations for the control and method of subsidising the National Radioelements Institute and amending the statutes of this institute* [Belgian Official Journal, 1991b], which, in particular,

- defines the technical (or nuclear) liabilities of the IRE as being *"the obligations resulting from the decommissioning of facilities, as well as the treatment, conditioning, storage and discharge or disposal of accumulated radioactive waste, including radioactive waste arising from the decommissioning of facilities, related to the Institute's nuclear activities"* and
- stipulates that the Federal State is responsible for financing this liability.

Law of 29 April 1999 *on the organisation of the electricity market* [Belgian Official Journal, 1999a], which, in particular,

- structures the financing for the obligations resulting from the decommissioning of the BP1 (former pilot reprocessing plant of Eurochemic or BP1 liability) and BP2 (former Waste department of SCK•CEN or BP2 liability) sites.

Law of 11 April 2003 *on the provisions created for the dismantling of nuclear power plants and the management of fissile materials irradiated in these power plants* [Belgian Official Journal, 2003d], which, in particular (see also inset 4 in section 7.3.2),

- makes Synatom responsible for ensuring coverage of the costs of dismantling nuclear power plants and managing the spent fuel from these power plants;
- requires Synatom to make provisions in its accounts for dismantling and for the management of spent fuel and requires the nuclear operator (Electrabel) and holders of a share in nuclear production to pay Synatom the amounts corresponding to the provisions;
- regulates Synatom's management of the financial resources that represent the equivalent value of the created provisions;
- assigns control over the creation and management of the provisions for the dismantling of nuclear power plants and the management of the spent fuel to a commission called the Commission for Nuclear Provisions.

4.2.6 Transparency and participation

Article 32 of the Constitution, which

- gives everyone the right to consult any administrative document and to obtain a copy of it, allowing for exceptions.

Article 179, § 2, of the Law of 8 August 1980 (ONDRAF/NIRAS Law) [Belgian Official Journal, 1980], which, in particular,

- allows ONDRAF/NIRAS to create a "medium-term fund" to cover the costs incurred in creating and maintaining the required societal support to ensure the integration of a disposal project into a local community, particularly costs related to the activities and projects of the local community which, through a participative process, ensures the continuity of societal support for the repository.

Royal Decree of 30 March 1981 (ONDRAF/NIRAS Royal Decree) [Belgian Official Journal, 1981], which

- requires ONDRAF/NIRAS to establish and implement an information and communication programme covering all its activities.

Law of 11 April 1994 *on administrative publicity* [Belgian Official Journal, 1994a].

Law of 15 April 1994 (FANC Law) [Belgian Official Journal, 1994b], which

- requires FANC to distribute balanced and objective information on the subject of nuclear security and radiation protection.

Law of 9 June 1999 *containing assent to the Convention on Environmental Impact Assessment in a Transboundary Context and Appendices I, II, III, IV, V, VI and VII, signed in Espoo on 25 February 1991* [Belgian Official Journal, 1999b].

Law of 17 December 2002 *containing assent to the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters and Annexes I and II, signed in Aarhus on 25 June 1998* [Belgian Official Journal, 2003c].

Law of 13 February 2006 *on the assessment of the effects of certain plans and programmes on the environment and on public participation in respect of the drawing up of certain plans and programmes relating to the environment* (hereafter the "SEA Law" (acronym for strategic environmental assessment)) [Belgian Official Journal, 2006a], which

- transposes Directive 2001/42/EC and Directive 2003/35/EC which amends Council Directives 85/337/EEC and 96/61/EC.

Law of 5 August 2006 *on public access to environmental information* [Belgian Official Journal, 2006b], which

- transposes Directive 2003/4/EC.

Part 2 Current spent fuel and radioactive waste management

Part 2 describes the existing situation in terms of the management of spent fuel and radioactive waste regarding most of the subjects stipulated in Directive 2011/70/Euratom and the Law of 3 June 2014, the other subjects being covered in the other parts of the national programme (see table 1 in chapter 2 for the correlation between the subjects to be included in the national programme and its structure).

ONDRAF/NIRAS' management of radioactive waste is central to part 2 (chapter 7). Its discussion is preceded by a description of the management of spent fuel by its owners (chapter 5) and a description of the management of radioactive waste by producers (chapter 6) (figure 2). Expertise and skills, including RD&D activities, the agreements concluded with foreign countries and interdependencies are covered in chapters 8, 9 and 10 respectively.

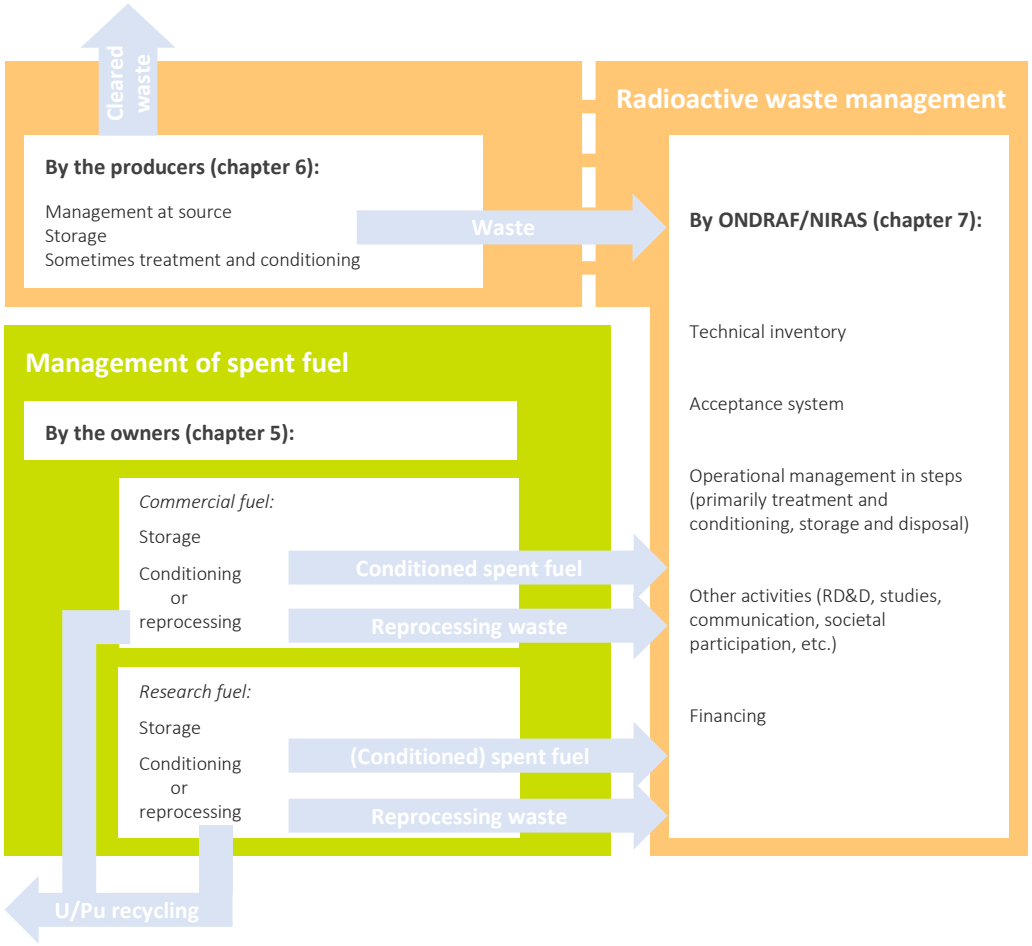

Figure 2 – Organisation of the management of spent fuel and radioactive waste in Belgium.

5 Management of spent fuel by its owners

Until ONDRAF/NIRAS takes charge of spent fuel from commercial nuclear power plants (section 5.1) [FPS Economy, 2015a; FPS Economy, 2015b; ONDRAF/NIRAS *et al.*, 2011] and research reactors (section 5.2) in the form of reprocessing waste or as radioactive waste, the spent fuel is managed by its owners, namely Synatom and SCK•CEN respectively.

5.1 Spent fuel from commercial nuclear power plants [subjects (a) to (d), (f), (i) and (j)]

Management policy and objectives [subject (a)] Pursuant to the national policy for the management of spent fuel from commercial nuclear power plants, namely the *safe storage of spent fuel followed by its reprocessing or disposal*, Synatom pursues the following general objectives:

- to bring past reprocessing contracts to completion,
- the safe storage of spent fuel followed by its reprocessing or disposal,
- to conduct a safety and feasibility study for the industrial conditioning of spent fuel,
- to finance RD&D in the field of the disposal of spent fuel and reprocessing waste,
- to allocate the costs, investments and charges related to the nuclear fuel cycle fairly among electricity producers.

Timeframes [subject (b)] In 1976 and 1978, several reprocessing contracts for spent fuel from commercial nuclear power plants were concluded by Synatom with the French company AREVA NC (COGEMA at the time). This fuel was reprocessed on the site of la Hague between 1980 and 2001. Most of the recoverable materials from these reprocessing contracts were recycled in the form of new fuel assemblies in Belgian reactors between 1994 and 2009 (UO_2) and 1995 and 2010 (MOX). The return to Belgium of the last waste resulting from these contracts is set to end in 2017.

The storage facilities for spent fuel at the Doel and Tihange sites, which were approximately 55% and 65% full respectively at the end of 2014, will be saturated by 2022. So as not to jeopardise nuclear electricity production because of the saturation of existing storage facilities, new storage facilities are currently under study for commissioning prior to this date.

Synatom conducted security studies (workers and population) and feasibility studies for the industrial conditioning of spent fuel from 1994 to 2001. These studies are currently being updated and should be finalised for 2016.

Inventory [subject (c)] At 31 December 2014, 3 932 tHM (tonnes of Heavy Metal) of spent fuel, including 66 tHM of MOX fuel, have been definitively unloaded from the Doel and Tihange reactors since they started operating:

- 30% of this fuel is stored in the reactor's cooling ponds,
- 54% is stored in the storage facilities at Doel and Tihange,
- 16% has been reprocessed at la Hague.
  - The recovered uranium has been integrated into the fabrication of fresh fuel assemblies mostly loaded at Doel 1 and 2, but also at Tihange 2 and Doel 4.
  - The recovered plutonium has been integrated into the fabrication of MOX fuel assemblies for Doel 3 and Tihange 2 or sold to third parties.
  - Virtually all the reprocessing waste, conditioned at la Hague, has been repatriated to Belgium and is stored in ONDRAF/NIRAS' building 136 at Belgoprocess, awaiting an

operational solution for its long-term management (table 5 in section 7.4.2). The repatriation of the remaining reprocessing waste is scheduled for 2017.

In 2025, when the last Belgian commercial nuclear reactor has been permanently shut down (table 2 in chapter 3), the total quantity of spent fuel stored at the Doel and Tihange sites will reach a maximum of 4 800 tHM.

Concepts / management plans [subject (d)] After being in the cooling pond of the reactor from which it was unloaded, the spent fuel is transferred to the storage facility on the power plant's site (annex 1 in [Kingdom of Belgium, 2014]). Following a comparative study started in the early 1990s, for its first storage facilities Synatom chose:

- wet storage in Tihange;
- dry storage in metal casks for storage and transport in Doel.

The transfers of spent fuel on the power plant sites are carried out under the responsibility of Electrabel, in accordance with IAEA regulations, in casks certified by FANC.

Eventually, the spent fuel is intended to be reprocessed or conditioned for disposal [FPS Economy, 2015a].

Synatom gathers and secures the documentation related to the irradiation history and the physico-chemical characteristics of the spent fuel assemblies.

Financing [subject (i)] Financing for the management of spent fuel from commercial nuclear power plants is provided in accordance with the Law of 11 April 2003 (inset 4 in section 7.3.2), which makes Synatom responsible for ensuring these costs are covered and requires it to make provisions.

Every three years since 2004, Synatom has presented an estimate of the total cost of managing spent fuel and dismantling nuclear power plants to the advisory and control body, the Commission for Nuclear Provisions. Several possible management scenarios are analysed: as a precaution, the amount to be provisioned is determined based on conservative scenarios incorporating margins for uncertainty.

Synatom invoices Electrabel for the total cost of managing the spent fuel.

RD&D [subject (f)] Synatom is represented within a network of international experts who address various subjects directly related to the evolution of spent fuel, including modelling of heat exchanges in dry storage, the behaviour of the structure materials of fuel assemblies or determining the residual heat of the fuel after its unloading.

Synatom is having an encapsulation and drying process for leaking fuel rods developed.

Furthermore, Synatom keeps abreast of the research and new advances applied in the design of new-generation casks, for example, in terms of materials designed for shielding and maintaining confinement. It also follows the research focused on the evolution of the physical properties of the materials subject to radiation and the assemblies stored in the casks.

Transparency and participation [subject (j)] Synatom sends the inventory of the quantities of spent fuel present in the facilities at the Doel and Tihange sites at 31 December of the previous year to the OECD, the IAEA and Euratom, annually and at their request.

Furthermore, Synatom holds regular consultation and information meetings with FANC during which all the subjects concerning the progress of projects and outstanding issues related to the management of spent fuel are addressed and analysed. Synatom also keeps FANC informed about any problem that may emerge in the management of spent fuel on the power plant sites.

Through its annual report [Synatom, 2014], Synatom also communicates more broadly about the management of its spent fuel, within the limits of its obligation to keep confidential any information deemed sensitive by the relevant authorities.

Inset 2 – Historical overview of the steps leading to the current situation in terms of the national policy for the management of spent fuel from commercial nuclear power plants.

1974: Promise of a parliamentary debate on the energy policy, covering in particular nuclear energy, including the fuel cycle

1976: Final report of the Evaluation Commission for Nuclear Energy [Commission of Elders, 1976] designed to prepare for the debate promised in 1974 (which would only take place in 1982–1983), which concludes:
"Measures must be taken so that irradiated fuel can be reprocessed […], for the following reasons:
- *reprocessing is a key step in the conditioning of radioactive waste;*
- *the possibility of using plutonium in reactors means the development, in good time, of an appropriate reprocessing capacity; [...]*
- *in terms of reprocessing, it currently seems very difficult to agree long-term contracts with foreign companies; in the absence of such contracts, Belgium will need to have its own reprocessing chain […]"*

1978: Elements for a New Energy Policy report [Claes, 1978], which confirms the recommendation of the Commission of Elders: *"Must irradiated fuel be reprocessed or not? Our response must take account of the specific features of the Belgian situation, namely: a confined territory, relatively large nuclear electricity production, membership of an economic community with limited energy resources. We believe that, with the current state of technology, it is in our interest to use fuel reprocessing as the most rational method for industrial countries with limited energy resources (reprocessing improves the energy balance) and high population density."*

1979: Communication from the government to Parliament of its Note on the energy policy [Government, 1979], which complements the Elements for a New Energy Policy report: *"The use of reprocessing may seem an economically rational method since it improves the energy balance. Waste conditioning, mainly by vitrification, is, in the current state of technology, one way allowing the nuclear fuel cycle to be 'completed' with the least harm for future generations."*

1980: Law of 8 August 1980, Article 179 [Belgian Official Journal, 1980], which, in particular, orders Synatom to manage activities relating to the nuclear fuel cycle, with the exception of those assigned to ONDRAF/NIRAS, and stipulates that *"The reprocessing of fissile materials in Belgium may not start until after the legislative Chambers have decided on its principle."*

1982: Updated version of the final report of the Evaluation Commission for Nuclear Energy [Commission of Elders, 1982], which *confirms and supplements the 1976 conclusions and recommendations.*

1982: Resolution of the Chamber of Representatives of 2 July 1982 [Chamber, 1982], which ratifies the choice of reprocessing, considering *"that Belgium must maximise the benefit of the investments that have been made within its borders in the field of reprocessing and decides in favour of restarting the Eurochemic reprocessing plant [...]. With regard to the excess fuel and while awaiting new reprocessing infrastructures better suited to domestic production, it considers that reprocessing can only be carried out in foreign facilities."*

1983: Resolution of the Senate of 18 March 1983 on restarting the Eurochemic plant [Senate, 1983], which closes the parliamentary debate on the energy policy announced in 1974 and according to which *"In order to maximise the benefit of the investments made in Belgium in the field of reprocessing, the necessary measures must be taken to restart the 'Eurochemic' plant."*

1987: Updated version of the report of the Evaluation Commission for Nuclear Energy [Commission of Elders, 1987], which aimed to provide an objective record of the issue, particularly with regard to the economic aspects of using nuclear energy and the fuel cycle, taking into account the elements highlighted by the Chernobyl accident.

1990: Report by the Nuclear Safety Information and Enquiry Commission on the issue of radioactive waste [Chernobyl Commission, 1990], which aimed to review and assess the provisions relating to the proper treatment and conditioning of radioactive waste in particular.

1990: Recommendations of the Nuclear Safety Information and Enquiry Commission approved by the Senate on 11 October 1990 after being amended [Senate, 1990], which include the *"Creation of a Commission comprised of Belgian and foreign experts not related to the decisions already made for reprocessing and responsible for delivering a detailed study of the Belgian situation. [...] Pending the parliamentary debate, there is a need to review whether past contracts with COGEMA in la Hague can be suspended and, in any case, no new similar contract shall be agreed."*

1990: Government communication of 19 November 1990 [Government, 1990] on the energy policy which contains the Senate's recommendation: *"before a new reprocessing contract is signed, irreversibly committing the Belgian industry, the government intends to appoint a commission comprised of Belgian and foreign experts to assess the advantages and disadvantages of this option in terms of the management of the irradiated fuel from an economic and ecological viewpoint as well as in terms of security*."

Inset 2 – Historical overview of the steps leading to the current situation in terms of the national policy for the management of spent fuel from commercial nuclear power plants (continued).

1992: **Report on the management of spent fuel in Belgium and the use of MOX fuel in Belgian power plants** [Ministry of Economic Affairs *et al.*, 1992] with a view to the parliamentary debate on these issues.

1993: **Resolution of the Chamber of Representatives of 22 December 1993** [Chamber, 1993], which orders the government

"1) in the future, to no longer prioritise the reprocessing strategy compared with the conditioning and direct disposal strategy (once through cycle)*. The government can therefore no longer consider reprocessing as the obvious reference strategy. It must create the conditions to allow the conditioning and direct disposal strategy to be developed as an alternative;*

2) for a period of 5 years:

- *not to execute the reprocessing contract agreed in 1990;*
- *not to exercise the options provided for by this contract, that Belgium should exercise in 1995;*
- *not to negotiate any new contract during this period dedicated to reviewing alternative solutions;*

3) to prioritise research and development, including internationally, so as to be able eventually to carry out the direct disposal of irradiated fuel, without reducing the current research programme in the field of deep disposal of reprocessing waste. […];

4) to submit to the Chamber, within 5 years, the elements for a new global evaluation of the situation, based in particular on the following criteria: non-proliferation, waste management, security, the protection of workers, the public and the environment, together with the economic aspects;

5) given the result of the legal analyses requested by the government and the Chamber of Representatives regarding the financial consequences that would arise from the termination of the reprocessing contract agreed in 1978, to allow the contract to run its term. The government shall review the possibility of transferring some of its reprocessing capacities for irradiated fuel not yet shipped to la Hague to a third party;

6) to allow the use of the plutonium from the 1978 reprocessing contract in the form of MOX fuel in Belgian nuclear power plants, in accordance with the review of currently possible destinations and the results of the safety analysis. This provides in particular that the nuclear power plants are not modified;

7) meanwhile, to ensure that:

- *the electricity producers and Synatom provide safe temporary storage for irradiated fuel;*
- *the electricity producers and Synatom conduct security studies (workers and population) and feasibility studies for the industrial conditioning of irradiated fuel;*
- *all the costs, investments and various primary or additional charges which are related to nuclear electricity production and the nuclear fuel cycle are charged to the electricity producers. These costs cannot be imposed on third parties;*

[…]

14) to communicate these conclusions, with a view to their execution, to the representatives of all the bodies concerned in the energy sector."

1993: **Decision of the Council of Ministers of 24 December 1993** [Council of Ministers, 1993], through which, in particular, *the government fully accepts the mission entrusted to it by the Chamber of Representatives.* In a letter of 2 February 1994, the Minister responsible for Energy confirmed his decision to implement the Chamber's resolution to Synatom.

1998: **Summary and evaluation report of the works conducted by the institutions and companies concerned, drafted in execution of the Chamber's resolution of 1993** [Administrations, 1998]
Was not submitted to Parliament by the government.

1998: **Decision of the Council of Ministers of 4 December 1998** [Council of Ministers, 1998b], by which, in particular, the government asks Synatom

- *to terminate, as soon as possible and at the latest by 23 December 1998, the reprocessing contract for 225 tonnes of fuel, agreed in 1991 with COGEMA, including the options provided for in this contract;*
- *not to sign any new reprocessing contracts without its formal agreement;*

and asks the organisations concerned

- *to prepare within an adequate period of time a report providing a more comprehensive and detailed view of the back-end of the nuclear fuel cycle.*

From 1998 to June 2014: The situation remains basically unchanged.

2014: **Law of 3 June 2014** [Belgian Official Journal, 2014c], which specifically stipulates that

- *national policies for the management of radioactive waste and spent fuel are based on at least six general principles, including the principle according to which the generation of radioactive waste shall be kept to the minimum which is reasonably practicable by means of various measures, including reprocessing;*
- *national policies contain the accepted hypotheses for the further use of the different types of spent fuel on the proposal of the holders of the spent fuel and after consultation with ONDRAF/NIRAS and FANC.*

5.2 Spent fuel from research reactors [subjects (a) to (d), (i) and (j)]

Until ONDRAF/NIRAS takes charge of spent fuel from research reactors in the form of reprocessing waste or as radioactive waste, the spent fuel is managed by its owners:

- SCK•CEN manages the spent fuel from the BR2 and BR3 reactors (table 5 in section 7.4.2) and will have to manage the spent fuel from the BR1 and VENUS reactors;
- Ghent University declared the spent fuel from the Thétis reactor as radioactive waste to ONDRAF/NIRAS, which took charge of it (table 5 in section 7.4.2).

The choices about the management of spent fuel are conditioned by

- the specific characteristics of the fuel;
- the existence of facilities able to reprocess it;
- the compatibility of the management solution for the end of the cycle for the fuel in question with the long-term management of reprocessing waste or spent fuel declared as waste.

Management policies and objectives [subject (a)] and inventory [subject (c)] The situation at 31 December 2014 is as follows.

- The *BR1 reactor* is still using its first fuel load. There is not yet a policy for its management. The expected inventory of BR1 fuel amounts to 29 t.
- The spent fuel from the *BR02 zero-power reactor* was reconditioned by CERCA, a subsidiary of AREVA, which fabricated new assemblies for the BR2 reactor.
- The spent fuel from the *BR2 reactor*, for which there were reprocessing solutions, is subject to a reprocessing policy.
  - In 1993, SCK•CEN signed a contract with UKAEA Dounreay (which became DSRL) for the reprocessing of 240 spent fuel assemblies from BR2 [Wathelet, 1993]. This fuel was reprocessed and the contract has ended.
  - In 1998, SCK•CEN signed a contract with COGEMA (which became AREVA NC) for the reprocessing at la Hague of the spent fuel that will be generated until BR2 stops operating [Di Rupo, 1997]. Within this framework, 1172 fuel assemblies have been reprocessed to date. This contract is ongoing. It was however suspended in 2006 and its continuation required a bilateral agreement between France and Belgium, ratified in 2014 (section 4.2.4) [Belgian Official Journal, 2014b]. One of its features is that it provides for the transfer of ownership of the residual quantities of uranium and plutonium to AREVA NC.

  Medium-level and high-level radioactive waste generated by the reprocessing of spent fuel from BR2 has been conditioned on site, repatriated to Belgium and taken charge of by ONDRAF/NIRAS. It is stored in ONDRAF/NIRAS' building 136 at Belgoprocess (table 5 in section 7.4.2). The inventory of future reprocessing waste is currently estimated to be approximately 0,5 m^3 of high-level conditioned waste.
- The spent fuel from the *BR3 reactor*, in the process of being dismantled since 1990, was declared as radioactive waste to ONDRAF/NIRAS by SCK•CEN. This fuel, which amounts to 2,4 tHM, has been dry stored in "dual purpose" transport and storage casks in a dedicated ONDRAF/NIRAS building at Belgoprocess since 2002 (table 5 in section 7.4.2). This fuel is still the property of SCK•CEN. In accordance with the terms of the agreement between ONDRAF/NIRAS and SCK•CEN, ONDRAF/NIRAS provides safe storage for a maximum duration of 50 years, pending an operational solution for its long-term management.

- The fuel from the *VENUS zero-power reactor*, which is similar to the spent fuel from BR3, but with a very low burnup, was unloaded in 2008 for further use when the reactor was transformed into VENUS-F (chapter 8). This fuel is stored at SCK•CEN.

  The fuel from the *VENUS-F reactor* of the GUINEVERE subcritical reactor project does not belong to SCK•CEN. It is supplied by the *Commissariat à l'énergie atomique et aux énergies alternatives* (Alternative Energies and Atomic Energy Commission) (France).

- The spent fuel from the *Thétis reactor* was declared as radioactive waste to ONDRAF/NIRAS by Ghent University and conditioned by Belgoprocess. It is stored in ONDRAF/NIRAS' building 155 at Belgoprocess as category B waste (table 5 in section 7.4.2).

Concepts / management plans [subject (d)] and timeframes [subject (b)] The spent fuel definitively unloaded from the BR2 reactor is placed in a cooling pond for a period of at least three years. It can then be transported to AREVA NC in la Hague to be reprocessed there. The current bilateral agreement provides for the repatriation of reprocessing waste before the end of 2030.

Financing [subject (i)] SCK•CEN is responsible for financing the management of its spent fuel from the research reactors for fuel loaded into the reactors after 1 January 1989. The Federal State is responsible, through the SCK•CEN technical liabilities fund, managed by ONDRAF/NIRAS, for fuel loaded into the reactors prior to 1 January 1989 (section 7.3.2). SCK•CEN makes the necessary provisions to cover the end-of-cycle costs for its fuel. These provisions are audited annually and ONDRAF/NIRAS evaluates them every five years as part of its nuclear liabilities inventory mission (section 7.3.2).

Transparency and participation [subject (j)] The bilateral agreement between Belgium and the French Republic on the reprocessing of spent fuel from BR2 at AREVA NC La Hague was subject to debate in the Belgian Parliament, the report of which is available on the Chamber and Senate websites.

6 Management of radioactive waste by producers

Producers manage their radioactive waste with a view to its clearance or before it is taken charge of by ONDRAF/NIRAS, under their responsibility and in accordance with the provisions of the nuclear licences issued by the safety authority and the approvals issued by ONDRAF/NIRAS. They finance this management through their annual or multi-annual budgets (see section 7.3.2 for the creation of provisions by producers for the decommissioning of their nuclear facilities and management of the resulting radioactive waste by ONDRAF/NIRAS). The management of very short-lived waste (section 6.2) and the management by Umicore of its radium-bearing waste in licensed storage facilities (section 6.3) are two special cases of radioactive waste management by producers in general (section 6.1).

6.1 Management of radioactive waste by producers in general

Radioactive waste producers endeavour to limit their radioactive waste generation at source. These efforts rely on optimising industrial practices and limiting volumes of materials that meet the definition of radioactive waste, for example by improving decontamination techniques, optimising dismantling techniques for nuclear equipment and facilities that have been put out of service, using recycling and reuse options as well as clearance possibilities, in accordance with the applicable regulations. Thus, as part of the remediation of the SCK•CEN site, and in particular the decommissioning of the BR3 reactor, SCK•CEN has invested in metal decontamination facilities. In particular, these decontamination facilities have made it possible to clear or fusion recycle the entire primary circuit. As for radioactive waste from infrastructure, this is minimised through SCK•CEN's use of advanced decontamination and characterisation techniques for concrete with a view to its clearance after treatment.

Radioactive waste producers are required to sort their waste according to its physical, chemical and radiological characteristics and each batch of waste that they are asking ONDRAF/NIRAS to take charge of must be accompanied by a detailed approval and characterisation file demonstrating that the waste complies with the ONDRAF/NIRAS acceptance criteria that are applicable to it (section 7.2.2).

Producers generally store their radioactive waste in non-conditioned form on their sites until ONDRAF/NIRAS takes charge of it, at the producers' request. Some producers (mainly Electrabel) do however carry out their own treatment and conditioning for some of their radioactive waste, which they then store until ONDRAF/NIRAS takes charge of it. The treatment, conditioning and storage of radioactive waste by producers are subject to the provisions of the nuclear licences issued by the safety authority. The treatment, conditioning, storage and characterisation equipment used must also be approved by ONDRAF/NIRAS (section 7.2.2). Finally, some producers subcontract treatment operations abroad, with a view to the partial recycling of metals in foundries, and then recover the corresponding radioactive waste.

Radioactive waste producers are required to avoid any excessive accumulation of radioactive waste on their sites. Inspections carried out jointly or independently by FANC, in its capacity as control authority, and by ONDRAF/NIRAS help to identify potential accumulations. ONDRAF/NIRAS has the right to access producer facilities and sites under its mission designed to prevent the creation of new nuclear liabilities (section 7.3.2) and the power to inspect under its competences regarding the approval of equipment (section 7.2.2). ONDRAF/NIRAS informs FANC of situations where it finds an excessive accumulation of radioactive waste. The FANC Law also enables FANC to order, at the cost

of the entity responsible, the removal of radioactive substances that pose a problem for the safety of workers and the public, and their management as radioactive waste by ONDRAF/NIRAS.

6.2 Management of very short-lived radioactive waste [subject (a)]

Almost all very short-lived radioactive waste comes from hospitals and medical research laboratories that use radioactive substances for therapeutic or diagnosis purposes. Given that the general regulations for radiation protection allow the clearance of waste when its activity level has sufficiently decreased, management by decay and subsequent clearance is a management policy for the potentially concerned waste.

Through the appropriate FANC licences, the internal departments of the hospitals and medical research laboratories manage their own very short-lived radioactive waste and store it in dedicated premises where it remains for anything from a few weeks to several years, until its activity has decreased enough for it to be cleared into the conventional, non-radioactive waste system in accordance with the approved procedures and the general regulations for radiation protection. The cleared waste does not therefore end up in ONDRAF/NIRAS' management system: the Regions have jurisdiction over its management. Such waste is no longer subsequently referred to in this national programme.

6.3 Umicore's management of its radium-bearing radioactive waste in licensed storage facilities

Umicore (formerly Union Minière) manages, under its responsibility, at its Olen site, two storage facilities subject to nuclear licences. These facilities, namely the UMTRAP and Bankloop facilities, contain radium-bearing radioactive waste that comes, directly or indirectly, from the activities of the radium and uranium extraction plant operated by Union Minière between 1922 and 1977 in Olen and then dismantled [ONDRAF/NIRAS & Umicore, 2012] (see chapter 11 for a description of the radium-bearing issue in its entirety).

- The *UMTRAP storage facility*, built in the 1980s by Union Minière, which was licensed for an indefinite period in 1991 by the safety authority at the time, contains approximately 55 000 m^3 of low-level or medium-level, long-lived non-conditioned waste, which has a specific radium-226 activity from 20 Bq/g to 30 000 Bq/g and represents a total activity estimated at 38 000 GBq.
- The *Bankloop storage facility*, licensed for 10 years by FANC in 2006, contains approximately 30 000 m^3 very low-level and low-level, long-lived non-conditioned waste from the remediation in 2007–2008 of a small brook, the Bankloop, and a band of contaminated land along both sides of it. This waste has a specific homogeneous radium-226 activity of 3,2 Bq/g and represents a total activity of 140 GBq.

The issue of the long-term management of the radioactive waste contained in the UMTRAP and Bankloop storage facilities is being considered as part of a much broader framework (chapter 11) [ONDRAF/NIRAS, 2015].

7 Management of radioactive waste by ONDRAF/NIRAS

The description of ONDRAF/NIRAS' management of radioactive waste is structured into four sections:

- a short description of the Belgian classification of radioactive waste, which is consistent with the IAEA 2009 classification [IAEA, 2009] (section 7.1);
- a general description of the existing management system, which focuses on its key components; this section does not contain an assessment, nor does it contain quantitative data (section 7.2);
- a description of the organisation for financing the management (section 7.3);
- a systematic, qualitative and quantitative review of the management of the different categories of radioactive waste, which gives a practical illustration of the general description given in section 7.2 and which contains cost elements (section 7.4).

Long-term management, for which ONDRAF/NIRAS is solely responsible, guides all the previous steps in the management system.

7.1 Classification of radioactive waste

For the long-term management of radioactive waste, ONDRAF/NIRAS has adopted a classification consisting of three categories [5], defined in accordance with the classification proposed in 1994 by the IAEA [IAEA, 1994] and that recommended by the European Commission in 1999 [EU, 1999].

- *Category A waste* is short-lived, low-level and medium-level conditioned waste containing limited quantities of long-lived radionuclides. It poses a risk to people and the environment for several hundreds of years. It can be considered for surface or near-surface disposal. It corresponds to low-level waste in the IAEA 2009 classification.
- *Category B waste* is low-level and medium-level conditioned waste contaminated with such quantities of long-lived radionuclides that it poses a risk to people and the environment for several tens to several hundreds of thousands of years in some cases [6]. Its thermal power is potentially significant at the time of its conditioning, but it will emit too little heat after the storage period to be classified as category C waste. It corresponds to medium-level waste in the IAEA 2009 classification.
- *Category C waste* is high-level conditioned waste containing large quantities of long-lived radionuclides and which, like category B waste, poses a risk for several tens to several hundreds of thousands of years in some cases. After the period currently considered for its storage (60 years, in the event of storage in poorly indurated clay — see section 7.4.2), its thermal power still causes a significant increase in the temperature of the repository's host medium. It corresponds to high-level waste in the IAEA 2009 classification. Category C waste includes vitrified waste from the reprocessing of spent fuel from commercial nuclear power plants and non-reprocessed spent fuel declared as waste, except for certain fuels from research reactors, which belong to category B.

[5] These categories do not cover the radium-bearing radioactive waste contained in Umicore's licensed storage facilities in Olen (section 6.3).

[6] Sealed sources that must be managed as radioactive waste end up in category B after treatment and conditioning.

7.2 General description of the management system

Since the early 1980s, ONDRAF/NIRAS has gradually developed and implemented a consistent management system aimed at protecting people and the environment from the risks presented by the radioactive waste that it takes charge of [ONDRAF/NIRAS, 2008]. This system is comprised of a sequence of technical steps (section 7.2.3) and these steps are connected together through an acceptance system for the waste designed to ensure, at each management step, the compatibility of the waste characteristics with the requirements ensuing from the subsequent steps (section 7.2.2). The entire system relies on a good knowledge of the technical inventory of radioactive waste to be managed (section 7.2.1). Other activities, that cut across the entire management system or are specific to a given step, complete the system (section 7.2.4).

7.2.1 Technical inventory

In accordance with its missions, ONDRAF/NIRAS has drawn up an inventory of all the radioactive waste that it has to manage and keeps this updated. This inventory has a section referring to quantities, a radiological section and a physico-chemical section. It is based on the knowledge of waste stored in ONDRAF/NIRAS' buildings operated by Belgoprocess and declarations from producers regarding their total future generation of spent fuel that will be declared as waste and radioactive waste from operating, dismantling and reprocessing operations (sections 7.4.1 and 7.4.2).

7.2.2 Acceptance system [subject (l)]

The acceptance system guarantees that the interdependencies between the successive steps in the management of radioactive waste due to the radiological and physico-chemical characteristics of such waste are taken into account in ONDRAF/NIRAS' management system. This system aims to ensure that at each step in the management chain, the radioactive waste has characteristics that are deemed compatible with the requirements ensuing from the subsequent steps in its management (figure 3) [ONDRAF/NIRAS & FANC, 2012].

There are three parts to the acceptance system.

- The establishment, by ONDRAF/NIRAS, of the *acceptance criteria* which non-conditioned and conditioned waste must satisfy for ONDRAF/NIRAS to take charge of it, as well as the establishment of the terms for transferring the ownership of this waste from the producers to ONDRAF/NIRAS. The acceptance criteria have been established based on the general rules drawn up by ONDRAF/NIRAS in accordance with the provisions of the ONDRAF/NIRAS Royal Decree [Belgian Official Journal, 1981] and approved by the competent authority on 10 February 1999 [Van den Bossche, 1999]. These also take into account the provisions of the nuclear licences for the transport of radioactive waste and the operation of treatment, conditioning and storage facilities for this waste. Once the long-term management solutions for category A, B and C waste are well established, the acceptance criteria will be adapted to take into account the requirements specific to these solutions and, subsequently, the provisions of the nuclear licences for construction, called "construction and operation licences" in the general regulations for radiation protection.
- The *approval*, by ONDRAF/NIRAS, in accordance with the provisions of the Royal Decree of 18 November 2002 [Belgian Official Journal, 2002b], of the treatment and conditioning equipment and processes, including the primary packagings of conditioned waste (i.e. the

confirmation that these facilities, processes and packagings are suitable for producing waste that complies with the applicable acceptance criteria), the approval of the methods for determining the radiological content and physico-chemical characteristics of non-conditioned and conditioned waste, and the approval of the storage buildings.

- The *acceptance*, by ONDRAF/NIRAS, of the conditioned or non-conditioned waste packages delivered by producers, after the administrative and technical verification of their compliance with the applicable acceptance criteria. This acceptance is accompanied by payment from the waste producers of a tariff intended to cover the cost of the waste's short-term, medium-term and long-term management (section 7.3.1) and by the transfer of ownership of the waste to ONDRAF/NIRAS. In the case of delivery of non-conditioned waste, the waste is also subject to a technical acceptance by ONDRAF/NIRAS, after its conditioning by Belgoprocess.

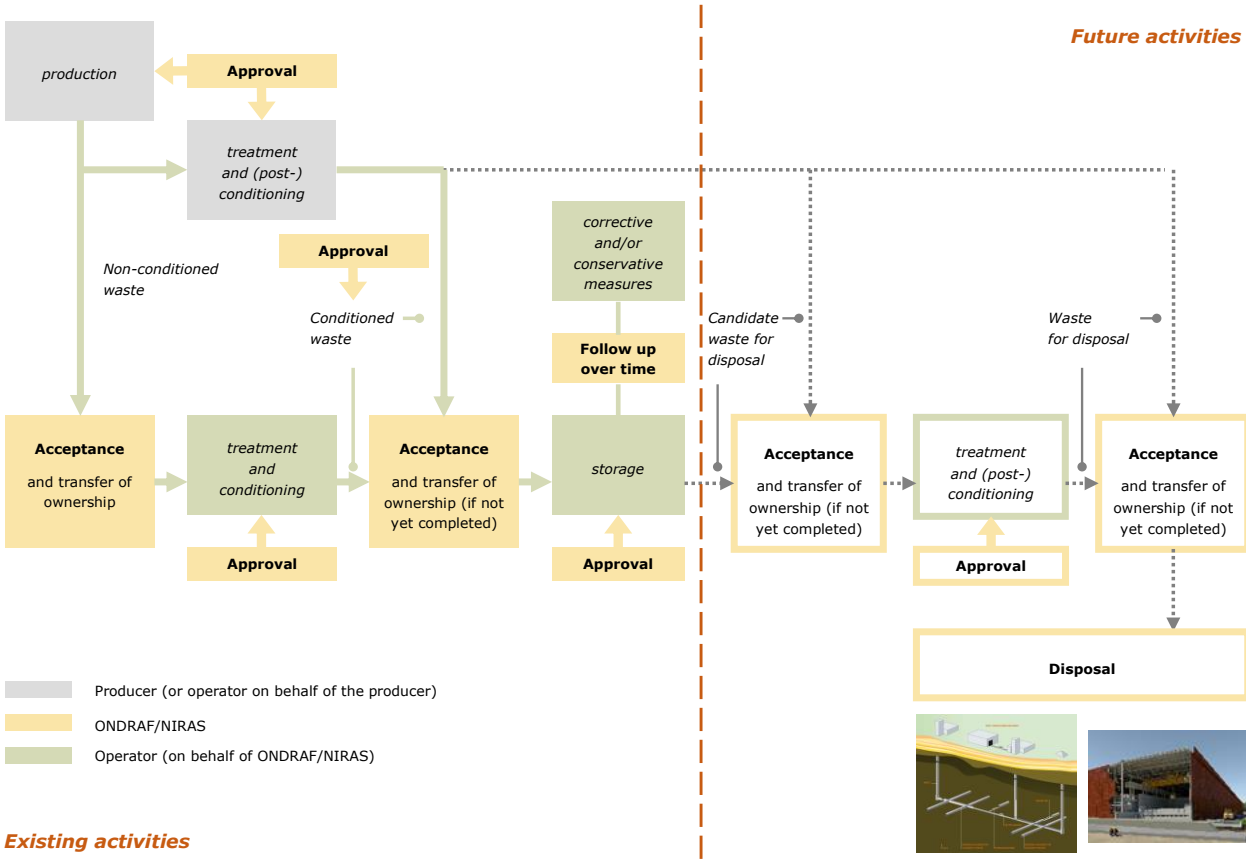

Figure 3 – Simplified diagram of the ONDRAF/NIRAS acceptance system for radioactive waste (after [ONDRAF/NIRAS & FANC, 2012]). The system currently in force for the acceptance of non-conditioned and conditioned waste will be extended to waste for disposal.

The acceptance system is applicable to waste which is treated and conditioned in Belgium, as well as waste from the reprocessing of Belgian spent fuel abroad which is then treated and conditioned on site before being returned to Belgium. This waste comes from the reprocessing of Synatom's spent fuel at la Hague and the reprocessing of spent fuel from SCK•CEN's BR2 research reactor at la Hague and Dounreay (chapter 5).

Radioactive waste from the treatment of contaminated equipment and materials of Belgian origin abroad, which is returned to Belgium, must be accompanied by detailed characterisation files demonstrating that it complies with ONDRAF/NIRAS' requirements.

7.2.3 Operational management in steps [subject (a)]

ONDRAF/NIRAS' radioactive waste management system comprises a series of steps that can be grouped into short-term (primarily treatment and conditioning — section 7.2.3.1), medium-term (primarily storage — section 7.2.3.2) and long-term (primarily disposal — section 7.2.3.3) management activities. The short-term and medium-term management activities are part of a policy of centralised, safe management in Mol–Dessel (inset 3). However, works on the disposal of radioactive waste are at very different stages of progress. This general section is complemented by the specific sections 7.4.1 and 7.4.2.

7.2.3.1 Short-term management

The short-term management of non-conditioned radioactive waste includes its collection, treatment and conditioning. Treatment and conditioning are a series of mechanical, chemical and physical operations designed to convert non-conditioned radioactive waste into packages that satisfy the operational requirements for handling, transport, storage and the final destination.

- Waste treatment aims to concentrate the radioactivity as much as possible in order to reduce the volumes of materials to be considered as radioactive waste and put these materials in a suitable physical and chemical state for conditioning. Treatment is generally performed by incineration, supercompaction or cutting for solid waste and by flocculation or evaporation for liquid waste.
- The conditioning of treated waste is performed by immobilising the waste in a matrix of glass, cement or bitumen, usually in cylindrical metal packaging. Vitrification and bituminization were practised in Belgium until 1991 and 2004 respectively.

ONDRAF/NIRAS subcontracts the treatment and conditioning activities for the radioactive waste of which it has taken charge to Belgoprocess, but retains responsibility for these activities (section IV.B.1 in [Kingdom of Belgium, 2014]).

7.2.3.2 Medium-term management

Medium-term management includes the storage of conditioned waste packages, pending a safe solution for their long-term management, and monitoring over time. This monitoring aims to control whether the conditioned waste packages remain compliant with the acceptance criteria that were applicable when they were accepted and remain compatible with their reference final destination. The first monitoring control of selected accepted packages must take place three years after their acceptance and subsequent controls at least every ten years during the storage period.

The storage buildings are located on Belgoprocess' site 1 and operated by Belgoprocess on behalf of ONDRAF/NIRAS (annex 3 in [Kingdom of Belgium, 2014]).

Inset 3 – Historical overview of the key steps that led to the policy of centralised management of treatment, conditioning and storage of radioactive waste at Mol–Dessel [BNS, 1994; NEA, 1996; SCK•CEN, 2002].

1952: The Belgian State creates the Belgian Research Centre for Nuclear Energy Applications (SCK-CEAEN), a non-profit organisation that in 1957 would become a public utility establishment called the Belgian Nuclear Research Centre (SCK•CEN).

1956: SCK•CEN (Mol) begins to build facilities for the treatment and conditioning of the mainly low-level, radioactive waste that it generates, that will make up its Waste department. SCK•CEN offers to take charge of the low-level radioactive waste of other producers and to treat or store it in its facilities. Often lacking management facilities, the other producers gradually begin to call on SCK•CEN and the trend of centralising the management of low-level waste becomes more widespread over time.

1956–1964: Commissioning of the experimental reactors BR1, BR02, BR2, BR3 and VENUS by SCK•CEN, which becomes the largest producer of radioactive waste in Belgium. (The BR02 reactor has been dismantled.)

1957: Belgium is one of four candidate countries for the construction of a pilot reprocessing plant for spent fuel, as part of the international project to create the company Eurochemic. The Dessel site is subsequently selected by the study group for the construction of this plant, in particular because of the proximity of the SCK•CEN research facilities and the signing by twelve member countries of the OEEC (which became the Organisation for Economic Co-operation and Development or OECD in 1961) of an agreement on the creation of the company Eurochemic.

1966: Eurochemic starts operating a pilot reprocessing plant in Dessel. The operation of this plant is a significant new source of radioactive waste, due to both the quantities generated and its radiological characteristics.

1969: The Belgian electricity producers create a specialist body called Synatom, responsible for coordinating certain common interest activities. In 1977, this becomes the *Société belge des combustibles nucléaires* (Belgian company for nuclear fuel).

1974: Eurochemic's reprocessing activities cease on the decision of its Board of Directors.

1975: The Belgoprocess study group is created, comprised of 50% of representatives from the Belgian State and 50% of representatives from the Belgian electricity producers, brought together under Synatom. The desire to restart the reprocessing plant and to take its capacity from 40 to 300 tonnes/year (reduced to 60 tonnes/year in 1976) is clearly announced.

1975: The Belgian State and the main private waste producers create the Belgowaste study group to analyse how to structure radioactive waste management formally and define the responsibilities and missions of the various actors so as to develop adequate and safe infrastructures, able to satisfy the concerns expressed by the public. Indeed, the cooperation which was freely established between SCK•CEN and waste producers is not based on any legal or regulatory obligation and SCK•CEN is unable to treat certain types of waste, which are therefore accumulating on its site.

1978: Commissioning of the Eurobitum facility on the Eurochemic site, designed for the treatment and bituminization of medium-level waste generated on site, and of the Eurostorage building (building 127) to store this waste.

1978: Agreement between the Belgian State and the company Eurochemic governing the transfer of ownership of the Eurochemic site and facilities to the Belgian State or a company to be established by it [Belgian State & Eurochemic, 1978].

1980: Commissioning on the SCK•CEN site of the BRE facility for the concentration of low-level and medium-level effluents.

1980: Following the works by Belgowaste, the legislature creates ONDRAF/NIRAS, a public body responsible for the management of radioactive waste present in Belgium [Belgian Official Journal, 1980]; the creation of ONDRAF/NIRAS is followed in 1981 by the setting out of its missions and functioning rules in a royal decree. ONDRAF/NIRAS would have to take over the activities of SCK•CEN which fall under its competence along with the personnel and facilities concerned [Belgian Official Journal, 1981].

1981: Construction of the PAMELA facility, designed for the vitrification of high-level effluents from reprocessing, begins on the Eurochemic site; it is followed in 1983 by the construction of a building for the storage of vitrified waste (building 129).

1984: Synatom, the company that owns the fuel of the commercial nuclear power plants, creates the company Belgoprocess, a wholly-owned subsidiary of Synatom, with a view to the possibility of bringing the Eurochemic facilities back into service.

1984: Following the 1983 moratorium on disposal at sea, ONDRAF/NIRAS begins to construct buildings for the storage of low-level waste (buildings 150 and 151) on the Eurochemic site.

1986: Synatom abandons its project to bring the reprocessing plant back into service. This would therefore have to be dismantled and the management of the dismantling waste and other waste accumulated on the site would require the construction of new treatment/conditioning and storage facilities, likely to be used to manage waste from other producers as well.

1986: At the request of the Federal State, the Belgoprocess shares, held by Synatom, are transferred to ONDRAF/NIRAS. ONDRAF/NIRAS is tasked with managing Eurochemic's facilities and operational waste and decommissioning its disused facilities. It entrusts these tasks to Belgoprocess and the site, on which there are several storage buildings, becomes Belgoprocess' site 1 (site BP1).

1989: The Federal State transfers ownership and operation of the site and facilities of SCK•CEN's Waste department to ONDRAF/NIRAS along with the radioactive waste stored there. ONDRAF/NIRAS entrusts the site's operation to Belgoprocess, which takes over the SCK•CEN personnel that were there. The site becomes Belgoprocess' site 2 (site BP2).

7.2.3.3 Long-term management

The Belgian, European and international legal and regulatory framework stresses each country's responsibility to manage its own radioactive waste and stipulates that long-term management solutions must be such that they offer a final destination for waste. In other words, and as stated by Directive 2011/70/Euratom [EU, 2011] and the Law of 3 June 2014 [Belgian Official Journal, 2014c], waste must, eventually, be placed in a repository, i.e. placed in a management facility without the intention to retrieve it. The Law of 3 June 2014 stipulates however that national policies in terms of radioactive waste management must contain methods for reversibility and retrievability, taking account of the need to ensure the safety of the repository. The European and international legal and regulatory framework also stipulates that radioactive waste must, unless otherwise specified, be disposed of in the Member State in which it was generated. As a consequence, ONDRAF/NIRAS' works on developing and implementing disposal solutions for category A, B and C waste aim to develop solutions to be implemented on Belgian territory. These works also include the four aspects of a sustainable solution, namely the technical and scientific, environmental and safety, financial and economic, as well as societal and ethical aspects.

The design and development of repositories are based on a systemic approach: these facilities, and their engineered barriers in particular, are designed according to the characteristics of the host medium and the waste to be isolated and confined so that the combination "site + engineered barriers + waste" as a whole can passively protect people and the environment, i.e. in such a way that the long-term safety after complete closure of the facility is assured without requiring human intervention [ONDRAF/NIRAS, 2011a; ONDRAF/NIRAS, 2013e].

On 31 January 2013, ONDRAF/NIRAS submitted the nuclear licence application, needed to begin the construction of the surface repository for category A waste, to FANC (section 7.4.1). This application is pending.

For many years ONDRAF/NIRAS has been conducting an RD&D programme on geological disposal for category B and C waste (section 7.4.2).

7.2.4 Other activities

Other activities, which are cross-cutting through the entire management system or are specific to a given step, are activities such as transport, pre-industrial studies on surface disposal, RD&D on geological disposal, economic studies on long-term management and communication.

7.3 Description of the organisation for financing the management [subject (i)]

After the acceptance process, ONDRAF/NIRAS takes charge of the radioactive waste from producers against payment by these producers of a tariff intended to cover the cost of short-term, medium-term and long-term management of this waste (section 7.3.1). For their part, in principle, producers make provisions to cover their future decommissioning costs, including the cost for ONDRAF/NIRAS to manage the radioactive waste from dismantling, while owners of the spent fuel make provisions in particular for ONDRAF/NIRAS to manage their reprocessing waste and/or spent fuel declared as waste (section 7.3.2). As part of its legal mission to produce a five-yearly inventory of nuclear liabilities, ONDRAF/NIRAS makes recommendations on organising coverage for these management costs

[ONDRAF/NIRAS, 2013a]. This general section is complemented by some quantitative data in sections 7.4.1 and 7.4.2.

7.3.1 Mechanisms set up by ONDRAF/NIRAS

In accordance with the provisions of the ONDRAF/NIRAS Law [Belgian Official Journal, 1980], ONDRAF/NIRAS must divide its costs, estimated at cost price, proportionally between the beneficiaries of its services, namely the radioactive waste producers. The allocation of responsibilities between ONDRAF/NIRAS and the producers is set out in the contracts between them.

The costs of managing radioactive waste can be divided into three main areas, which are financed using separate methods [ONDRAF/NIRAS, 2011a]:

- short-term management activities (section 7.3.1.1),
- medium-term and long-term management activities (section 7.3.1.2),
- technical inventory, acceptance system and other activities, particularly RD&D (section 7.3.1.3).

An insolvency fund is intended to cover financial obligations regarding decommissioning and radioactive waste management of defaulting producers (section 7.3.1.4).

7.3.1.1 Financing of short-term management activities

Financing for the treatment and conditioning of radioactive waste is provided via two different mechanisms:

- the “main” radioactive waste producers, namely Synatom, Electrabel, FBFC International, Belgonucleaire, IRE and SCK•CEN on the one hand and the Federal State as the financially liable entity for nuclear liabilities on the other hand, finance the treatment and conditioning of their waste in accordance with the provisions of the agreements between them and ONDRAF/NIRAS. Since 1996, these agreements have been based on a capacity reservation system that stipulates that each “main” producer guarantees the payment to ONDRAF/NIRAS of an agreed fraction of the fixed costs for the treatment and conditioning facilities and the payment of the variable operating costs for the management of its waste as it is accepted by ONDRAF/NIRAS. In practice, the “main” producers pay their share of the fixed costs according to a contractual schedule and pay the tariff amounts corresponding to the variable portion of the costs for the treatment and conditioning of their non-conditioned waste as ONDRAF/NIRAS takes charge of it. Pursuant to the provisions in the agreements, these tariffs can be revised every five years.
- the “small” radioactive waste producers finance the treatment and conditioning of their waste through so-called “all-in” tariff payments that cover the treatment, conditioning, storage, long-term management and general activities.

7.3.1.2 Financing of medium-term and long-term management activities

Financing for the medium-term and long-term management of radioactive waste must cover the cost of technical activities and the cost of so-called “associated” conditions which accompany the implementation of disposal projects. Indeed, local populations who agree to the disposal of radioactive waste on their territory and the related detriment serve the public interest, which justifies some form of compensation. Technical costs are covered by tariff payments made by waste producers

into a centralised fund, the long-term fund. The costs of associated conditions will be covered by the medium-term fund.

Long-term fund The long-term fund, created in accordance with the ONDRAF/NIRAS Law and operational since early 1999, is ONDRAF/NIRAS' responsibility. Its mechanism is based on a capitalisation system. It is provisioned by radioactive waste producers every time they transfer new waste to ONDRAF/NIRAS, according to a funding mechanism which, in principle, ensures that ONDRAF/NIRAS will eventually be able to cover its fixed costs and enables it to cover its variable costs as they arise.

Currently, the long-term fund mechanism is such that tariff increases are carried forward on waste still to be taken charge of by ONDRAF/NIRAS from the revision date of the tariffs. This means that the very last producer delivering waste to ONDRAF/NIRAS would potentially have to cover the management costs for the radioactive waste from all other producers, where such costs have not been covered by these producers. This system will have to be made compliant with the provisions of the Royal Decree of 25 April 2014 [Belgian Official Journal, 2014a], which amends the ONDRAF/NIRAS Royal Decree, by 31 December 2018 at the latest. This new decree, which specifies the guiding principles for provisioning the long-term fund, stipulates indeed that, from now on, tariff increases will be passed onto producers based on their full programme for generating radioactive waste, in other words, both the waste that they have already transferred to ONDRAF/NIRAS and the waste still to be transferred.

Medium-term fund The medium-term fund is designed to cover the costs of implementing the conditions associated with a disposal project, including potentially creating a local development fund (section 7.4.1), so that the project taken as a whole — or integrated project — presents added value for the local populations concerned. In accordance with the provisions of the ONDRAF/NIRAS Law, the medium-term fund will be financed by a so-called "integration" contribution levied against the radioactive waste producers and calculated based on the total capacity of the repository and the respective total waste quantities from the producers that are intended to be disposed of within it. The amount of the medium-term fund for surface disposal is set by the ONDRAF/NIRAS Law at 130 million EUR_{2010} to be indexed. The obligation for producers to contribute to the medium-term fund begins as soon as the repository has been the subject of a nuclear construction and operation licence and the necessary non-nuclear permits. The medium-term fund must be fully established no later than three months after the confirmation licence, which allows its commissioning, is issued.

7.3.1.3 Financing of the technical inventory, acceptance system and other activities, particularly RD&D

The technical inventory, acceptance system and other activities are financed based on the terms set out in the bilateral agreements with waste producers. These usually provide for quarterly advance payments with settlement based on the closure of ONDRAF/NIRAS' annual accounts.

7.3.1.4 Insolvency fund

The insolvency fund, implemented in 1992, is, in accordance with the provisions of the ONDRAF/NIRAS Law, mainly intended to finance services for the management of radioactive waste and the decommissioning of nuclear facilities that are not covered following the bankruptcy or insolvency of the financially liable entities, which are implicitly identified as not including the financially liable entities for class I nuclear facilities. The insolvency fund also covers the cost of

managing sources declared by FANC as orphans and waste. It does not cover services resulting from the bankruptcy or insolvency of entities that are financially liable for radium-bearing radioactive waste from old radium extraction activities and NORM radioactive waste (chapter 11).

The insolvency fund is financed by invoicing a reserve of 5% calculated on the cost of the transport, treatment, conditioning and storage services invoiced to producers by ONDRAF/NIRAS.

7.3.2 Provisions made by the producers and ONDRAF/NIRAS' nuclear liabilities inventory mission

As part of its legal missions, every five years, ONDRAF/NIRAS draws up an inventory of the nuclear facilities and sites containing radioactive substances, estimates the management cost, i.e. all the costs for decommissioning, remediation, radioactive waste management and, if necessary, managing spent fuel, to be charged to each financially liable entity and evaluates the existence and sufficiency of the provisions made to cover the costs. In connection with this, it also evaluates the availability of these provisions. This mission, called the "nuclear liabilities inventory", is financed by fees charged to nuclear facilities operators and holders of radioactive substances or, failing this, their owners.

The nuclear liabilities inventory [ONDRAF/NIRAS, 2013a] is primarily a financial exercise, which should enable ONDRAF/NIRAS' supervisory authority to ensure that every financially liable entity (table 3) plans in time the necessary resources to cover its management costs or, if this is not the case, should enable it to impose the necessary corrective measures in a timely fashion. This inventory also contains recommendations on organising coverage for the costs of managing spent fuel and radioactive waste.

The organisation of the financing for the management is currently provided for by the following elements:

- general elements of law (civil law, accounting law, administrative law, tax law, etc.);
- various specific legislation and regulations, principally
  - the ONDRAF/NIRAS Law and Royal Decree (sections 4.2.5 and 7.3.1);
  - the Law of 11 April 2003 on the provisions relating to the dismantling of nuclear power plants and the management of the spent fuel (inset 4 at the end of section 7.3.2);
  - provisions relating to cases where different institutional bodies are held financially responsible, primarily provisions relating to the financial liability of the Federal State regarding the nuclear liabilities of Belgoprocess, SCK•CEN and IRE (section 4.2.5).

Table 3 – Summary, drawn up from the third nuclear liabilities inventory report by ONDRAF/NIRAS [ONDRAF/NIRAS, 2013a], of the (main) financially liable entities responsible for covering the management costs associated with a selection of significant sites in Belgium and the main financing mechanisms established by these entities, and similar information for several specific waste groups (orphan sources and "potential" radium-bearing and NORM radioactive wastes).

Sites (or groups of waste)	Financially liable entities (main)	Main financing mechanisms
Electrabel (Doel and Tihange)	Operational waste: Electrabel	Annual budget
	Spent fuel and dismantling: Synatom	"External" accounting provisions with additional measures
FBFC International (Dessel)	FBFC International	Accounting provisions with additional measures
Belgonucleaire (Dessel)	Belgonucleaire	Accounting provisions with additional measures
SCK•CEN (Mol)	Excluding liabilities: SCK•CEN	Accounting provisions with additional measures
	Liabilities: Federal State	External fund, without separate legal personality, with additional measures
IRMM (Geel)	European Commission	Budget planning
Universities	Universities	Accounting provisions, annual budget or none depending on who is responsible
IRE (Fleurus)	Liabilities: Federal State	External fund, without separate legal personality, with additional measures
Private radioisotope production companies	The companies concerned	Accounting provisions
	Special case of a company declared bankrupt and no longer having financial resources (2012): – financing by the Walloon Region through an internal fund for the management costs referred to in agreements prior to the bankruptcy; – for the management costs not referred to in these agreements, financing through the insolvency fund	
Hospitals	Hospitals	Accounting provisions or none depending on who is responsible
Belgoprocess (Mol and Dessel)	Excluding liabilities: ONDRAF/NIRAS	Internal funds with additional measures
	Liabilities: Federal State	External fund, without separate legal personality, with additional measures
Umicore (UMTRAP, Bankloop and "potential" radium-bearing radioactive waste) (Olen)	Umicore	Accounting provisions
Orphan sources	—	Insolvency fund
"Potential" NORM radioactive waste	Site operator, user or owner	Environmental accounting provisions, not specific to potential costs for management of NORM waste as radioactive waste

Inset 4 – Overview of the Law of 11 April 2003 *on the provisions created for the dismantling of nuclear power plants and the management of fissile materials irradiated in these power plants* and its implementation [Belgian Official Journal, 2003d].

The Law of 11 April 2003 makes Synatom responsible for ensuring coverage of the costs of dismantling nuclear power plants, including the cost of managing the resulting radioactive waste, and of managing the fuel irradiated in these power plants. It

- stipulates that Synatom makes provisions for the dismantling and management of irradiated fuel in its accounts;
- stipulates that Electrabel [1] and companies with a share in industrial electricity production by fission must pay Synatom the amounts corresponding to the contributions to the provisions for the dismantling and management of irradiated fuel;
- states that if such provisions prove to be insufficient during dismantling or fuel management operations, Electrabel and the companies with a share in industrial electricity production by fission of nuclear fuels will make contributions to cover the insufficiency of these provisions;
- authorises Synatom to loan to Electrabel, at the market rate for industrial credit, the equivalent value of the provisions, up to a maximum of 75% of the total amount of these provisions, provided that Electrabel can be considered a good quality debtor. This maximum percentage of 75% can be modified by royal decree debated in the Council of Ministers;
- introduces a so-called "negative pledge" into the loan agreements, by which Electrabel is prohibited from subjecting its assets to any mortgage or other security for its financial debt, except if it can constitute or procure an equivalent security for Synatom, on the understanding that this prohibition shall include the usual exceptions for existing securities, securities established in the normal course of business and securities for the acquisition of new assets;
- requires that Synatom retains, at all times, sufficient liquidity, in the form of cash investments or disposable assets, so as to be able to finance all expenses related to dismantling and the management of its irradiated fuel for the next three years of operation;
- establishes the Commission for Nuclear Provisions, for which it specifies the composition and to which it gives an advisory and control competence over the setting up and management of provisions.
  The Commission for Nuclear Provisions issues opinions, binding for Synatom, regarding
  - the methods of making provisions for dismantling and fuel management and periodically evaluates the appropriate nature of these methods;
  - the revision of the maximum percentage of the financial resources representing the equivalent value of the provisions that Synatom can loan to Electrabel;
  - the asset categories in which Synatom invests the share of the financial resources that it cannot loan to Electrabel and the conditions under which these investments are made.

  The Commission for Nuclear Provisions requires ONDRAF/NIRAS' opinion for its opinions and decisions regarding the existence and sufficiency of the provisions. Every year, it submits an activity report to the Minister responsible for Energy, who sends this report to the federal legislative Chambers and ensures appropriate publicity for the report;
- requires that Synatom provides a report to the Commission for Nuclear Provisions every three years describing the basic arrangements for making provisions, such as the underlying strategic approach, the development programme, the implementation programme, the calendar, the estimated financial resources required, the amount of expenses and the payment schedule;
- grants a general lien on Electrabel's movable property, in favour of Synatom, as soon as the Commission for Nuclear Provisions orders Synatom to demand the full or partial repayment of the loans concerned. This lien guarantees the repayment of the loans concerned up to the repayment amount set by the Commission for Nuclear Provisions.

In practice, and with regard to the management of spent fuel, Synatom's periodic report, the most recent dated 2013, compares various management options and takes into account:

- the best current knowledge of the costs relating to the purchase of casks, the loading and transport of casks, the operation of existing storage facilities, the construction of additional storage facilities, etc.;
- the bids for reprocessing services sent by AREVA NC;
- ONDRAF/NIRAS' contractual tariffs for taking charge of the radioactive waste;
- the technical and economic analysis of the feasibility of the industrial conditioning of spent fuel conducted by Synatom during the 1994–2001 period;
- an initial evaluation of the cost of geological disposal of the conditioned spent fuel produced by ONDRAF/NIRAS.

[1] The designation "nuclear operators" used in the law has been replaced by "Electrabel", which is currently the only operator that satisfies the definition of nuclear operator given in the law.

7.4 Systematic review of the management of category A, B and C waste

The systematic, qualitative and quantitative review of the management of category A (section 7.4.1) and categories B and C (section 7.4.2) radioactive waste gives a practical illustration of the general description of ONDRAF/NIRAS' radioactive waste management system given in section 7.2.

7.4.1 Category A waste [subjects (a) to (f), (h) and (j)]

ONDRAF/NIRAS' management of category A waste is summarily reviewed in table 4, in relation to subjects (a) to (f), (h) and (j) stipulated by Directive 2011/70/Euratom and the Law of 3 June 2014. Only the national policy for the long-term management of such waste is discussed in the text itself, below.

From 1960 until 1982, Belgium, like many other countries at the time, applied the policy of disposal at sea for the long-term management of its category A waste [Claes, 1978]. During this period, SCK•CEN arranged for approximately 30 000 tonnes of radioactive waste to be disposed of into the North Atlantic, in agreement with the safety authority and in accordance with the radiological standards set by the IAEA. From 1970, this practice was also conducted under the supervision of the OECD's Nuclear Energy Agency (NEA). In 1984, Belgium voluntarily subscribed to the 1983 de facto international moratorium on this issue between the signatory countries to the London Convention on the Prevention of Marine Pollution [Belgian Official Journal, 1984]. This moratorium became a definitive ban in 1993, a decision to which the Belgian Government subscribed in 1994.

The national policy in terms of the long-term management of category A waste is now surface disposal on the territory of the municipality of Dessel. This solution is designed to ensure long-term passive safety. In other words, once the repository is completely closed and after release from regulatory control, the system created by the facility and its site will be able to protect people and the environment without requiring human intervention.

Two decisions by the Council of Ministers can be considered as establishing the national policy in terms of the long-term management of category A waste.

- On 16 January 1998, the Council of Ministers opted for *"a solution that was definitive or could become definitive, and was progressive, flexible and reversible"* for the long-term management of category A waste [Council of Ministers, 1998a; Di Rupo, 1998], based on a report by ONDRAF/NIRAS comparing the various possible options for this management particularly from a safety, environmental and financial perspective [ONDRAF/NIRAS, 1997].
- On 23 June 2006, on the basis of four preliminary disposal projects developed within the partnerships established on a voluntary basis between ONDRAF/NIRAS and the municipalities of Mol and Dessel [STOLA-Dessel, 2004; MONA, 2005], the Council of Ministers decided that category A waste would be disposed of on the territory of the municipality of Dessel [Council of Ministers, 2006; Verwilghen, 2006]. The preliminary technical projects, developed from proposals drafted by ONDRAF/NIRAS, were integrated into larger projects (preliminary integrated projects), comprising a significant societal aspect. In its decision, the Council of Ministers specifically requested that ONDRAF/NIRAS continue to develop the integrated surface disposal project in Dessel, maintain the existing participative process and even extend it.

On 31 January 2013, the detailed studies for the integrated surface disposal project in Dessel, conducted in close consultation with the local populations concerned through the STORA (formerly STOLA-Dessel) partnership in Dessel and the MONA partnership in Mol, resulted in ONDRAF/NIRAS

submitting a nuclear construction and operation licence application for the repository to FANC [ONDRAF/NIRAS, 2013b]. This application is currently being considered by FANC.

Table 4 – Summary analysis of the management route for waste that becomes category A waste in relation to subjects (b) to (f), (h) and (j) stipulated by Directive 2011/70/Euratom and the Law of 3 June 2014. The other subjects are covered in other parts of the national programme (see table 1 in chapter 2).

<table>
<tr><th>Management steps and subjects studied</th><th>Analysis</th></tr>
<tr><td colspan="2">1. SHORT-TERM MANAGEMENT</td></tr>
<tr><td colspan="2">Treatment and conditioning</td></tr>
<tr><td>Concepts / management plans (d)</td><td>The CILVA facility is Belgoprocess' main operational facility for the treatment and conditioning of most (in volume) of the non-conditioned waste taken charge of by ONDRAF/NIRAS that becomes category A waste after conditioning. CILVA is used for the treatment, by supercompaction, incineration or cutting, of low-level solid and liquid waste and the conditioning by cementation of the resulting supercompacted solid or powdered waste (section IV.B.1 in [Kingdom of Belgium, 2014]).
ONDRAF/NIRAS plans to build a new reception and storage centre for low-level, medium-level and high-level, non-conditioned waste.</td></tr>
<tr><td>RD&D (f)</td><td>Certain treatment and conditioning processes are subject to improvement. In particular, these improvements look at aspects related to the ageing of waste in storage.</td></tr>
<tr><td>Timeframes (b)</td><td>Scheduled date for the commissioning of the reception and storage centre for non-conditioned waste: 2018.</td></tr>
<tr><td>Costs (h)</td><td>Covered by the tariff payments that accompany ONDRAF/NIRAS' taking charge of the waste (section 7.3.1.1).</td></tr>
<tr><td>Transparency and participation (j)</td><td>Websites and annual reports of ONDRAF/NIRAS and Belgoprocess, possibility to visit the BP1 and BP2 sites, information meetings.</td></tr>
<tr><td colspan="2">2. MEDIUM-TERM MANAGEMENT</td></tr>
<tr><td colspan="2">Storage</td></tr>
<tr><td>Inventory (c)</td><td>Conditioned waste stored at Belgoprocess at 31 December 2013 (after [Kingdom of Belgium, 2014])
(see heading 3.1 for the total inventory of existing or planned waste)
<table>
<tr><th>Category</th><th>Building</th><th>(commissioned)</th><th>Package volume [m³]</th><th>Number of packages</th><th>Occupancy rate</th></tr>
<tr><td>A</td><td>150</td><td>(1986)</td><td>1 914</td><td>3 317</td><td>99%</td></tr>
<tr><td></td><td>151</td><td>(1988)</td><td>14 153</td><td>35 114</td><td>98%</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Total: 38 431</td><td></td></tr>
</table></td></tr>
<tr><td>Concepts / management plans (d)</td><td>ONDRAF/NIRAS plans to build a storage building dedicated to waste packages presenting an ASR (alkali-silica reaction) phenomenon. This will free up storage capacity in buildings 150 and 151 [ONDRAF/NIRAS & Belgoprocess, 2014].</td></tr>
<tr><td>RD&D (f)</td><td>See heading 1.</td></tr>
<tr><td>Timeframes (b)</td><td>Scheduled date for the commissioning of the storage building dedicated to waste packages presenting an ASR phenomenon: 2018.</td></tr>
<tr><td>Costs (h)</td><td>Covered by the tariff payments to the long-term fund that accompany ONDRAF/NIRAS' taking charge of the waste (section 7.3.1.2).
The cost of the future building dedicated to packages presenting an ASR phenomenon will be borne by the producers concerned.</td></tr>
<tr><td>Transparency and participation (j)</td><td>Websites and annual reports of ONDRAF/NIRAS and Belgoprocess, possibility to visit the BP1 and BP2 sites, information meetings.</td></tr>
</table>

3. LONG-TERM MANAGEMENT

3.1 Post-conditioning and disposal

Inventory (c)

Existing or planned waste (over a realistic period, variable depending on the (type of) waste producer, but that may exceed 50 years in some cases), with the assumption that each of the seven commercial nuclear reactors will be operated during 40 years [ONDRAF/NIRAS, 2010]: 70 500 m^3.
This volume is comprised of both conditioned waste packages and monoliths of future bulk waste and should not consequently be compared to the volume of the stored conditioned waste packages.

The 10-year extension in the operating period for the Tihange 1 reactor in late 2013 will not have a significant impact on the waste volumes to be managed (annex 7 in [GEMIX, 2009]).

Concepts / management plans (d)

The integrated surface disposal project includes the disposal project itself and five associated components presenting socio-economic benefits for the region [ONDRAF/NIRAS, 2010; ONDRAF/NIRAS, 2013c].

The disposal project itself comprises mainly

- the *modular repository*, composed of adjoining modules in reinforced concrete designed to receive monoliths, in other words caissons in which waste packages or bulk waste have been immobilised in mortar.
  The modules are fitted with a side inspection gallery at their base and there is an inspection space and a drainage system beneath each one for the timely detection of any fissures or water infiltration. The modules are constructed on a multi-layer embankment almost three metres thick to ensure that they are always above the water level, even in the case of very heavy rain or flooding.
  Once a module is filled with monoliths, the remaining gaps are filled with gravel, which allows the retrieval of the monoliths if necessary, and the module is then closed with a concrete top slab.
  Each module is protected from the elements for the duration of its use by a fixed steel roof. This roof is designed to be replaced, when the repository is fully closed, by a permanent, low permeability cover comprised of various natural and artificial protection layers forming a tumulus.
- an *access road* and a *transfer dock* along the Bocholt-Herentals canal in order to limit local road traffic due to the construction then the operation of the repository as far as possible; these developments should also benefit companies on the neighbouring industrial estate;
- a *caisson plant*;
- a *monolith production facility*.

The associated components presenting socio-economic benefits for the region are as follows:

- a communication path which, specifically, will become a hub for information about radioactive waste management and which will have multi-purpose premises that can be made available to the local communities;
- a so-called “local” fund to support or finance projects and activities that improve the quality of life of the local population over the short, medium and long terms;
- continued consultation and participation throughout the entire life of the project;
- the development of employment and retention of nuclear knowledge in the region;
- a project to monitor the health of the region’s inhabitants.

RD&D (f)

The RD&D is structured around the following themes in particular [ONDRAF/NIRAS, 2010; ONDRAF/NIRAS, 2013c]:

- long-term safety;
- the long-term behaviour of the concretes;
- improvement of construction techniques;
- the monitoring and study over several decades of the behaviour of a test cover representative of the planned multi-layer cover;
- long-term knowledge management;
- the methods for continued societal participation.

Timeframes (b)

The following table presents the most accurate calendar currently available for the implementation of the integrated disposal project. Some of the integrated project's components have already been implemented. The implementation of the others is subject to the granting of the nuclear construction and operation licence for the repository, or may begin on the positive opinion of the FANC Scientific Council on the licence application file for the repository.

Project component	Calendar	
Access road	acceptance 19 November 2014	
Transfer dock	acceptance 7 October 2013	
Caisson plant	construction starts	T_0 = positive opinion of the FANC Scientific Council on the licence application file for the repository + 3 months
	operation starts	T_0 + 2 years
Monolith production facility	construction starts	T_0 = positive opinion of the FANC Scientific Council on the licence application file for the repository + 3 months
	operation starts	T_0 + 4 years (non-nuclear) construction and environment permits issued early 2013 nuclear construction and operation licence issued 11 April 2014
Repository	construction starts	T_1 = date nuclear construction and operation licence is granted for the repository + 3 months (application submitted to FANC 31 January 2013; case under review)
	operation starts	T_1 + 4 years
	operation ends	T_1 + 54 years
	complete closure	T_1 + 104 years
Communication path	construction starts	mid-2016
	operation starts	end 2019
Local fund	setting up starts	date nuclear construction and operation licence is granted for the repository

Costs (h)

- Cost of the disposal project itself (construction, operation, closure and institutional control): 1,25 billion EUR_{2012} (undiscounted cost, margins for risks included);
- Cost of associated conditions: capped at 130 million EUR_{2010} to be indexed [Belgian Official Journal, 1980].

Transparency and participation (j)

Participation: partnerships methodology, underway since 1998 [STOLA-Dessel, 2004; MONA, 2005; PaLoFF, 2005; ONDRAF/NIRAS, 2005a; ONDRAF/NIRAS, 2005b; ONDRAF/NIRAS, 2005c; ONDRAF/NIRAS, 2006a; ONDRAF/NIRAS, 2006b; Bergmans, 2005; NEA, 2010; ONDRAF/NIRAS, 2010]:

- co-development of preliminary integrated disposal projects with ONDRAF/NIRAS;
- close consultation with ONDRAF/NIRAS for the development of the integrated project to be implemented.

Transparency:

- ONDRAF/NIRAS' dedicated website, ONDRAF/NIRAS' electronic newsletter, websites of the STORA and MONA partnerships, cAt project leaflets, information evenings, open days, etc.;
- FANC website.

Maintaining transparency and participation is an integral part of the integrated disposal project.

3.2 Post-closure phase

Post-closure concepts (e)

The post-closure concept is still to be introduced into the regulations.

A monitoring and control programme designed to verify the proper functioning of the repository is planned. This specifically includes the following elements [ONDRAF/NIRAS, 2013c]:

- the facility's environmental impact (principally radiological monitoring of the ambient air quality, the soil and the ground and surface waters);
- checks of the base of the modules from the inspection space, detection of water in the inspection space, characterisation of the drainage water, etc.;

	▪ monitoring of control structures; ▪ groundwater level measurements as information intended for hydrogeological models.
RD&D (f)	Monitoring and study over several decades of the behaviour of a test cover representative of the multi-layer cover.
Timeframes (b)	Intention to maintain monitoring and controls for 250 years after the complete closure of the repository [ONDRAF/NIRAS, 2013c].
Costs (h)	See heading 3.1 above.
Transparency and participation (j)	Maintaining transparency and participation until the controls are ended is an integral part of the integrated disposal project. Financing through a local fund, long after the closure of the repository, of projects improving the local quality of life will be the living memory of the repository.

7.4.2 Category B and C waste [subjects (a) to (f), (h) and (j)]

ONDRAF/NIRAS' management of category B and C waste is summarily reviewed in table 5, in relation to subjects (a) to (f), (h) and (j) stipulated by Directive 2011/70/Euratom and the Law of 3 June 2014, using the same approach as for the review of the management of category A waste. However, the situation differs in terms of a national policy for long-term management, since contrary to the case of category A waste, and as discussed below, there is not yet a national policy for the long-term management of category B&C waste.

RD&D on the geological disposal of category B&C waste in Boom Clay has not revealed any prohibitive element regarding either safety or feasibility. It was extended to geological disposal in Ypresian Clay during the 2000s [SAFIR Commission, 1990; SAFIR 2 Committee, 2001; NEA, 2003; ONDRAF/NIRAS, 2011a; ONDRAF/NIRAS, 2013e]. In September 2011, ONDRAF/NIRAS submitted its strategic plan for the long-term management of B&C waste, or the B&C Waste Plan, to its supervisory authority [ONDRAF/NIRAS, 2011a]. This plan was supported by both the environmental impact assessment to which it was subject pursuant to the SEA Law [Resource Analysis, 2010] and the statement summarising how ONDRAF/NIRAS had taken account of the results of this impact assessment and the consultation of official bodies, including FANC, and the general public [ONDRAF/NIRAS, 2011b]. The statement and the executive summary of the B&C Waste Plan were published in the Belgian Official Journal on 30 September 2011.

The solution for the long-term management of B&C waste that ONDRAF/NIRAS recommends in its B&C Waste Plan is geological disposal in poorly indurated clay (Boom Clay or Ypresian Clay) in a single repository on Belgian territory. This solution is designed to ensure long-term passive safety. It was selected after a comparison of the reasonably possible management options made as part of the environmental impact assessment procedure, based on the four aspects of a sustainable solution (technical and scientific, environmental and safety, financial and economic, as well as societal and ethical aspects). It allows the long-term management of all B&C waste, including non-reprocessed spent fuel and waste from reprocessing. It is subject to conditions set out in the conclusions of the Waste Plan.

Pursuant to the Law of 3 June 2014 and based on its B&C Waste Plan, in 2015, ONDRAF/NIRAS plans to send a proposal for a national policy for the long-term management of B&C waste to the Ministers responsible for Energy and the Economy. At the same time, it continues its RD&D activities on geological disposal in poorly indurated clay.

Table 5 – Summary analysis of the management route for waste that becomes category B or C waste in relation to subjects (b) to (f), (h) and (j) stipulated by Directive 2011/70/Euratom and the Law of 3 June 2014. The other subjects are covered in other parts of the national programme (see table 1 in chapter 2).

<table>
<tr><th>Management steps and subjects studied</th><th>Analysis</th></tr>
<tr><td colspan="2">1. SHORT-TERM MANAGEMENT</td></tr>
<tr><td colspan="2">Treatment and conditioning</td></tr>
<tr><td>Concepts / management plans (d)</td><td>Belgoprocess has operational facilities for the treatment and conditioning of most (in volume) of the non-conditioned waste taken charge of by ONDRAF/NIRAS and which becomes category B waste after conditioning (section IV.B.1 in [Kingdom of Belgium, 2014]). The main facilities are as follows:
■ PAMELA facility, currently used for the treatment of solid waste containing alpha emitters and medium-level or high-level solid waste, by cutting or supercompaction, and its conditioning by cementation;
■ HRA-Solarium facility, for the treatment and conditioning of medium-level waste and certain radium-bearing radioactive waste by compaction and cementation;
■ CILVA facility, for the treatment, by supercompaction, incineration or cutting, of low-level solid and liquid waste and the conditioning by cementation of the resulting supercompacted solid or powdered waste.
ONDRAF/NIRAS plans to build a new reception and storage centre for low-level, medium-level and high-level, non-conditioned waste.</td></tr>
<tr><td>RD&D (f)</td><td>Support for the development and improvement of treatment and conditioning or reconditioning processes (for example for resins or organic waste).</td></tr>
<tr><td>Timeframes (b)</td><td>Scheduled date for the commissioning of the reception and storage centre for non-conditioned waste: 2018.</td></tr>
<tr><td>Costs (h)</td><td>Covered by the tariff payments that accompany ONDRAF/NIRAS' taking charge of the waste (section 7.3.1.1).</td></tr>
<tr><td>Transparency and participation (j)</td><td>Websites and annual reports of ONDRAF/NIRAS and Belgoprocess, possibility to visit the BP1 and BP2 sites, information meetings.</td></tr>
<tr><td colspan="2">2. MEDIUM-TERM MANAGEMENT</td></tr>
<tr><td colspan="2">Storage</td></tr>
<tr><td>Inventory (c)</td><td>Conditioned waste stored at Belgoprocess at 31 December 2013 (after [Kingdom of Belgium, 2014])
(see heading 3.1 for the total inventory of existing or planned waste)
<table>
<tr><th>Category</th><th>Building</th><th>(commissioned)</th><th>Package volume [m³]</th><th>Number of packages</th><th>Occupancy rate</th></tr>
<tr><td>B</td><td>127</td><td>(1976)</td><td>3 863</td><td>15 855</td><td>83%</td></tr>
<tr><td></td><td>136D [1]</td><td>(2009)</td><td>104</td><td>462</td><td>17%</td></tr>
<tr><td></td><td>155 [2, 3]</td><td>(2006)</td><td>1 404</td><td>3 442</td><td>33%</td></tr>
<tr><td>C</td><td>129</td><td>(1985)</td><td>215</td><td>2 335</td><td>86%</td></tr>
<tr><td></td><td>136C [1]</td><td>(2000)</td><td>70</td><td>390</td><td>66%</td></tr>
<tr><td></td><td></td><td></td><td></td><td>Total: 22 484</td><td></td></tr>
</table>
[1] Building 136 has been specifically designed for the storage of radioactive waste from reprocessing.
[2] Including conditioned radium-bearing radioactive waste.
[3] The spent fuel from the Thétis research reactor has been declared as radioactive waste to ONDRAF/NIRAS by Ghent University and conditioned by Belgoprocess. It is stored in building 155, as category B waste.</td></tr>
</table>

	The spent fuel from the BR3 research reactor has been declared as radioactive waste to ONDRAF/NIRAS by SCK•CEN. It is dry stored at Belgoprocess in a dedicated building, building 156, in execution of the agreement to this effect between ONDRAF/NIRAS and SCK•CEN. It remains the property of SCK•CEN.
Concepts / management plans (d)	Studies are underway to evaluate the needs in terms of storage capacities.
Timeframes (b)	See subject (d) above.
Costs (h)	Covered by the tariff payments to the long-term fund that accompany ONDRAF/NIRAS' taking charge of the waste (section 7.3.1.2).
Transparency and participation (j)	Websites and annual reports of ONDRAF/NIRAS and Belgoprocess, possibility to visit the BP1 and BP2 sites, information meetings.

3. LONG-TERM MANAGEMENT

3.1 Post-conditioning and disposal

Inventory (c)	Existing or planned waste (over a realistic period, variable depending on the (type of) waste producer, but that may exceed 50 years in some cases), with the assumption that each of the seven commercial nuclear reactors will be operated during 40 years [ONDRAF/NIRAS, 2011a]: ▪ category B [1]: 11 100 m^3 – 10 430 m^3 (depending on the future management of commercial spent fuel); ▪ category C: 600 m^3 – 4 500 m^3 (depending on the future management of commercial spent fuel). [1] including radium-bearing radioactive waste, conditioned or intended to be conditioned and stored at Belgoprocess (total volume of conditioned waste estimated at 2 290 m^3), but excluding radium-bearing radioactive waste in the Umicore licensed storage facilities in Olen. The 10-year extension in the operating period for the Tihange 1 reactor in late 2013 will not have a significant impact on the waste volumes to be managed (annex 7 in [GEMIX, 2009]).
Concepts / management plans (d)	ONDRAF/NIRAS plans to dispose of category B and C waste in a single facility [ONDRAF/NIRAS, 2011a]. At the present stage of the studies, the repository considered is a generic facility for poorly indurated clay. It has been developed based on knowledge about Boom Clay. The validity of its design would have to be confirmed for Ypresian Clay. The geological repository considered consists of a network of horizontal galleries built at mid-thickness in the clay layer. Shafts provide access to a main gallery which leads to the disposal galleries, of a smaller diameter. These galleries are divided into several sections dedicated to groups of wastes with similar characteristics. The system of engineered barriers considered for category C waste is based on the use of supercontainers designed to confine the radionuclides and chemical contaminants during the thermal phase, i.e. during the period during which the temperature of the host formation is greater than the temperature range for which the migration properties have been validated, particularly due to the temperature increase caused by such waste. These supercontainers are units formed by an overpack in carbon steel (and the container(s) of vitrified waste or spent fuel that it contains) and the thick layer of concrete protection surrounding it. For handling reasons, category B waste is placed in concrete caissons and subsequently embedded in mortar to form monoliths. Both the supercontainers and monoliths provide radiological shielding to protect workers during handling on the surface and during the operation and closure of the repository. After emplacement of the waste, empty spaces in the disposal galleries are backfilled with materials chosen for their capacity to contribute to the system's overall safety. All access galleries and shafts are backfilled and sealed at the end of underground operations, potentially after a period of in situ controls. The system created by the facility, the waste that it contains and the host formation must then ensure passive safety. After closure, the geological repository can be controlled from the surface, and future generations can prolong the controls for as long as they wish. Controls intended to prevent the risk of nuclear proliferation will be compulsory in the case of the disposal of spent fuel. The solution of geological disposal in poorly indurated clay is flexible enough to be adapted to variations in the volumes of B&C waste to be managed. The surface area of the facility for the inventory of existing or planned B&C waste is approximately 2 km^2 in the case of full reprocessing of all spent fuel from commercial nuclear power plants and approximately 3 km^2 in the case of the disposal of this fuel in conditioned form [Resource Analysis, 2010].

	The development of concepts for the surface facilities that will be needed, particularly regarding the fabrication of the supercontainers and caissons and for putting category C waste into supercontainers and category B waste into caissons for its disposal, is being considered.
RD&D (f)	RD&D in terms of geological disposal of B&C waste was started by SCK•CEN in 1974 and continued from the early 1980s under the aegis of ONDRAF/NIRAS, which has retained SCK•CEN as main partner for the research. In accordance with a Resolution of the Chamber of 22 December 1993, ONDRAF/NIRAS gives equal consideration to the geological disposal of reprocessing waste and that of non-reprocessed spent fuel from commercial nuclear power plants in conditioned form [Chamber, 1993]. *Key scientific and technical knowledge acquired:* RD&D in terms of geological disposal in poorly indurated clay has not revealed any prohibitive element regarding either safety or feasibility [SAFIR Commission, 1990; SAFIR 2 Committee, 2001; NEA, 2003; ONDRAF/NIRAS, 2011a; ONDRAF/NIRAS, 2013e]. The HADES underground laboratory in Boom Clay, the construction of which started in 1980 and which has subsequently been extended several times, is a first-class RD&D tool [EURIDICE, 2014]. The excavation of the PRACLAY gallery in 2007, perpendicular to the main gallery, demonstrated the feasibility of building gallery crossings in deep poorly indurated clay. The PRACLAY gallery is designed for the installation of an in situ real-scale heater experiment, planned for a minimum duration of 10 years and aiming to confirm the good behaviour of the clay and the gallery lining under the influence of a thermal load comparable to that which would be caused by category C waste. This test began in late 2014, after many years of preparation. *Principal future RD&D activities*, in the event that the technical solution recommended by ONDRAF/NIRAS for the long-term management of B&C waste is confirmed: ONDRAF/NIRAS' future RD&D programme was subject to a detailed report, which identifies the RD&D priorities with a view to drafting a first safety and feasibility case (safety and feasibility case 1 or SFC1) while already indicating RD&D subjects for the longer term [ONDRAF/NIRAS, 2013e]. Future RD&D will have to establish the arguments to support the decisions marking out the decision-making process. Thus, it will aim to confirm, refine and integrate the knowledge acquired, develop certain areas of knowledge and demonstrate directly or indirectly all aspects not yet demonstrated in the construction, operation and closure of a repository. Future RD&D will also cover the participative process of the disposal project. The RD&D programme has always been and remains conducted and reviewed within the scope of multilateral or bilateral international cooperation.
Timeframes (b)	Indicative, scientific and technical, development and implementation schedule for a geological repository established assuming disposal in poorly indurated clay: ■ construction and operation licence: T_0; ■ start of disposal of category B waste: T_0 + 15 years; ■ start of disposal of category C waste: T_0 + 55 years, given the need to allow category C waste to cool at the surface for a minimum of 60 years in order to avoid undue disturbances in the host formation; ■ complete closure of the repository: T_0 + 100 years minimum.
Costs (h)	■ Repository (construction, operation, closure and institutional control): approximately 3,2 billion EUR_{2012} (undiscounted cost, margins for risks included) [ONDRAF/NIRAS, 2013d] Principal hypotheses: generic concept for disposal in Boom Clay, at a depth similar to that of the HADES laboratory, and full reprocessing for all commercial spent fuel. ■ RD&D: approximately 360 million EUR_{2008} for the 1974–2014 period, which is approximately 9 million EUR_{2008} per year, for all RD&D activities related to geological disposal, including the costs for the HADES laboratory [ONDRAF/NIRAS, 2011a]. This average annual cost is likely to continue.
Transparency and participation (j)	Transparency: ■ dedicated websites of ONDRAF/NIRAS and EURIDICE, possibility to visit the HADES underground laboratory; ■ FANC website. Participation as part of the development of the B&C Waste Plan: ■ societal consultation at ONDRAF/NIRAS' instigation in the form of a series of dialogue days, an interdisciplinary conference and a public forum [ONDRAF/NIRAS, 2011a; King Baudouin Foundation, 2010];

	▪ consultation procedure with official bodies, including FANC, and the general public under the SEA Law, the results of which were taken into account when finalising the Waste Plan [ONDRAF/NIRAS, 2011b]. As with the disposal project for category A waste, in its B&C Waste Plan [ONDRAF/NIRAS, 2011a], ONDRAF/NIRAS plans to develop the long-term management solution for B&C waste within a participative framework.
3.2 Post-closure phase	
Post-closure concepts (e)	The post-closure concept is still to be introduced into the regulations. ONDRAF/NIRAS committed itself to [ONDRAF/NIRAS, 2011a]: ▪ ensure operational reversibility and examine the measures that may facilitate the potential retrieval of the waste packages after partial or complete closure of the repository for a period to be defined in consultation with the stakeholders, including FANC; ▪ maintain the controls for the proper functioning of the disposal system which will be performed in addition to the regulatory controls for a period to be defined in consultation with the stakeholders, including FANC; ▪ make the most appropriate preparations for the transfer of knowledge about the repository and the waste it contains to future generations.
RD&D (f)	Studies underway on the controls, reversibility and retrievability.
Timeframes (b)	The definition of schedules, for RD&D and for the post-closure phase itself, is premature.
Costs (h)	See heading 3.1 above.
Transparency and participation (j)	In its Waste Plan, ONDRAF/NIRAS plans to conduct a societal consultation on the requirements for waste retrievability, controllability of the disposal system and knowledge transfer, this within the scope of the decision-making process to be established.

8 Expertise and skills, including RD&D [subject (f)]

Article 8 of Directive 2011/70/Euratom on the expertise and skills of the personnel of the parties concerned by the management of spent fuel and radioactive waste was transposed into Belgian law by Article 5 of the Law of 3 June 2014. This last article will be applicable once its implementing rules have been established by royal decree. The acquisition, maintenance and development of the necessary expertise and skills are nevertheless concerns that have already been taken into account, as illustrated by the following examples:

- the very existence, for over 60 years, of SCK•CEN, a research centre dedicated to pacific applications of radioactivity (see also inset 3 in section 7.2.3.2) [SCK•CEN, 2002];
- the organisation, by the Belgian Nuclear Higher Education Network (BNEN), a consortium of six Belgian universities and SCK•CEN, of a post-graduate qualification in nuclear engineering, which comprises in particular a course on the nuclear fuel cycle and a course on MOX and thorium fuels, radiochemistry and dismantling;
- the organisation, by SCK•CEN, of a SCK•CEN Academy, which organises courses in all SCK•CEN's RD&D fields, especially radioactive waste management;
- the retention of the nuclear knowledge in the Mol–Dessel region as a condition set by the local communities for constructing the surface repository for category A waste on the territory of the municipality of Dessel;
- the continuity of RD&D in terms of management, in particular the long-term management, of radioactive waste since the mid-1960s, i.e. before the first commercial nuclear reactors were commissioned;
- the creation in 1995, by ONDRAF/NIRAS and SCK•CEN, of the EIG PRACLAY, which became the EIG EURIDICE (European Underground Research Infrastructure for Disposal of Nuclear Waste in Clay Environment), primarily to manage the HADES underground research laboratory, recognised by the IAEA as a centre of excellence for disposal technologies and training of scientists. HADES (High-Activity Disposal Experimental Site) was built jointly by SCK•CEN and ONDRAF/NIRAS from 1980, on the SCK•CEN site at Mol, at a depth of 225 metres, in order to study poorly indurated clays. It has subsequently been extended several times and is still operating. A great deal of research is conducted there, in situ, in a broad international framework, especially in terms of understanding the behaviour of clays and engineered barriers and the industrial feasibility of a repository. Over time, EIG EURIDICE has acquired a technical and scientific expertise in understanding the thermal and hydromechanical behaviour of poorly indurated clay (for example: PRACLAY large-scale heater experiment), underground excavation and construction technologies and instrumentation and surveillance;
- finally, the existence, at SCK•CEN, of major research tools such as the BR2 reactor and the VENUS-F reactor, related to the GUINEVERE project, along with the development since the late 1990s of the MYRRHA project also help with knowledge retention. The MYRRHA project is a nuclear research infrastructure designed to allow the optimal continuation, in an international context, of the necessary research regarding innovative solutions for high-level waste, the qualification of materials for fusion reactors, maintenance of medical radioisotope production and fundamental nuclear research, in association with Belgian and international universities and research centres. MYRRHA received the support of the Federal Government in 2010 and Europe considered it as a priority European research infrastructure (ESFRI) in the same year.

RD&D in terms of the management of spent fuel and radioactive waste is essentially that conducted on behalf of Synatom (section 5.1) and that conducted on behalf of ONDRAF/NIRAS, mostly by SCK•CEN, whose pioneering role in RD&D for radioactive waste management dates back to the 1960s (section 7.4) [SCK•CEN, 2002]. Since its creation, ONDRAF/NIRAS has played a major role in the direction of SCK•CEN's RD&D in radioactive waste management.

FANC and Bel V conduct independent research to:

- retain a sufficiently extensive and sound knowledge base in order to ensure that safety requirements are well-founded and adequate;
- develop their technical and scientific expertise and keep it updated;
- be able to look critically at the arguments of developers and operators.

The research and development programme by FANC and Bel V for radioactive waste management aims to establish the tools necessary for the independent review of the (preliminary) safety cases for repositories set up by ONDRAF/NIRAS and to develop and retain the expertise in the field in question.

Generally, retaining expertise and skills, including RD&D, benefits from discussions or collaborations with foreign countries (depending on the case, international bodies, nuclear power plant operators, radioactive waste management agencies, research centres, etc.). These discussions and collaborations are used to share best practice, knowledge and resources.

9 Foreign radioactive waste generated or present in Belgium and related agreements [subject (k)]

Introductory note: All Belgian radioactive waste is managed in Belgium. Radioactive waste sent for treatment and conditioning abroad must be returned to Belgium. Subject (k) is considered as covering the management of foreign waste present in Belgium.

Within the framework of several, mostly old, arrangements, Belgium agreed to take charge, and therefore manage over the long term, radioactive waste of foreign origin.

Eurochemic waste In 1957, twelve countries of the OEEC (which became the OECD) decided to build a pilot reprocessing plant for spent fuel, the Eurochemic pilot plant ([NEA, 1996] and inset 3 in section 7.2.3.2). Belgium's application as host country led to the commissioning of the pilot plant at Dessel in 1966. However, Eurochemic's reprocessing activities were stopped in 1974. In 1986, the abandonment of the project to restart the pilot plant required Belgium to dismantle the facilities that would not be used anymore and manage the radioactive waste from dismantling as well as other radioactive waste that had accumulated on site. Since 2002, the dismantling and radioactive waste management costs have been covered by a federal contribution charged on the kWh as part of the Belgoprocess liability.

Kalkar waste In 1972, Germany, the Netherlands and Belgium agreed to build a fast breeder reactor, the SNR 300 *(Schneller Natriumgekühlter Reaktor)*, at Kalkar, in Germany. Work began in 1971 and construction was completed in 1986. However, the reactor was never started and, in 1991, Germany decided to cancel the project.

Part of the reactor's first core was manufactured in Belgium. After negotiations between Germany and Belgium, the German company SBK agreed to take back the fuel assemblies from the core and the production surpluses and to take responsibility for the costs of managing the waste remaining in Belgium. By its decision of 22 November 1996, the Belgian Government appointed the Minister responsible for Energy and ONDRAF/NIRAS to begin negotiations in order to reach an agreement for the treatment, conditioning, storage and long-term management of this waste in Belgium. At the end of 1998, these negotiations led to an agreement and in 1999 were reflected in two contracts between SBK and ONDRAF/NIRAS for the management in Belgium of the waste present on the Belgonucleaire and Belgoprocess sites [Council of Ministers, 1998c; SBK & ONDRAF/NIRAS, 1999; SBK *et al.*, 1999].

IRMM waste Established in 1957 by Article 8 of the Euratom Treaty and including in particular the IRMM based in Geel, the European Commission's Joint Research Centre was originally entirely dedicated to nuclear energy. Since the 1980s, it has diversified its activities and today, nuclear activities account for only a quarter of its activities.

Based on the Euratom Treaty, the Joint Research Centre has to manage its nuclear liabilities and decommission its nuclear facilities, including those of the IRMM, once they have been definitively shut down. Financing for the corresponding costs is provided by a specific budget heading in the European Commission's multiannual financial framework, in agreement with the European Parliament and Council. Annual budgets are currently known until 2020 and are regularly adjusted depending on needs and priorities. The Joint Research Centre's strategies and expenditure are monitored by a committee which reports to the European Parliament and Council every four years [EC, 2013].

Luxembourg waste Since it does not have facilities for managing its own industrial and medical radioactive waste, the Grand Duchy of Luxembourg has solicited the services of Belgium.

In 1990, the Grand Duchy of Luxembourg's request led to an agreement for the treatment of Grand Duchy's radioactive waste in Belgium, confirmed by letter from ONDRAF/NIRAS' supervisory authority to the Luxembourg Minister for Health [Deworme, 1990]. This agreement was confirmed in 1992 and 1994. In 1994, ONDRAF/NIRAS was allowed by its supervisory authority to take charge of a quantity of radioactive waste from the Grand Duchy of Luxembourg every year as long as the volume of such waste once conditioned does not exceed 0,1 m^3 [Wathelet, 1994].

In order to take account of the new context imposed by Directive 2011/70/Euratom, the Belgian and Luxembourg Governments have agreed to formalise the 1994 authorisation in a bilateral agreement establishing the technical and financial framework for the management and disposal of Luxembourg radioactive waste by Belgium [Michel & Bettel, 2015].

10 Interdependencies [subject (l)]

Interdependencies between the different management steps for spent fuel and radioactive waste, from generation to disposal, cover various aspects: operational and long-term safety, the management of waste streams (destorage, disposal, etc.), logistics, the roles and responsibilities of the different actors, etc. Their consideration is therefore central to the consistency of all the management steps for spent fuel and radioactive waste.

In order to comprehend the aspects of the interdependencies and their consequences across all the management steps and guarantee consistency, ONDRAF/NIRAS has set up or is developing various tools, which are a legal requirement:

- the integrated management system;
- the acceptance system;
- the technical inventory of radioactive waste.

Integrated management system In order to ensure interdependencies between the different steps for the management of radioactive waste as best as possible and specifically guarantee that all requirements ensuing from the need to ensure long-term safety are passed on across the previous management steps, ONDRAF/NIRAS is implementing an integrated management system for all the steps in the management of radioactive waste. This system is based on the IAEA recommendations [IAEA, 2011]. Its backbone is the acceptance system (section 7.2.2).

Acceptance system The acceptance system guarantees that the interdependencies between the successive steps in the management of radioactive waste due to the radiological and physico-chemical characteristics of such waste are taken into account in ONDRAF/NIRAS' management system (section 7.2.2). It aims to ensure that at each step in the management chain, the radioactive waste has characteristics that are deemed compatible with the requirements set out by the subsequent steps in its management [ONDRAF/NIRAS & FANC, 2012]. This is a legal mission for ONDRAF/NIRAS [Belgian Official Journal, 1981; Van den Bossche, 1999; Belgian Official Journal, 2002b].

Technical inventory As part of its inventory mission (section 7.2.1), ONDRAF/NIRAS has data on the types of waste currently in existence and to be generated in the future, its respective volumes and characteristics and the production schedules drawn up by the producers. This information is used to manage the waste streams and related infrastructures (occupancy rate for storage buildings, commissioning date for new infrastructures, etc.).

Furthermore, under the terms of the Royal Decree of 30 November 2011 [Belgian Official Journal, 2011], every nuclear operator must implement an integrated management system.

Part 3 Review of special cases: radium-bearing radioactive waste, NORM radioactive waste and new types of future waste

This part covers radioactive material that ONDRAF/NIRAS may have to take charge of as radioactive waste and in which case should be subject to specific long-term management (chapter 11) as well as new types of future waste resulting from planned or proposed changes in facilities and/or practices that may have an impact on the management (chapter 12).

11 Radium-bearing radioactive waste and NORM radioactive waste [subject (n)]

ONDRAF/NIRAS has identified two similar types of long-term management issues as requiring consideration: the issue of radium-bearing radioactive waste and that of NORM radioactive waste [ONDRAF/NIRAS, 2015], which refer to subject (n) "Historical situations and work activities" of the Law of 3 June 2014.

Radium-bearing radioactive waste is

- *radium-bearing waste*, i.e. waste containing radium which is essentially defined based on its origin, namely historical radium production activities on the Olen site and radium-specific applications,
- that has *radioactive waste status* in the legal and regulatory sense, i.e. waste containing one or several radionuclides, the activity or concentration of which cannot be ignored for radiation protection reasons and for which the long-term management must therefore be provided by ONDRAF/NIRAS, unlike "non-radioactive" radium-bearing waste, which is likely to be disposed of in conventional landfill.

Similarly, NORM radioactive waste is

- *NORM waste*, i.e. waste from traditional industrial processes which has levels of natural radioactivity significantly higher than the average values encountered in the environment,
- that is *radioactive* in the legal and regulatory sense and for which the long-term management must therefore be provided by ONDRAF/NIRAS, unlike "non-radioactive" NORM waste.

The radium-bearing waste present at Olen is distributed across the Umicore site and its surrounding areas and is the cause of extremely diverse situations (table 6): concentrated contaminations in landfills, diffuse contamination of land and waste in storage facilities subject to nuclear licence, which therefore has radioactive waste status (section 6.3).

Table 6 – Distribution of existing and "potential" radium-bearing radioactive waste, all non-conditioned, on the Umicore site at Olen and the surrounding areas and estimated characteristics based on available information [ONDRAF/NIRAS & Umicore, 2012; ONDRAF/NIRAS, 2013a].

	Total volume of landfill or diffuse contamination [m³]	Total radiologically contaminated volume estimated by Umicore [m³]	Total volume of radioactive waste [m³]	Specific radium-226 activity [Bq/g]	Total alpha activity [GBq]
Licensed storage facilities					
UMTRAP	n.a.	n.a.	55 000	20 to 30 000	38 000
Bankloop	n.a.	n.a.	30 000	3,2; homogeneous	140
Remediation decision made (but execution delayed)					
D1 landfill	200 000	130 000	unknown [1]	average: 7,6 highly heterogeneous	1 539
Remediation decision likely					
SI landfill	207 000	21 400	unknown [1]	< 30, homogeneous	270
Entire site	~ 100 000	20 000 to 30 000 [2]	unknown [1]	unknown	unknown
Remediation probably unnecessary					
Landfill II	unknown	25 000	unknown [1]	unknown	unknown
Certain streets in Geel and Olen	unknown	unknown	unknown [1]	maximum ~ 7	unknown

[1] The volume of waste likely to have to be taken charge of by ONDRAF/NIRAS as radioactive waste may be less than or greater than the radiologically contaminated volume estimated by Umicore.

[2] There is great uncertainty about the estimated volume.

Similarly, NORM waste appears in concentrated (for example in the form of deposits in industrial facilities or in landfills and basins) or diffuse (for example, contamination of water courses by industrial discharges) forms [Stals *et al.*, 2015]. The sector where the issue can be seen most clearly is that of the phosphate industry (phosphate fertilizers) [Paridaens & Vanmarcke, 2001]: the total volume of gypsum and sludge that, potentially, cannot be ignored in terms of radiation protection has been estimated at 35 million cubic metres.

Radium-bearing and NORM wastes have the special feature of presenting mixed contamination: in nearly all cases, and as is the case with radioactive waste which already ends up in categories A, B or C after treatment and conditioning, the radioactive contamination is accompanied by a chemical contamination. However, unlike radioactive waste that ends up in these three categories, the radiological risk is often similar to or even lower than the chemical risk. Consultation and cooperation between the federal authorities having jurisdiction over nuclear issues and the regional authorities having jurisdiction over the environment is therefore essential. The Regions have jurisdiction over the management of radium-bearing and NORM wastes that do not have radioactive waste status.

Concentrated and diffuse radium-bearing and NORM contaminations are the cause of existing exposure situations which do not yet have a legal and regulatory framework for their management. The intervention decisions made on a case-by-case basis by FANC until now indicate that intervention may take the form of a risk management plan, in other words administrative and/or surveillance measures, or of remediation. Remediation itself may consist in confining the contamination on site, without removing materials, or may be done by removing radiologically contaminated materials which, depending on the case, may be disposed of in conventional landfill or must be managed as radioactive waste. "Potential" radium-bearing and NORM radioactive wastes are radiologically similar, in the sense that they are long-lived and most are very low-level and low-level wastes.

In practice, ONDRAF/NIRAS has not yet received a request to take charge of the radium-bearing radioactive waste contained in Umicore's licensed storage facilities at Olen, for which the inventory is well-known (table 6), nor has it received a request to take charge of other radium-bearing or NORM radioactive waste, except radium-bearing radioactive waste that is conditioned or intended to be

conditioned, stored on the sites operated by Belgoprocess and which is currently associated with category B waste (section 7.4.2), and very small quantities of operational NORM radioactive waste, which will probably also be associated with category B waste after conditioning.

Given that

- the legal and regulatory framework for radiation protection and safety does not contain the necessary elements to enable ONDRAF/NIRAS to estimate the inventory of radium-bearing and NORM radioactive wastes that will result from future remediations and for which it must provide long-term management [ONDRAF/NIRAS, 2015];
- NORM waste from certain work activities may be used as raw materials for other work activities;

the volume of radium-bearing radioactive waste to be managed in the long term by ONDRAF/NIRAS ranges potentially from approximately 85 000 m^3 to an order of magnitude of 200 000 m^3 and the volume of NORM radioactive waste ranges potentially from a very small volume to several millions of m^3.

The long-term management of radium-bearing and NORM radioactive wastes must still be subject to national policy(ies). The parties concerned with the management of these wastes, among others Umicore, ONDRAF/NIRAS, FANC and OVAM (*Openbare Vlaamse Afvalstoffenmaatschappij* — Public Waste Agency of Flanders), have already spent many years considering their long-term management [FANC & ONDRAF/NIRAS, 2001; ONDRAF/NIRAS & Umicore, 2012; ONDRAF/NIRAS, 2015].

12 Planned or anticipated modifications to facilities and/or practices likely to have an impact on the management [subject (m)]

ONDRAF/NIRAS will collect information on the modifications that operators plan or anticipate making to their facilities and/or practices and which are likely to generate new types of radioactive waste (including spent fuel which would be declared as waste) and therefore have an impact on the management of spent fuel and radioactive waste [subject (m) “Modifications”] using the questionnaire related to its radioactive waste inventory mission.

Part 4 Performance indicators [subject (g2)]

This fourth part presents a synoptic view of the national programme for the management of spent fuel and radioactive waste, at 31 December 2014, using several key performance indicators (table 7). This synoptic view is inspired by the structure of the national programme, in that it distinguishes between the management of spent fuel and radioactive waste by the owners/producers on the one hand, and the management of radioactive waste by ONDRAF/NIRAS on the other, and in that it divides the management of radioactive waste by ONDRAF/NIRAS into short-term and medium-term management on the one hand, and long-term management on the other.

The performance indicators selected refer to certain important subjects for the national programme:

- whether or not there is a national policy;
- whether or not there is general regulation and regulation dedicated to radiation protection and safety;
- whether or not there is operational management;
- whether or not there is a financing mechanism;
- whether or not there is RD&D.

Table 7 – Synoptic view of the national programme for the management of spent fuel and radioactive waste, at 31 December 2014, according to several key indicators. [✓ : yes; ✗ : no; ● : interim situation]

	MANAGEMENT BY PRODUCERS / OWNERS					TRANSFER	MANAGEMENT BY ONDRAF/NIRAS										
							SHORT AND MEDIUM TERMS (treatment, conditioning and storage)					LONG TERM (disposal)					
	National policy?	Regulation: general?	Regulation: dedicated?	Operational management?	Financing mechanism?		National policy?	Regulation: general?	Regulation: dedicated?	Operational management?	Financing mechanism?	National policy?	Regulation: general?	Regulation: dedicated?	RD&D?	Operational management?	Financing mechanism?
Very short-lived waste	✓ [1]	✓	✓	✓	✓		not applicable					not applicable					
Category A waste	n.a. [2]	✓	✓	✓	✓	⇒	✓ [3]	✓	✓	✓	✓ [4]	✓ [5]	✓	● [6]	✓	✗ [7]	✓ [4]
Category B waste	n.a. [2]	✓	✓	✓	✓	⇒	✓ [3]	✓	✓	✓	✓ [4]	✗ [8]	✓	● [6]	✓	✗	✓ [4]
Category C waste (reprocessing)	not applicable					[11]	✓ [3]	✓	✓	✓	✓ [4]	✗ [8]	✓	● [6]	✓	✗	✓ [4]
Category C waste (spent fuel)	not applicable					[11]	✓ [3]	✓	✓	✓	✓ [4]	✗ [8]	✓	● [6]	✓	✗	✓ [4]
Spent fuel from Synatom	✓ [9]	✓	✓	✓	✓	[11]	not applicable					not applicable					
Spent fuel from SCK•CEN	✓ [10]	✓	✓	✓	✓	[11]	not applicable					not applicable					
Radium-bearing radioactive waste (UMTRAP and Bankloop)	n.a. [2]	✓	✓	✓	✓	⇒	✗	✓	✓	✗ [12]	✓ [4]	✗	✓	● [6]	✗	✗ [12]	✓ [4]
"Potential" radium-bearing radioactive waste [13]	n.a.	✓	● [14]	✓	✓	⇒ ? [14]	✗	✓	✓	✗ [12]	✓ [4]	✗	✓	● [6]	✗	✗ [12]	✓ [4]
"Potential" NORM radioactive waste [13]	n.a.	✓	● [14]	✓	✓	⇒ ? [14]	✗	✓	✓	✗ [12]	● [15]	✗	✓	● [6]	✗	✗ [12]	● [15]

[1] *Policy of waste management by decay and subsequent clearance* (section 6.2).

[2] The management of radioactive waste by producers must comply with a set of principles and obligations, but is not subject to an actual policy.

[3] *Policy of centralised short-term and medium-term management at Mol–Dessel* (section 7.2.3).

[4] There are financing mechanisms (section 7.3). The existence, sufficiency and availability of the provisions made by producers to cover their future management costs are evaluated by ONDRAF/NIRAS in its nuclear liabilities inventory report [ONDRAF/NIRAS, 2013a], which identifies areas of improvement for covering such costs.

[5] *Policy of surface disposal on the territory of the municipality of Dessel* (section 7.4.1).

[6] There is a general legal and regulatory framework for the long-term management of radioactive waste. FANC plans to supplement this with specific provisions for such management. In its reference framework for long-term management [ONDRAF/NIRAS, 2015], ONDRAF/NIRAS identifies the specific legal and regulatory elements that it deems necessary (chapter 11).

[7] ONDRAF/NIRAS submitted the licence application for the surface repository to FANC on 31 January 2013 (section 7.4.1).

[8] The elements needed to propose a national long-term management policy for B&C waste are available (section 7.4.2). Pursuant to Article 179, § 6, of the Law of 8 August 1980, ONDRAF/NIRAS will send such a proposal to the Ministers responsible for the Economy and Energy.

[9] *Policy for the management of spent fuel from Synatom: safe storage followed by its reprocessing or disposal* (section 5.1).

[10] *Policy for the management of spent fuel from SCK•CEN: reprocessing for BR2 spent fuel; safe storage for BR3 spent fuel* (section 5.2).

[11] Decisions on the future of spent fuel will have to be made before it is transferred to ONDRAF/NIRAS.

[12] No operational management by ONDRAF/NIRAS, because there has not yet been a request to take charge of this radium-bearing or NORM radioactive waste (chapter 11).

[13] Waste from the dismantling of facilities of certain NORM industries or from future remediations of existing exposure situations which would take radioactive waste status (chapter 11).

[14] No dedicated regulation allowing ONDRAF/NIRAS to assess whether it will have to manage radium-bearing and/or NORM wastes from future remediations as radioactive waste (chapter 11).

[15] Some owners make environmental accounting provisions, not specific to potential costs for the management of NORM waste as radioactive waste (section 7.3.2).

Acronyms

AFCN/FANC	*Agence fédérale de Contrôle nucléaire / Federaal Agentschap voor Nucleaire Controle* (Federal Agency for Nuclear Control) (Belgium)
ASR	alkali-silica reaction
BP	Belgoprocess (Belgium)
EC	European Commission
ENSREG	European Nuclear Safety Regulators Group
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EURIDICE	European Underground Research Infrastructure for Disposal of Nuclear Waste in Clay Environment
HADES	High-Activity Disposal Experimental Site
IAEA	International Atomic Energy Agency
IRE	*Institut national des radioéléments* (National Radioelements Institute) (Belgium)
IRMM	Institute for Reference Materials and Measurements (Belgium)
MOX	mixed-oxide fuel
NEA	OECD Nuclear Energy Agency (France)
NORM	naturally occurring radioactive materials
OECD	Organisation for Economic Cooperation and Development (France)
ONDRAF/NIRAS	*Organisme national des déchets radioactifs et des matières fissiles enrichies / Nationale instelling voor radioactief afval en verrijkte splijtstoffen* (Belgian Agency for Radioactive Waste and Enriched Fissile Materials) (Belgium)
OVAM	*Openbare Vlaamse Afvalstoffenmaatschappij* (Public Waste Agency of Flanders) (Belgium)
RD&D	research, development and demonstration
SCK•CEN	*Studiecentrum voor Kernenergie / Centre d'Etude de l'Energie Nucléaire* (Belgian Nuclear Research Centre) (Belgium)
SEA	strategic environmental assessment (environmental impact assessment as defined by the Law of 13 February 2006 and Directive 2001/42/EC)
SFC	safety and feasibility case
tHM	tonne of Heavy Metal

References

The consolidated versions of the laws and royal decrees quoted are available on http://www.ejustice.just.fgov.be/loi/loi.htm (in French) or http://www.ejustice.just.fgov.be/wet/wet.htm (in Dutch).

[Administrations, 1998] Administration de l'Energie, Service de Protection contre les Radiations ionisantes, Service technique de Sécurité des Installations nucléaires, Service des Questions scientifiques et nucléaires, Sécurité nucléaire, Mise en œuvre de la résolution de la Chambre des Représentants, relative à l'utilisation de combustibles contenant du plutonium et de l'uranium dans les centrales nucléaires belges, ainsi qu'à l'opportunité du retraitement des barres de combustible: Rapport de synthèse et d'évaluation des travaux réalisés par les institutions et entreprises concernées, octobre 1998 // Bestuur Energie, Dienst voor Bescherming tegen Ioniserende Stralingen, Dienst voor de Technische Veiligheid van de Kerninstallaties, Dienst Wetenschappelijke en Nucleaire Vraagstukken, Nucleaire Veiligheid, Uitvoering van de resolutie van de Kamer van Volksvertegenwoordigers betreffende het gebruik van plutonium- en uraniumhoudende brandstoffen in de Belgische kerncentrales en de opportuniteit van de opwerking van nucleaire brandstofstaven: Synthese- en evaluatierapport van de werken verwezenlijkt door de betrokken instellingen en ondernemingen, oktober 1998

[Belgian Official Journal, 1980] Loi du 8 août 1980 relative aux propositions budgétaires 1979–1080, Moniteur belge du 15 août 1980 // Wet van 8 augustus 1980 betreffende de budgettaire voorstellen 1979–1980, Belgisch Staatsblad van 15 augustus 1980

[Belgian Official Journal, 1981] Arrêté royal du 30 mars 1981 déterminant les missions et fixant les modalités de fonctionnement de l'organisme public de gestion des déchets radioactifs et des matières fissiles enrichies, Moniteur belge du 5 mai 1981 // Koninklijk besluit van 30 maart 1981 houdende bepaling van de opdrachten en de werkingsmodaliteiten van de openbare instelling voor het beheer van radioactief afval en verrijkte splijtstoffen, Belgisch Staatsblad van 5 mei 1981

[Belgian Official Journal, 1984] Loi du 20 décembre 1984 portant approbation de la Convention sur la prévention de la pollution des mers résultant de l'immersion de déchets, des Annexes, de l'Additif et de l'Appendice, faits à Londres, Mexico, Moscou et Washington le 29 décembre 1972 et modifiés à Londres le 12 octobre 1978, le 1er décembre 1978 et le 1er décembre 1980, Moniteur belge du 22 octobre 1985 // Wet van 20 december 1984 houdende goedkeuring van het Verdrag inzake de voorkoming van de verontreiniging van de zeeën ten gevolge van het storten van afvalstoffen, van de Bijlagen, het Addendum en het Bijvoegsel, opgemaakt te Londen, Mexico, Moskou en Washington op 29 december 1972 en gewijzigd te Londen op 12 oktober 1978, 1 december 1978 en 1 december 1980, Belgisch Staatsblad van 22 oktober 1985

[Belgian Official Journal, 1991a] Arrêté royal du 16 octobre 1991 portant les règles relatives au contrôle et au mode de subvention du Centre d'Etudes de l'Energie nucléaire et modifiant les statuts de ce Centre, Moniteur belge du 22 novembre 1991 // Koninklijk besluit van 16 oktober 1991 houdende de regelen betreffende het toezicht op en de subsidiëring van het Studiecentrum voor Kernenergie en tot wijziging van de statuten van dit centrum, Belgisch Staatsblad van 22 november 1991

[Belgian Official Journal, 1991b] Arrêté royal du 16 octobre 1991 fixant les règles relatives au contrôle et au mode de subvention de l'Institut national des Radioéléments, et modifiant les statuts de cet institut, Moniteur belge du 22 novembre 1991 // Koninklijk besluit van 16 oktober 1991

houdende de regelen betreffende het toezicht op en de subsidiëring van het Nationaal Instituut voor Radio-elementen, en tot wijziging van de statuten van dit instituut, Belgisch Staatsblad van 22 november 1991

[Belgian Official Journal, 1994a] Loi du 11 avril 1994 relative à la publicité de l'administration, Moniteur belge du 30 juin 1994 // Wet van 11 april 1994 betreffende de openbaarheid van bestuur, Belgisch Staatsblad van 30 juni 1994

[Belgian Official Journal, 1994b] Loi du 15 avril 1994 relative à la protection de la population et de l'environnement contre les dangers résultant des rayonnements ionisants et relative à l'Agence fédérale de Contrôle nucléaire, Moniteur belge du 29 juillet 1994 // Wet van 15 april 1994 betreffende de bescherming van de bevolking en van het leefmilieu tegen de uit ioniserende stralingen voortspruitende gevaren en betreffende het Federaal Agentschap voor Nucleaire Controle, Belgisch Staatsblad van 29 juli 1994

[Belgian Official Journal, 1999a] Loi du 29 avril 1999 relative à l'organisation du marché de l'électricité, Moniteur belge du 11 mai 1999 // Wet van 29 april 1999 betreffende de organisatie van de elektriciteitsmarkt, Belgisch Staatsblad van 11 mei 1999

[Belgian Official Journal, 1999b] Loi du 9 juin 1999 portant assentiment à la Convention sur l'évaluation de l'impact sur l'environnement dans un contexte transfrontière, et aux Appendices I, II, III, IV, V, VI et VII, faits à Espoo le 25 février 1991, Moniteur belge du 31 décembre 1999 // Wet van 9 juni 1999 houdende instemming met het Verdrag inzake milieu-effectrapportage in grensoverschrijdend verband, en met de Aanhangsels I, II, III, IV, V, VI en VII, gedaan te Espoo op 25 februari 1991, Belgisch Staatsblad van 31 december 1999

[Belgian Official Journal, 2001] Arrêté royal du 20 juillet 2001 portant règlement général de la protection de la population, des travailleurs et de l'environnement contre le danger des rayonnements ionisants, Moniteur belge du 30 août 2001 // Koninklijk besluit van 20 juli 2001 houdende algemeen reglement op de bescherming van de bevolking, van de werknemers en het leefmilieu tegen het gevaar van de ioniserende stralingen, Belgisch Staatsblad van 30 augustus 2001

[Belgian Official Journal, 2002a] Loi du 2 août 2002 portant assentiment à la Convention commune sur la sûreté de la gestion du combustible usé et sur la sûreté de la gestion des déchets radioactifs, faite à Vienne le 5 septembre 1997, Moniteur belge du 25 décembre 2002 // Wet van 2 augustus 2002 houdende instemming met het Gezamenlijk Verdrag inzake de veiligheid van het beheer van bestraalde splijtstof en inzake de veiligheid van het beheer van radioactief afval, gedaan te Wenen op 5 september 1997, Belgisch Staatsblad van 25 december 2002

[Belgian Official Journal, 2002b] Arrêté royal du 18 novembre 2002 réglant l'agrément d'équipements destinés à l'entreposage, au traitement et au conditionnement de déchets radioactifs, Moniteur belge du 3 décembre 2002 // Koninklijk besluit van 18 november 2002 houdende regeling van de erkenning van uitrustingen bestemd voor de opslag, verwerking en conditionering van radioactief afval, Belgisch Staatsblad van 3 december 2002

[Belgian Official Journal, 2003a] Accord de coopération du 17 octobre 2002 entre l'Etat fédéral et les Régions relatif à la gestion des déchets libérés, Moniteur belge du 15 janvier 2003 // Samenwerkingsakkoord van 17 oktober 2002 tussen de federale Staat en de Gewesten met betrekking tot het beheer van vrijgegeven afvalstoffen, Belgisch Staatsblad van 15 januari 2003

[Belgian Official Journal, 2003b] Loi du 31 janvier 2003 sur la sortie progressive de l'énergie nucléaire à des fins de production industrielle d'électricité, Moniteur belge du 28 février 2003 // Wet van 31 januari 2003 houdende de geleidelijke uitstap uit kernenergie voor industriële elektriciteits-productie, Belgisch Staatsblad van 28 februari 2003

[Belgian Official Journal, 2003c] Loi du 17 décembre 2002 portant assentiment à la Convention sur l'accès à l'information, la participation du public au processus décisionnel et l'accès à la justice en matière d'environnement, et aux Annexes I et II, faites à Aarhus le 25 juin 1998, Moniteur belge du 24 avril 2003 // Wet van 17 december 2002 houdende instemming met het Verdrag betreffende toegang tot informatie, inspraak bij besluitvorming en toegang tot de rechter inzake milieuaangelegenheden, en met de Bijlagen I en II, gedaan te Aarhus op 25 juni 1998, Belgisch Staatsblad van 24 april 2003

[Belgian Official Journal, 2003d] Loi du 11 avril 2003 sur les provisions constituées pour le démantèlement des centrales nucléaires et pour la gestion des matières fissiles irradiées dans ces centrales, Moniteur belge du 15 juillet 2003 // Wet van 11 april 2003 betreffende de voorzieningen aangelegd voor de ontmanteling van de kerncentrales en voor het beheer van splijtstoffen bestraald in deze kerncentrales, Belgisch Staatsblad van 15 juli 2003

[Belgian Official Journal, 2006a] Loi du 13 février 2006 relative à l'évaluation des incidences de certains plans et programmes sur l'environnement et à la participation du public dans l'élaboration des plans et des programmes relatifs à l'environnement, Moniteur belge du 10 mars 2006 // Wet van 13 februari 2006 betreffende de beoordeling van de gevolgen voor het milieu van bepaalde plannen en programma's en de inspraak van het publiek bij de uitwerking van de plannen en programma's in verband met het milieu, Belgisch Staatsblad van 10 maart 2006

[Belgian Official Journal, 2006b] Loi du 5 août 2006 relative à l'accès du public à l'information en matière d'environnement, Moniteur belge du 28 août 2006 // Wet van 5 augustus 2006 betreffende de toegang van het publiek tot milieu-informatie, Belgisch Staatsblad van 28 augustus 2006

[Belgian Official Journal, 2009] Arrêté royal du 24 mars 2009 portant règlement de l'importation, du transit et de l'exportation de substances radioactives, Moniteur belge du 17 avril 2009 // Koninklijk besluit van 24 maart 2009 tot regeling van de invoer, de doorvoer en de uitvoer van radioactieve stoffen, Belgisch Staatsblad van 17 april 2009

[Belgian Official Journal, 2011] Arrêté royal du 30 novembre 2011 portant prescriptions de sûreté des installations nucléaires, Moniteur belge du 21 décembre 2011 // Koninklijk besluit van 30 november 2011 houdende veiligheidsvoorschriften voor kerninstallaties, Belgisch Staatsblad van 21 december 2011

[Belgian Official Journal, 2014a] Arrêté royal du 25 avril 2014 modifiant l'arrêté royal du 30 mars 1981 déterminant les missions et fixant les modalités de fonctionnement de l'organisme national public de gestion des déchets radioactifs et des matières fissiles, Moniteur belge du 18 juin 2014 // Koninklijk besluit van 25 april 2014 tot wijziging van het koninklijk besluit van 30 maart 1981 houdende bepaling van de opdrachten en de werkingsmodaliteiten van de openbare instelling voor het beheer van radioactief afval en splijtstoffen, Belgisch Staatsblad van 18 juni 2014

[Belgian Official Journal, 2014b] Loi du 5 mai 2014 portant assentiment à l'Accord entre le Gouvernement du Royaume de Belgique et le Gouvernement de la République française relatif au traitement de combustibles usés belges à La Hague, fait à Paris le 25 avril 2013, Moniteur belge du 2 septembre 2014 // Wet van 5 mei 2014 houdende instemming met het Akkoord tussen de Regering van het Koninkrijk België en de Regering van de Franse Republiek betreffende de behandeling van Belgische verbruikte brandstoffen te La Hague, gedaan te Parijs op 25 april 2013, Belgisch Staatsblad van 2 september 2014

[Belgian Official Journal, 2014c] Loi du 3 juin 2014 modifiant l'article 179 de la loi du 8 août 1980 relative aux propositions budgétaires 1979–1980 en vue de la transposition dans le droit interne

de la Directive 2011/70/Euratom du Conseil du 19 juillet 2011 établissant un cadre communautaire pour la gestion responsable et sûre du combustible usé et des déchets radioactifs, Moniteur belge du 27 juin 2014 // Wet van 3 juni 2014 houdende wijziging van artikel 179 van de wet van 8 augustus 1980 betreffende de budgettaire voorstellen 1979–1980, wat de omzetting in het interne recht betreft van Richtlijn 2011/70/Euratom van de Raad van 19 juli 2011 tot vaststelling van een communautair kader voor een verantwoord en veilig beheer van verbruikte splijtstof en radioactief afval, Belgisch Staatsblad van 27 juni 2014

[Belgian State & Eurochemic, 1978] Convention entre le Gouvernement du Royaume de Belgique et la Société Eurochemic sur la reprise des installations et l'exécution des obligations légales de la Société, 24 juillet 1978

[Bergmans, 2005] Bergmans A., Van "de burger als beleidssubject" naar "de burger als partner": de Belgische queeste naar een langetermijnoplossing voor het beheer van het laagradioactief en kortlevend afval, Proefschrift, Universiteit Antwerpen, Faculteit Politieke en Sociale Wetenschappen, 2005

[BNS, 1994] Belgian Nuclear Society, Un demi-siècle de nucléaire en Belgique – Témoignages, Pierre Govaerts, André Jaumotte et Jacques Vanderlinden (eds.), Coll. Mémoires d'Europe, Presses Interuniversitaires Européennes, Bruxelles, 1994

[Chamber, 1982] Chambre des Représentants, Note préparatoire du Gouvernement au débat sur l'énergie, Résolution n° 7 relative aux options dans le domaine de l'énergie nucléaire, adoptée le 2 juillet 1982, Doc. Ch. 272 (1981-1982) // Kamer van Volksvertegenwoordigers, Voorbereidende nota van de Regering omtrent het energiedebat, Resolutie nr 7 betreffende de opties op het gebied van de kernenergie, aangenomen op 2 juli 1982, Doc. K. 272 (1981-1982)

[Chamber, 1993] Chambre des Représentants, Résolution 541/9 – 91/92 relative à l'utilisation de combustibles contenant du plutonium et de l'uranium dans les centrales nucléaires belges, ainsi qu'à l'opportunité du retraitement des barres de combustible, adoptée le 22 décembre 1993 // Kamer van Volksvertegenwoordigers, Resolutie 541/9 – 91/92 betreffende het gebruik van plutonium- en uraniumhoudende brandstoffen in Belgische kerncentrales en de opportuniteit van de opwerking van nucleaire brandstofstaven, aangenomen op 22 december 1993

[Chernobyl Commission, 1990] Commission d'information et d'enquête en matière de sécurité nucléaire, Rapport au Sénat (De Wasseige & Didden), Problématique des déchets radioactifs, 3 juillet 1990, Doc. S. 113-13 (S.E. 1988) // Commissie van informatie en onderzoek inzake nucleaire veiligheid, Verslag aan het Senaat (De Wasseige & Didden), Problematiek in verband met het kernafval, 3 juli 1990, Doc. S. 113-13 (B.Z. 1988)

[Claes, 1978] Claes W., Eléments pour une nouvelle politique énergétique, Ministère des Affaires économiques, 1978 // Claes W., Elementen voor een nieuw energiebeleid, Ministerie van Economische Zaken, 1978

[Commission of Elders, 1976] Commission d'évaluation en matière d'énergie nucléaire, Rapport final, Ministère des Affaires économiques, mars 1976 // Commissie van Beraad inzake Kernenergie, Eindrapport, Ministerie van Economische Zaken, maart 1976

[Commission of Elders, 1982] Commission d'évaluation en matière d'énergie nucléaire, Rapport final, Eléments d'actualisation, Ministère des Affaires économiques, mars 1982 // Commissie van Beraad inzake Kernenergie, Eindrapport, Actualiseringselementen, Ministerie van Economische Zaken, maart 1982

[Commission of Elders, 1987] Prof. Dr. J. Hoste & Prof. Dr. A. Jaumotte, La production électronucléaire après l'accident de Tchernobyl, actualisation, en 1987, du rapport de la Commission d'évaluation en matière d'énergie nucléaire, Ministère des Affaires économiques, décembre

1987 // Prof. Dr. J. Hoste & Prof. Dr. A. Jaumotte, Thermonucleaire Elektriciteitsproduktie na de ramp van Tsjernobyl, aanpassing in 1987 van het rapport van de Evaluatiecommissie inzake kernenergie, Ministerie van Economische Zaken, december 1987

[Council of Ministers, 1993] Conseil des ministres, Séance du 24 décembre 1993 // Ministerraad, Vergadering van 24 december 1993

[Council of Ministers, 1998a] Conseil des ministres, Séance du 16 janvier 1998, Gestion à long terme des déchets radioactifs de faible activité. 98A40450.039

[Council of Ministers, 1998b] Conseil des ministres, Séance du 4 décembre 1998, Mise en œuvre de la résolution de la Chambre des Représentants, relative à l'utilisation de combustibles contenant du plutonium et de l'uranium dans les centrales nucléaires belges, ainsi qu'à l'opportunité de retraitement des barres de combustible. 1992A74770.042

[Council of Ministers, 1998c] Conseil des ministres, Séance du 4 décembre 1998, Déchets produits lors de la fabrication en Belgique de 40 % du premier cœur du réacteur Kalkar. 1991A42450.012

[Council of Ministers, 2006] Ministerraad, Vergadering van 23 juni 2006, Berging van radioactief afval (categorie A). 2006A42450.020

[Deworme, 1990] Letter from the Secretary of State for Energy, Elie Deworme, to the Minister for Health of the Grand Duchy of Luxembourg, 10 October 1990

[Di Rupo, 1997] Letter from the Minister for the Economy, Elio Di Rupo, to the Chairman of SCK•CEN, Conclusion d'un contrat avec la COGEMA (France) portant sur le traitement de combustible irradié du BR2, ref. BL/vd/0044-Cab., 18 June 1997

[Di Rupo, 1998] Letter from the Minister for the Economy, Elio Di Rupo, to ONDRAF/NIRAS, Décision du Gouvernement sur les déchets radioactifs de catégorie A, ref. BL/vd/203-Cab., 26 January 1998

[EC, 2013] Communication from the Commission to the Council and the European Parliament, Decommissioning of Nuclear Installations and Management of Radioactive Waste: Management of Nuclear Liabilities arising out of the Activities of the Joint Research Centre (JRC) carried out under the Euratom Treaty, COM(2013)734 final, Brussels, 25 October 2013

[ENEF, 2013] ENEF, Guidelines for the establishment and notification of National Programmes under the Council Directive 2011/70/euratom of 19 July 2011 on the responsible and safe management of spent fuel and radioactive waste, January 2013

[EU, 1999] Commission Recommendation of 15 September 1999 on a classification system for solid radioactive waste (1999/669/EC, Euratom), Official Journal L 265, 13 October 1999

[EU, 2011] Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, Official Journal L 199, 2 August 2011

[EU, 2013] Council Directive 2013/59/Euratom of 5 December 2013 laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation, and repealing Directives 89/618/Euratom, 90/641/Euratom, 96/29/Euratom, 97/43/Euratom and 2003/122/Euratom, Official Journal L 13, 17 Januari 2014

[EURIDICE, 2014] EIG EURIDICE, Activity Report 2013, Doc. 14-107, 2014

[FANC, 2015] AFCN, Avis de l'AFCN sur le Programme National du 10 avril 2015, réf. 2015-04-29-AW-5-4-1-FR, 7 mai 2015, communiqué par lettre de l'AFCN (réf. 2015-04-29-AW-5-1-2-NL, 7 mai 2015)

[FANC & ONDRAF/NIRAS, 2001] FANC & NIRAS, Sanering van de radioactieve verontreiniging op de terreinen UMICORE te Olen en in de omgeving, Gemeenschappelijk standpunt van FANC en NIRAS met betrekking tot de radiologische aspecten, november 2001

[FPS Economy, 2015a] SPF Economie, Informations générales sur le cycle du combustible nucléaire en Belgique *(sous presse)* // FOD Economie, Algemene informatie over de Belgische splijtstofcyclus *(ter perse)*

[FPS Economy, 2015b] SPF Economie, Etude préliminaire sur les stratégies de gestion du combustible nucléaire en Belgique *(sous presse)* // FOD Economie, Vergelijkende studie van de beheerstrategieën van de Belgische splijtstof *(ter perse)*

[GEMIX, 2009] Groupe GEMIX, Quel mix énergétique idéal pour la Belgique aux horizons 2020 et 2030 ?, rapport final, septembre 2009 // Groep GEMIX, Welke is de ideale energiemix voor België tegen 2020 en 2030?, Eindverslag, september 2009

[Government, 1979] Communication du gouvernement relative à la politique énergétique du 25 juillet 1979, Doc. Chambre des Représentants n° 279 (S.E. 1979) // Mededeling van de Regering over het energiebeleid van 25 juli 1979, Doc. Kamer van Volksvertegenwoordigers nr 279 (B.Z. 1979)

[Government, 1990] Communication du gouvernement du 19 novembre 1990 // Mededeling van de Regering van 19 november 1990

[IAEA, 1994] IAEA, Classification of Radioactive Waste — A Safety Guide, Safety Series No. 111-G-1.1, Vienna, May 1994

[IAEA, 2009] IAEA, Classification of Radioactive Waste, General Safety Guide No. GSG-1, Vienna, November 2009

[IAEA, 2011] IAEA, The Management System for Facilities and Activities, Safety Requirements, IAEA Safety Standards No. GS-R-3, Vienna, July 2006

[IAEA, 2014] IAEA, Country Nuclear Power Profiles, Belgium, updated 2014

[King Baudouin Foundation, 2010] Conférence citoyenne « Comment décider de la gestion à long terme des déchets radioactifs de haute activité et de longue durée de vie ? », rapport final, Ed. Fondation Roi Baudouin, janvier 2010 // Publieksforum "Hoe beslissen over het langetermijnbeheer van hoogradioactief en langlevend afval?", eindrapport, Uitgever Koning Boudewijnstichting, januari 2010

[Kingdom of Belgium, 2014] Kingdom of Belgium, Fifth meeting of the Contracting Parties to the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, National Report, October 2014

[Kingdom of Belgium, 2015] Représentation permanente de la Belgique près l'Union européenne, Notification à la Commission du programme national et du rapport national au titre de la directive 2011/70/Euratom du Conseil sur la gestion responsable et sûre du combustible usé et des déchets radioactifs, réf. 20150831/01304, 3 septembre 2015

[Michel & Bettel, 2015] Michel Ch. & Bettel X., Communiqué de presse, Déclaration conjointe – Gäichel VIII, 5 février 2015

[Ministry of Economic Affairs *et al.*, 1992] Ministère des Affaires économiques – Administration de l'Energie, Ministère de l'Emploi et du Travail – Service technique de Sécurité des Installations nucléaires et Ministère de la Santé publique et de l'Environnement – Service de Protection contre les Radiations ionisantes, La gestion du combustible usé en Belgique et l'utilisation du combustible MOX dans les centrales belges, Rapport pour débat parlementaire, octobre 1992 // Ministerie van Economische Zaken – Administratie voor Energie, Ministerie van Tewerkstelling

en Arbeid – Dienst voor de Technische Veiligheid van de Kerninstallaties en Ministerie van Volksgezondheid en Leefmilieu – Dienst voor Bescherming tegen Ioniserende Stralingen, Het beheer van de verbruikte splijtstof in België en het gebruik van MOX-splijtstof in de Belgische centrales, Rapport voor parlementair debat, oktober 1992

[MONA, 2005] MONA, MONA, een weg naar de aanvaardbaarheid van een berging van categorie A-afval in Mol?, januari 2005

[National Programme Committee, 2015] Comité du programme national, Réponse du CPNPC du 13 mai 2015 à l'avis de l'AFCN dans le cadre de la finalisation de son programme national de gestion des combustibles usés et des déchets radioactifs, 13 mai 2015 // Comité van het nationale programma, Antwoord van het CPNCP van 13 mei 2015 op het advies van het FANC in het kader van de afwerking van zijn nationale programma voor het beheer van verbruikte splijtstoffen en radioactief afval, 13 mei 2015

[NEA, 1996] Wolff J.-M., Histoire de la Société Eurochemic – 1956-1990 (Société européenne pour le traitement chimique des combustibles irradiés), Trente-cinq années de coopération internationale dans le domaine des techniques nucléaires: Du traitement chimique des combustibles irradiés à la gestion des déchets radioactifs, OCDE/AEN, 1996

[NEA, 2003] NEA, SAFIR 2: Belgian R&D Programme on the Deep Disposal of High-level and Long-lived Radioactive Waste: An International Peer Review, OECD/NEA, 2003

[NEA, 2010] NEA, Partnering for Long-term Management of Radioactive Waste — Evolution and Current Practice in Thirteen Countries, OECD/NEA No. 6823, 2010

[ONDRAF/NIRAS, 1997] ONDRAF, Comparaison des diverses options pour la gestion à long terme des déchets radioactifs de faible activité et de courte durée de vie — Aspects sûreté et différences de coûts, rapport NIROND 97-04, juin 1997 // NIRAS, Vergelijking van de verschillende opties voor het beheer op lange termijn van laagactief en kortlevend afval — Aspecten veiligheid en kostprijsverschillen, rapport NIROND 97-04, juni 1997

[ONDRAF/NIRAS, 2005a] ONDRAF, La mise en dépôt final, sur le territoire belge, des déchets radioactifs de faible et moyenne activité et de courte durée de vie — Rapport préparatoire à la remise par l'ONDRAF au Gouvernement fédéral des dossiers des partenariats locaux, rapport NIROND 2005-07 F, mars 2005 // NIRAS, Berging, op Belgisch grondgebied, van laag- en middelactief afval met korte levensduur — Rapport ter voorbereiding van de overhandiging door NIRAS aan de federale regering van de dossiers van de lokale partnerschappen, rapport NIROND 2005-07 N, maart 2005

[ONDRAF/NIRAS, 2005b] ONDRAF, La mise en dépôt final, sur le territoire belge, des déchets radioactifs de faible et moyenne activité et de courte durée de vie — Rapport de l'ONDRAF relatif au projet intégré de dépôt final développé par STOLA-Dessel, rapport NIROND 2005-08 F, avril 2005 // NIRAS, Berging, op Belgisch grondgebied, van laag- en middelactief afval met korte levensduur — Rapport van NIRAS betreffende het geïntegreerde bergingsproject ontwikkeld door STOLA-Dessel, rapport NIROND 2005-08 N, april 2005

[ONDRAF/NIRAS, 2005c] ONDRAF, La mise en dépôt final, sur le territoire belge, des déchets radioactifs de faible et moyenne activité et de courte durée de vie — Rapport de l'ONDRAF relatif au projet intégré de dépôt final développé par MONA, rapport NIROND 2005-09 F, juin 2005 // NIRAS, De berging, op Belgisch grondgebied, van laag- en middelactief afval met korte levensduur — Rapport van NIRAS betreffende het geïntegreerde bergingsproject ontwikkeld door MONA, rapport NIROND 2005-09 N, juni 2005

[ONDRAF/NIRAS, 2006a] ONDRAF, La mise en dépôt final, sur le territoire belge, des déchets radioactifs de faible et moyenne activité et de courte durée de vie — Rapport de l'ONDRAF

relatif au projet intégré de dépôt final développé par PaLoFF, rapport NIROND 2006-01 F, March 2006 // NIRAS, De berging, op Belgisch grondgebied, van laag- en middelactief afval met korte levensduur — Rapport van NIRAS betreffende het geïntegreerde bergingsproject ontwikkeld door PaLoFF, rapport NIROND 2006-01 N, maart 2006

[ONDRAF/NIRAS, 2005b] ONDRAF, La mise en dépôt final, sur le territoire belge, des déchets radioactifs de faible et moyenne activité et de courte durée de vie — Rapport de clôture de l'ONDRAF relatif à la période 1985–2006, invitant le Gouvernement fédéral à décider de la suite à donner au programme de dépôt, rapport NIROND 2006-02 F, mai 2006 // NIRAS, De berging, op Belgisch grondgebied, van laag- en middelactief afval met korte levensduur — Afsluitend rapport van NIRAS betreffende de periode 1985–2006, waarbij de federale regering verzocht wordt te beslissen over het gevolg dat moet worden gegeven aan het bergingsprogramma, rapport NIROND 2006-02 N, mei 2006

[ONDRAF/NIRAS, 2008] ONDRAF, Rapport de gestion — Situation actuelle de la gestion des déchets radioactifs en Belgique, rapport NIROND 2008-02 F, décembre 2008 // NIRAS, Beheerrapport — Huidige toestand van het beheer van radioactief afval in België, rapport NIROND 2008-02 N, december 2008

[ONDRAF/NIRAS, 2010] ONDRAF/NIRAS, The cAt project in Dessel — A long-term solution for Belgian category A waste, report NIROND 2010-02 E, March 2010

[ONDRAF/NIRAS, 2011a] ONDRAF/NIRAS, Waste Plan for the long-term management of conditioned high-level and/or long-lived radioactive waste and overview of related issues, report NIROND 2011-02 E, September 2011

[ONDRAF/NIRAS, 2011b] ONDRAF, Déclaration relative au Plan Déchets en application de la loi du 13 février 2006 — Plan Déchets pour la gestion à long terme des déchets radioactifs conditionnés de haute activité et/ou de longue durée de vie et aperçu de questions connexes, rapport NIROND 2011-03 F, septembre 2011 // NIRAS, Verklaring betreffende het Afvalplan ter uitvoering van de wet van 13 februari 2006 — Afvalplan voor het langetermijnbeheer van geconditioneerd hoogradioactief en/of langlevend afval en overzicht van verwante vragen, NIROND 2011-03 N, september 2011

[ONDRAF/NIRAS, 2013a] ONDRAF, Troisième rapport d'inventaire des passifs nucléaires de l'ONDRAF à sa tutelle (période 2008–2012) — Evaluation de l'existence, de la suffisance et de la disponibilité des provisions destinées à couvrir les coûts nucléaires estimés associés aux installations nucléaires et aux sites contenant des substances radioactives, hors coûts de gestion des déchets d'exploitation futurs, rapport NIROND 2012-02 F, janvier 2013 // NIRAS, Derde rapport over de inventaris van de nucleaire passiva van NIRAS aan haar voogdij (periode 2008–2012) — Evaluatie van het bestaan, de toereikendheid en de beschikbaarheid van de provisies bestemd om de geraamde nucleaire kosten te dekken met betrekking tot de nucleaire installaties en de sites die radioactieve stoffen bevatten, behalve de kosten van het beheer van het toekomstige exploitatieafval, rapport NIROND 2012-02 N, januari 2013

[ONDRAF/NIRAS, 2013b] NIRAS, Vergunningsaanvraagdossier voor de oppervlaktebergingsinrichting van categorie A-afval in Dessel, januari 2013

[ONDRAF/NIRAS, 2013c] ONDRAF/NIRAS, The Safety Case – A milestone for the safe surface disposal of the Belgian Category A waste at Dessel, January 2013

[ONDRAF/NIRAS, 2013d] ONDRAF/NIRAS, Cost Evaluation of Geological Disposal of Category B&C Waste for the Long Term Fund (Revision of 2013), report NIROND-TR 2013-04 E, December 2013

[ONDRAF/NIRAS, 2013e] ONDRAF/NIRAS, ONDRAF/NIRAS Research, Development and Demonstration (RD&D) Plan for the geological disposal of high-level and/or long-lived

radioactive waste including irradiated fuel if considered as waste — State-of-the-art report as of December 2012, report NIROND-TR 2013-12 E, December 2013

[ONDRAF/NIRAS, 2015] ONDRAF, Référentiel de gestion à long terme des déchets radioactifs — Approche unifiée d'identification de solutions de gestion à long terme, plus particulièrement pour les déchets radioactifs radifères et les déchets radioactifs NORM, et considérations relatives à l'établissement de plans stratégiques en vue de leur gestion, rapport NIROND 2015-01 F, février 2015 // NIRAS, Referentiekader voor het langetermijnbeheer van radioactief afval — Eenvormige aanpak voor het bepalen van oplossingen voor het langetermijnbeheer, in het bijzonder voor radioactief radiumhoudend afval en radioactief NORM-afval, en overwegingen inzake het opstellen van strategische plannen voor het beheer ervan, rapport NIROND 2015-01 N, februari 2015

[ONDRAF/NIRAS & Belgoprocess, 2014] ONDRAF & Belgoprocess, Fûts présentant du gel — Plan d'actions, Dossier de presse, septembre 2014 // NIRAS & Belgoprocess, Actieplan voor veilig beheer vaten met gelvorming, Persdossier, september 2014

[ONDRAF/NIRAS & FANC, 2012] NIRAS & FANC, Visiedocument FANC/NIRAS over de integratie van een operationele bergingsinstallatie in het acceptatiesysteem van NIRAS, november 2012

[ONDRAF/NIRAS & Umicore, 2012] ONDRAF/NIRAS & Umicore, Vision document on the long-term management of the radioactively contaminated sites and the radioactive waste at the Olen-Site, 12 September 2012, sent by ONDRAF/NIRAS to Umicore by letter (EDO/AV/2013-0157), 22 January 2013, and sanctioned by Umicore by letter to ONDRAF/NIRAS, 7 February 2013

[ONDRAF/NIRAS *et al.*, 2011] ONDRAF, Synatom, AREVA et Belgoprocess, Dossier d'information, Retour de déchets radioactifs compactés depuis la France vers la Belgique, avril 2011 // NIRAS, Synatom, AREVA en Belgoprocess, Informatiedossier, Terugkeer van gecompacteerd radioactief afval vanuit Frankrijk naar België, april 2011

[PaLoFF, 2005] PaLoFF, Fleurus-Farciennes — Avant-projet de dépôt final de déchets faiblement radioactifs et des mesures d'accompagnement requises, Version détaillée, décembre 2005

[Paridaens & Vanmarcke, 2001] Paridaens J. & Vanmarcke H., Inventarisatie en karakterisatie van verhoogde concentraties aan natuurlijke radionucliden van industriële oorsprong in Vlaanderen. Studie uitgevoerd in opdracht van de Vlaamse Milieumaatschappij, MIRA, MIRA/2001/01, SCK•CEN, juni 2001

[Resource Analysis, 2010] Resource Analysis, Strategic Environmental Assessment (SEA) pour le Plan Déchets de l'ONDRAF — Rapport principal, juin 2010 // Resource Analysis, Strategic Environmental Assessment (SEA) over het Afvalplan van NIRAS — Hoofdrapport, juni 2010

[SAFIR Commission, 1990] Commission d'évaluation SAFIR, Rapport final, Secrétariat d'Etat à l'Energie, 1990 // Evaluatiecommissie SAFIR, Eindrapport, Staatsecretariaat voor Energie, 1990

[SAFIR 2 Committee, 2001] Comité de lecture scientifique consultatif du rapport SAFIR 2, Avis final, Annexe 5 de l'Aperçu technique du rapport SAFIR 2 (NIROND 2001-05 F), décembre 2001 // Raadgevend wetenschappelijk leescomité SAFIR 2, Eindadvies, Bijlage 5 van het Technisch overzicht van het SAFIR 2-rapport (NIROND 2001-05 N), december 2001

[SBK & ONDRAF/NIRAS, 1999] Agreement between Schnell-Brüter-Kernkraftwerksgesellschaft mbH and ONDRAF/NIRAS regarding the SNR fabrication waste, 5 February 1999

[SBK *et al.*, 1999] Agreement between Schnell-Brüter-Kernkraftwerksgesellschaft mbH and ONDRAF/NIRAS and Belgonucleaire SA regarding the SNR fabrication waste, 22 April 1999

[SCK•CEN, 2002] SCK•CEN, 1952–2002, 2002

[SEA Advisory Committee, 2015] Comité d'avis SEA, Avis portant sur la nécessité ou non d'opérer une évaluation des incidences sur l'environnement dans le contexte du projet de Programme national de gestion du combustible usé et des déchets radioactifs, 11 septembre 2015, communiqué par lettre du Comité d'avis SEA (réf. E2/NM//AFF/SA/011/2015-001928, 24 septembre 2015) // Adviescomité SEA, Advies over de vraag of een beoordeling van de gevolgen voor het milieu al dan niet noodzakelijk is binnen de context van het Nationaal Programma voor het beheer van verbruikte splijtstoffen en radioactief afval, 11 september 2015, meegedeeld per brief van het Adviescomité SEA (ref. E2/NM//AFF/SA/011/2015-001928, 24 september 2015)

[Senate, 1983] Sénat de Belgique, Débat sur la politique de l'énergie, Résolution « 2.4 Eurochemic et retraitement » adoptée le 18 mars 1983, Doc. S. (1982-1983) 437 // Belgische Senaat, Debat over het energiebeleid, Resolutie "2.4 Eurochemic en opwerking", aangenomen op 18 maart 1983, Doc. S. (1982-1983) 437

[Senate, 1990] Sénat de Belgique, Problématique des déchets radioactifs, Recommandations présentées par la Commission d'information et d'enquête en matière de sécurité nucléaire et approuvées par le Sénat le 11 octobre 1990 après avoir été amendées, Doc. S. 113-18 (S.E. 1988) // Belgische Senaat, Problematiek in verband met het kernafval, Aanbevelingen voorgesteld door de Commissie van informatie en onderzoek inzake nucleaire veiligheid en na amendering goedgekeurd door de Senaat op 11 oktober 1990, Doc. S. 113-18 (B.Z. 1988)

[Stals *et al.*, 2015] Stals M., Pellens V., Schroeyers W., Schreurs S., Hult M., Lutter G., Actualisering van de synoptische balans van de NORM-problematiek in de Belgische industrie, Rapport opgesteld in opdracht van NIRAS, NuTeC-UHasselt, maart 2015

[STOLA-Dessel, 2004] STOLA-Dessel, Het Belgisch laagactief en kortlevend afval: thuis in Dessel? Een geïntegreerd bergingsproject met een technisch en een maatschappelijk luik, november 2004

[Synatom, 2014] Synatom, Rapport annuel 2013, août 2014 // Synatom, Jaarverslag 2013, augustus 2014

[Van den Bossche, 1999] Letter from the Minister of the Interior, Luc Van den Bossche, to ONDRAF/NIRAS, Uw voorstellen van algemene regels voor de acceptatie van geconditioneerd en niet-geconditioneerd kernafval, 10 February 1999

[Verwilghen, 2006] Letter from the Minister for Energy, Marc Verwilghen, to ONDRAF/NIRAS, Berging op Belgisch grondgebied van het afval van categorie A, ref. MV/EDC/BA/cb/2006-007081, 5 July 2006

[Wathelet, 1993] Letter from the Minister for Economic Affairs, Melchior Wathelet, to the Ambassador of the United Kingdom of Great Britain and Northern Ireland, ref. 9.EN/TVR/DMP, 5 November 1993

[Wathelet, 1994] Letter from the Minister for Economic Affairs, Melchior Wathelet, to ONDRAF/NIRAS, Prise en charge en Belgique de déchets radioactifs du Grand-Duché de Luxembourg, ref. 9.EN/0.250/94/0375/TVR/DMP, 22 April 1994