Country Nuclear Power Profiles
2017 Edition

BELGIUM

(Updated 2017)

PREAMBLE

This report provides information on the status and development of nuclear power programmes in Belgium, including factors related to the effective planning, decision making and implementation of the nuclear power programme that together lead to safe and economical operations of nuclear power plants.

The CNPP summarizes organizational and industrial aspects of nuclear power programmes and provides information about the relevant legislative, regulatory and international framework in Belgium.

Belgium has seven nuclear power reactors in operation.

1. COUNTRY ENERGY OVERVIEW

1.1. Energy Information

1.1.1. Energy Policy

The economic and energy policy responsibilities are distributed between the federal State and regional powers (Flanders, Wallonia and Brussels Capital Region).

Six constitutional revisions between 1970 and 2013 dissolved administrative and legal powers between the federal, regional and linguistic levels. Each of the three Belgian regions (Flanders, Wallonia and Brussels Capital Region) and each of the three linguistic communities (Dutch, French and German speaking) has its own executive and legislative bodies, at the same hierarchical level as the federal Parliament and Government.

The (linguistic) communities are primarily responsible for cultural affairs and education, which includes most R&D funding in a general sense. However, policy related to the nuclear sector, the nuclear fuel cycle and R&D in both nuclear fusion and fission remains exclusively under the federal Government.

Generally, the federal Government oversees:

- Security of supply;
- National prospective studies;
- Nuclear fuel cycle and nuclear R&D programmes;
- Large stockholding installations;
- Production and transmission / transport of energy (electricity grid >70 kV), including large storage infrastructure;
- Transport tariffs (federal regulator CREG);
- Energy statistics and balances;
- Offshore wind energy.

The federal Government has the exclusive competence for nuclear energy and is responsible for ensuring the security of the country’s energy supply.

The regional competences include:

- Promotion of the efficient use of energy;
- New and renewable sources of energy (not including nuclear);
- Non-nuclear energy R&D;
- Market regulation for distribution;
- Distribution and transmission of electricity (electricity grid <70 kV);
- Public distribution of natural gas;
- Distribution tariffs (regional regulators — VREG, CWaPE and Brugel);
- District heating equipment and networks;
- Recovery of waste energy from industry or other uses;
- Regional energy statistics and balances.

Renewable energy sources remain in the exclusive competency of the regions, yet the federal Government is also responsible for regulating the development of offshore wind farms due to the fact that it manages territorial waters. Several coordinating bodies were established to facilitate communication between federal and regional governments.

In 1992, the federal Government and the three regional governments created a formal body for discussions on all energy matters, called CONCERE/ENOVER (“Groupe de Concertation Etat–régions pour l’Energie” in French or “Energie-Overleggroep Staat–Gewesten” in Dutch). This “Energy Consultation Group between the State and the regions” holds plenary monthly sessions and has a number of permanent (e.g. energy efficiency) and ad hoc (e.g. smart meters) thematic working groups.

Two other policy making forums include the Federal Interdepartmental Commission for Sustainable Development (established in 1997) and the National Climate Commission (established in 2003), bringing together different stakeholders related to energy from regional and federal levels.

At the federal level, energy matters are handled by the Federal Public Service (FPS) Economy, SMEs, Self-employed and Energy; environmental issues are handled by the Federal Public Service (FPS) Health, Food Chain Safety and Environment; while the Federal Public Service (FPS) Mobility and Transport is responsible for matters which relate to both aforementioned FPSs.

Federal Public Services (FPSs) are a specific feature of the Belgian institutional structure, equivalent to Ministries but with responsibilities that do not necessarily coincide with the areas covered by one specific Minister. Each FPS can report to several Ministers, and each Minister can have several FPSs under his/her authority.

Alongside the FPSs, Belgium also supports federal Public Planning Services (PPSs) which handle ad hoc matters that require coordination between several FPSs, such as the Sustainable Development PPS, created in 2002.

BELSPO, the Belgian Science Policy PPS, is responsible for research programmes as well as for Belgium’s participation in European and international R&D organizations and networks.

The Federal Planning Bureau conducts modelling and analytical studies on economic, energy, social and environmental issues, and develops different scenarios and outlooks.

The Directorate-General for Energy, which is a part of the Federal Public Service for Economy, SMEs, Self-Employed and Energy, is the key administration that develops and implements energy policy. Its main objectives are to ensure an uninterrupted, sustainable and affordable supply of energy, to prepare for the nuclear phase-out, to guarantee the safety of energy infrastructure and appliances, and to prepare the transition towards a low carbon energy system. All of these policy actions are based on advanced data analyses and projections, executed by its Energy Observatory.

Since 11 October 2014, Marie Christine Marghem is the federal Minister for Energy, Environment and Sustainable Development in the federal Government under Prime Minister Charles Michel.

The priorities set by the current Government can be summarized as follows:

To ensure security of electricity supply and to take the necessary measures to improve generation adequacy;

- To contribute to the completion of the internal European energy market and the development of strategic and interconnected European energy networks while unlocking greater flexibility potential within the power system;

- To offer a stable and favourable investment climate favouring innovation and providing predictability through long term guarantees;
- To monitor the energy price in order to guarantee the affordability of the energy bill for industry and households, while also safeguarding competitiveness;
- To establish an interfederal long term energy vision and “energy pact” between the federal State and regions.

Belgium signed (in 1992) and ratified (in 1996) the United Nations Framework Convention on Climate Change. Following this, Belgium ratified the Kyoto Protocol in 2002. The Paris Agreement, which entered into force on 4 November 2016, was ratified by Belgium on 6 April 2017.

The implementation of climate change policies and measures is based on joint plans drawn up by the federal and regional governments, which set their own priorities and are free to determine their own goals within the scope of their powers. However, regional governments have major responsibilities in areas such as rational use of energy, promoting renewable energy sources, town and country planning, agriculture and waste management (except for nuclear waste management, which is a federal matter).

In this context, federal and regional authorities are also expanding an integrated Energy and Climate Plan, in line with EU obligations. This plan, which will include concrete national policy measures to achieve the 2030 objectives, is set to be finalised by the end of 2018.

1.1.2. Estimated Available Energy

Belgium’s total primary energy supply (TPES) was equivalent to 53 million tonnes of oil-equivalent (Mtoe) in 2015. This rate marks 0.6% more than 2014 rates and 8.5% less than in 2005. Energy supply peaked at 60 Mtoe in 2010, after consistent growth for more than 25 years. Yet, from 2010 to 2015, TPES declined by 11.4%.

With no domestic oil or natural gas production, Belgium relies on energy imports, particularly since the end of the coal mining era (the last mine was shut down in 1992). In 2015, domestic production accounted for 20.1% of TPES. Belgian energy policy is therefore guided by the concern to diversify both its sources of supply and its suppliers.

In order to meet energy needs, the country mainly imports fossil fuels. In 2015, it imported 60.4 Mtoe of crude oil and oil products, and exported 29.0 Mtoe; Belgium houses one of the largest petrochemical clusters in the world. In 2015, the country imported 32 080 kilotons (kt) of crude oil and 24 223 kt of oil products, while the level of inland demand for petroleum products has stagnated in recent years at 23 400 kt. Net imports of oil and oil products have declined by 4.3% from 2005, as domestic demand for oil has fallen and exports from the country’s large refining sector are growing. Belgium is a major hub of natural gas flow in the region, with some 18.81 billion cubic meters (bcm) being imported, including 2.5 bcm of LNG. Of these imports, 17.14 bcm are consumed domestically while 1.69 bcm are re-exported (2015). Natural gas net imports amounted to 13.9 Mtoe in 2015, a 6.4% reduction compared to ten years prior.

Coal imports totalled 3.2 Mtoe with 0.06 Mtoe of coal products exports. Coal net imports were 40.8% lower in 2015 than in 2005.

TABLE 1. ESTIMATED AVAILABLE ENERGY SOURCES

	Estimated available energy sources					
	Fossil fuels			Nuclear	Renewables	
	Solid	Liquid	Gas	Uranium	Hydro	Other renewable
Total amount in specific units*	0	0	0	0	<0.1	<0.1
Total amount in exajoule (EJ)	0	0	0	0	<0.1	<0.1

* Solid, Liquid: Million tons; Gas: Billion m^3; Uranium: Metric tons; Hydro, Renewable: TW

Note: Solid and gas reserves are not economically exploitable.

Source: FPS Economy — Energy Observatory.

1.1.3. Energy Statistics

Belgium’s total final consumption (TFC) amounted to 41.7 Mtoe in 2015. The TFC number includes final energy consumption by end users in the form of electricity, heat, gas, oil products, etc.; TFC excludes fuels used in electricity and heat generation and other energy industries, including transformations, such as refining. TFC represents around 78% of TPES, with the remainder used in power generation and other energy transformations (oil refining, iron and steel, cement). TFC has remained essentially flat since 2000. Demand peaked at 42.3 Mtoe in 2010 and has contracted

by 1.3% since that time.

Industry is the largest consuming sector, accounting for 46% of TFC in 2015. Furthermore, demand in industry increased by 7.3% over the last decade. Its share in TFC has increased marginally from 43.3% in 2005. The residential sector accounted for 19.5% and transport for 21.5% of TFC. TFC in households declined by 18% from 2005 to 2015, and its share in total TFC fell from 23.9%. TFC in transport increased by 3.7% over the same period, but its share has remained unchanged.

The commercial and public services sector, including agriculture, fishing and forestry, has increased final energy demand over the past decade by 6.3%.

TABLE 2. ENERGY STATISTICS

Compound annual growth rate CAGR = $(EV/BV)^{1/n}$ - 1

where:

EV = Ending valueBV = Beginning valuen = Number of years (10 years usually)

							Average annual growth rate (%)
	1980	1990	2000	2005	2010	2015*	2000 to 2015*
Energy consumption [EJ]**							
- Total	2.04	2.01	2.43	2.44	2.52	2.23	-0.54
-Solids***	0.52	0.44	0.34	0.22	0.16	0.13	-5.58
- Liquids	0.90	0.74	0.95	0.99	0.98	0.96	+0.07
- Gases	0.41	0.34	0.56	0.62	0.70	0.58	+0.27
- Nuclear	0.14	0.47	0.53	0.52	0.52	0.28	-3.76
- Hydro	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-
- Other renewables	0.07	0.03	0.05	0.07	0.15	0.18	+9.03
Energy production							
- Total	0.30	0.45	0.57	0.58	0.65	.0.45	-1.5
- Solids***	0.18	0.04	0.01	<0.01	<0.01.	<0.01.	—
- Liquids	0.00	0.00	0.00	0.00	0.00	0.00	—
- Gases	<0.01	<0.01	<0.01	0.00	0.00	0.00	—
- Nuclear	0.12	0.40	0.53	0.52	0.52	.0.28	-3.76
- Hydro	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	—
- Other renewables	0.00	0.01	0.04	0.06	0.13	0.16	+10.41
Net import (Import - Export)							
- Total	1.81	1.71	2.12	2.25	2.26	.2.13	+0.02

* Latest available official data.

** Energy consumption = Primary energy consumption + Net import (Import - Export) of secondary energy.

*** Solid fuels include coal, lignite.

Source: FPS Economy — Energy Observatory.

1.2. The Electricity System

1.2.1. Electricity System and Decision Making Process

The Belgian energy market liberalization process began in April 1999 with the transposition of the first EU Directive on Electricity and Gas Markets. The Law of 1 June 2005 fully implemented the EU Directive 2003/54/EC on the common rules for the internal electricity market.

Due the fact that Belgium is a federal State with energy responsibilities distributed between the federal State and the regions, the Belgian electricity market is subdivided in a Flemish, a Walloon and a Brussels market, each of these markets only partly depending on the legal framework of the federal level.

Liberalization was carried out in gradual steps, with the electricity market opening on 1 June 2003 in Flanders. Wallonia and the Brussels Capital Region followed in 2004 and 2007, respectively. From 1 January 2007, the right to choose

suppliers was granted to all consumers in all regions.

The Third Energy Package (Directive 2009/72/EC and EC Regulation no. 714/2009 of 13 July 2009) was transposed into Belgian law by the Laws of 8 January 2012, 26 December 2013 and 8 May 2014, amending the Law of 29 April 1999 on the organization of the electricity market (and the Law of 12 April 1965 on the transport of gaseous and other products by pipeline).

The opening up of the European electricity markets led to the introduction of a power exchange in Belgium, BELPEX, established in 2006. BELPEX facilitates anonymous, cleared trading in two different market segments, namely a day-ahead market segment (DAM) and a continuous intraday market segment (CIM). BELPEX is fully owned by EPEX SPOT. The BELPEX day-ahead market segment is coupled with APX in the Netherlands and UK, EPEX Spot in France and Germany and Nord Pool Spot in the Nordic region. The intraday market segment is coupled with APX in the Netherlands and Nord Pool Spot in the Nordic region.

The regulatory framework for the electricity market is elaborate, including four energy regulators. The primary federal regulator for the electricity and gas markets is known as the Commission for the Regulation of Electricity and Gas (CREG). This Commission advises public authorities on the functions of the electricity market and to monitor the application of related laws and regulations. It also regulates and licenses electricity transmission above 70 kV, approves transmission tariffs and monitors the wholesale market at the national level. The operating costs of the CREG are covered by licensing fees and levies on electricity and natural gas.

In January 2014, powers of the CREG increased due to provisions of the Law of January 2012 and the decision of the Constitutional Court of 7 August 2013, which confirmed that the regulator had exclusive jurisdiction with respect to application, determination and exemption of tariffs.

As part of the 6th State Reform (special Law of 6 January 2014), powers to set distribution tariffs were transferred from the federal level (CREG) to the regional regulators. The reform took effect in July 2014.

Each region maintains its own regulatory institution for the electricity and gas markets: the Flemish Regulation Entity for Electricity and Gas markets (VREG), the Walloon Commission for Energy (CWaPE) and the Commission for Energy Regulation in the Brussels-Capital Region (Brugel). The three regional regulators are responsible for the licensing and the regulation of distribution of natural gas and electricity, the transmission of electricity below 70 kV, technical regulations for the management and extension of natural gas networks, monitoring retail market competition in the regional electricity and gas markets and the green certificate schemes, arbitrating grid access disputes and advising the respective regional governments.

The four Belgian regulators for electricity and gas launched a structural consultative process in the framework of the Forum of Belgian Energy Regulators (FORBEG). It is an informal platform for discussion and voluntary collaboration and information exchange between the regulators with a plenary session and several working groups focusing on the following issues: technical questions, information, complaints, green power, tariffs and strategy.

The management of the Belgian electricity transmission system, on the other hand, is observed by a single transmission system operator (TSO): ELIA System Operator.

According to Article 8 of the Law of 29 April 1999 on the organization of the electricity market, ELIA has sole responsibility for operating, maintaining and developing the high voltage transmission system, including interconnections to other grids, in order to ensure continuity of supply according to the model of “full ownership unbundling”. By decision of the federal regulator on 6 December 2012, this licence is valid for 20 years and can be renewed. Since ELIA enjoys a legal monopoly, it is subject to a special legal framework and to the authority of regulators responsible for checking and approving the way in which it operates (for instance, with respect to tariffs).

ELIA System Operator has been listed on the regulated market of Euronext Brussels since June 2005. Its core shareholder is the municipal holding company Publi-T, founded in 2001. Publipart, which also represents the interests of the Belgian municipalities, holds a 2.53% stake in the company. Roughly 52.26% of ELIA shares are traded freely on the stock exchange.

ELIA employs more than 1100 professionals and owns and operates over 8000 km of high voltage lines and underground cables throughout Belgium. ELIA also supplies power directly to major companies connected to the grid.

As part of its duties, ELIA drew up a plan for the development of the federal transmission grid in 2015. It did so in partnership with the Belgian Directorate-General for Energy and the Federal Planning Bureau.

The development plan covers a ten year period (2015–2025); is compatible with ENTSO-E’s Ten-Year Network Development Plan (2014–2024) and takes account of the latest prospective study carried out by the Directorate-General for Energy in cooperation with the Federal Planning Bureau (in French).

The Development Plan 2015–2025 is the product of a consultative process involving the federal regulator (CREG), the

Minister responsible for the regulation of the Marine Environment, the regional governments and the Federal Council for Sustainable Development.

The final version of the Development Plan 2015–2025 was approved by the Minister for Energy Marie Christine Marghem on 17 November 2015.

The plan involves an increase from 3.5 to 6.5 GWe import capacity from Germany, the Netherlands and the United Kingdom. It also plans to integrate more renewable energy, including 2.3 GWe of offshore wind.

Belgium has long been a proponent of regional collaboration in the field of electricity generation. The PENTALATERAL Energy Forum is the leading forum for discussion and cooperation between the Benelux countries, France and Germany. Its main objectives are market integration and security of supply. It aims at the creation of a regional Northwest-European electricity market as an intermediate step towards a common European electricity market.

Belgium is also reinforcing interconnection capacities with its neighbours:

- The project ALEGrO involves the realization of a HVDC link with a bidirectional rated power of approximately 1000 MW capacity, as the first interconnection between Belgium (Lixhe) and Germany (Oberzier). Commissioning is expected in 2020.
- NEMO will be the first interconnector between the United Kingdom and Belgium, a 1 GW HVDC link. Technical commissioning is planned by 2018 and commercial operation in 2019. NEMO will enhance market integration, facilitate the penetration of renewable energy sources in the energy mix and contribute to security of supply by providing import capacity in a context of decommissioning of power plants.
- The BRABO project is part of greater efforts to upgrade the Belgian electricity grid and is necessary to increase import capacity from the Netherlands. Commissioning is expected in 2020. A bilateral study investigates the options for developing 1 GW additional cross-border capacity between Belgium and the Netherlands.

In 2014, the transmission system operators of the Pentalateral Energy Forum, at the request of Belgium, conducted a comprehensive investigation into capacity planning and additional “regional” investments. On 8 June 2015, the initiative got a new impetus with the signing of a “Political Agreement”, adopting a new work programme.

Moreover, the development of offshore capacities, particularly in the North Sea, is just as vital to the success of Europe’s energy policy. The Belgian Government has played a major role in launching and coordinating “The North Seas Countries’ Offshore Grid Initiative” (NSCOGI). It was established by a Memorandum of Understanding on 3 December 2010 in order to form a regional platform for facilitating coordinated development of a possible offshore grid. The initiative was set up by the 10 North Seas Countries governments and supported by ACER, ENTSO-E, the national regulatory authorities as well as the European Commission. Offshore wind in the North Sea region has the potential to generate over 8% of Europe’s power supply by 2030. The NSCOGI five year celebration conference in Ostend on 23 October 2015 was an occasion for Member States to renew their commitment, while Minister for Energy Marie Christine Marghem expressed her intention to propose a new action plan for the coming five years.

The support scheme for offshore wind parks has meanwhile been adapted to make it more flexible, by taking the real revenues and costs into account, and minimising the cost for consumers.

Regional support schemes in favour of renewable energy were also recently adapted to account for the increasing share of renewables in the energy mix and decreasing costs of renewable technologies.

Still, nuclear energy remains the main energy source for electricity generation in Belgium. There are seven reactor units in commercial operation in Belgium, four in Doel and three in Tihange. Together, these plants can generate about 55 per cent of the country’s electricity needs.

In spite of this dependency, on 31 January 2003, the federal Parliament passed a law prohibiting the construction of new nuclear units intended for the industrial production of electricity by nuclear fission in Belgium, thus limiting the operation of existing reactors to 40 years. According to this law, nuclear fission energy will be phased out between 2015 and 2025.

However, successive governments have amended the law in order to ensure the security of supply of electricity, while always confirming the decision to phase out all nuclear power reactors by 2025.

Two prospective studies were performed to forecast the future energy needs of Belgium based on different economic scenarios, in which the question of the long term operation (LTO) of nuclear power plants was also addressed. The “Study on the Outlook for Electricity Supplies 2008-2017” was published in 2009 and the “Study on the Outlook for Electricity Supplies by 2030” was published in 2015 (both in French and Dutch only). These studies were subjected to a strategic environmental assessment and have been subject to public consultation.

On 4 July 2012 the federal Government decided to postpone the shutdown of Tihange 1 by ten years, mainly out of

concern for the security of the electricity supply.

On 18 December 2014, the new federal Government again confirmed the decision to phase out all nuclear power reactors by 2025, but, as a result of generation adequacy concerns and the lack of investments in new generation capacity, the calendar for the nuclear phase-out was once more adjusted. It decided it would allow the Doel 1 and 2 reactors to continue operating for ten more years, until 2025 (conditional on the approval by the Federal Agency for Nuclear Control FANC/AFCN and an agreement with their operator and owner, ELECTRABEL). Following the approval by the FANC/AFCN, this decision was confirmed by Parliament on 19 June 2015.

In the future, it is planned that the decommissioned nuclear plants should be replaced by new CCGT power plants. To attract the necessary investments, analysis is currently ongoing to identify measures to improve the functioning of the energy market and to assess generation adequacy and the necessity of the introduction of capacity mechanisms.

The current federal Government also decided to create an energy transition fund, with adequate resources, in order to encourage R&D in innovative projects in the field of energy and in particular to develop energy production and energy storage.

By amendment of the Law of 29 April 1999 on the organization of the electricity market, it introduced on 26 March 2014 a Strategic Reserve mechanism to cover any structural shortage in generation during the winter months, but also in preparation for the envisaged phase-out of nuclear energy by 2025.

The Strategic Reserve is organised, managed and if necessary activated by ELIA and differs from the balancing resources which ELIA uses all year round to offset the sum of ARPs' (Access Responsible Parties) residual imbalances in real time.

1.2.2. Structure of the Electric Power Sector

ENGIE, formerly GDF SUEZ, has the dominant position on the Belgian market through its 100% subsidiary ELECTRABEL, the former incumbent electricity supplier. Out of a total of some 110 generation plants connected to the ELIA grid (voltage of 30 kV or more) at the end of 2015, ELECTRABEL owns 64, thus controlling over 75% (11 339 MW) of electricity generating capacity (15 072.20 MW), down from 89% in 2002.

The Tihange and Doel nuclear power plants are operated by ELECTRABEL, though EDF BELGIUM owns 50% of Tihange Unit 1 (450 MW) and EDF LUMINUS has a stake of 10.2% in four nuclear units (Tihange 2 and 3 and Doel 3 and 4).

EDF BELGIUM owns a 63.5% stake in EDF LUMINUS; the other 36.5% is held by the historical Flemish and Walloon inter-municipal shareholders of SPE (PUBLILEC, PUBLILUM, SOCOFE, VEH, ETHIAS and NETHYS). SPE, "Société coopérative de Production d'Electricité", was established as a municipalities' joint utility in 1978. CENTRICA acquired a majority stake in July 2008, which it sold to EDF in 2009. SPE LUMINUS took over the sales activities of EDF BELGIUM in September 2010 and was renamed EDF LUMINUS in November 2011. With an installed capacity of 1 955 MW (17 plants) at the end of 2015, EDF LUMINUS, first challenger, represents about 10% of the Belgian electricity generating capacity. In addition to its holdings in nuclear installations, EDF LUMINUS is a wellestablished green energy producer which has gas fired power plants, wind farms and hydraulic power stations at various sites in Flanders and Wallonia.

The legal separation between companies involved in production, transmission and distribution of electricity was completed in 2007 and both the Transmission System Operator (TSO) ELIA and the regional Distribution System Operators (DSOs) are fully legally unbundled from supply/production companies. Each DSO has a monopoly over the territory in which it operates.

The Distribution System Operators (DSOs) in Belgium are:

- ORES, RESA (group NETHYS), Régie de Wavre, AIESH and AIEG in Wallonia;
- SIBELGA in the Brussels-Capital Region;
- EANDIS and INFRAX in Flanders.

DSOs have municipal shareholders and have a legal requirement to be 100% local government owned by 2018. With regard to the Brussels-Capital Region, ELECTRABEL has already withdrawn from the capital of SIBELGA. As a result, the municipalities have had 100% ownership of SIBELGA's capital since 31 December 2012.

INTER-RÉGIES, created in 1955 in Brussels under the name "INTERPUBLIC", is the umbrella association of the pure public sector owned electricity, natural gas and cable distribution system operators who have only municipal and provincial shareholders, while INTERMIXT represents the municipal shareholders of the mixed inter-municipal distribution system operators.

SYNERGRID, the Belgian Federation of the Electricity and Gas network operators, represents the common interests of

the transmission system operators ELIA and FLUXYS (for gas) and the distribution system operators.

FEBEG is the 32-member association of Belgian electricity and gas companies, i.e. electricity generators, traders and shippers of electricity and gas, electricity and gas suppliers and suppliers of energy services.

FEBELIEC, the “Federation of Belgian Industrial Energy Consumers” represents the industrial energy consumers in Belgium in issues about energy and climate politics on the Belgian and European level.

AGORIA is the largest employers’ federation in Belgium; it brings together and defends the interests of companies in the technology industry, including nuclear technology.

1.2.3. Main Indicators

By the end of 2015, some 21 146 MW of electricity generation capacity was installed in Belgium, including 3 122 MW of photovoltaic, 2 176 MW of wind (1 464 MW onshore and 712 MW offshore) and 5 927 MW of nuclear.

Electricity production amounted to 70.6 TWh in 2015, or 2.8% less than in 2014. Generation peaked at 95.2 TWh in 2010 and has been falling since. From 2010 to 2015, electricity generation fell by 26%, primarily because of long and extensive outages at the country’s nuclear power plants.

Nuclear plants produced 26.10 TWh in 2015, a decrease of 7.6 TWh over 2014. Data for recent years are abnormal due to exceptional events causing the temporary stoppage of several nuclear units. For almost five months in 2014 and most of 2015, around half of the nuclear capacity in Belgium has been off-line (for more information, see Section 2.2.1.). Despite this uncommon situation, the share of nuclear power generation was 36.9% due to the decrease in overall generation in Belgium. The share of nuclear power in total generation was relatively stable during the 2000s, at around 55%. Since 2011, the share has fallen from 54.2% to 36.9%, as total nuclear power generation declined by 54.1% over the same period because of the above mentioned long outages of two reactors.

Total gas fired generation amounted to 22.8 TWh (32.3% of total generation) in 2015, an increase of 3.5 TWh compared to 2014. Electricity generation from natural gas grew for decades to reach a peak of 31.4 TWh in 2010 (33.0% of the total). Since then however, gas use in electricity generation has fallen by 33.8%, as imports from cheaper sources have gained ground.

Coal plants generated 4.2 TWh in 2015, a decrease of 0.15 TWh compared to 2014. Gas and coal fired generation reached their lowest levels since 2007.

Renewables and wastes represent 22.3% of electricity production in Belgium, made up of biofuels and waste (9.6%), wind (7.9%), solar (4.3%) and hydropower (0.5%). In 2015, all offshore wind farms injected 2.6 TWh into the transmission grid, an increase of 17.6% compared to 2014. Adding onshore generation, total wind energy amounted to 5.57 TWh, an increase of 20.8 % compared to 2014.

Renewables’ share in generation has increased from 2.8% in 2005. On average, biofuels and waste grew at 10.5% per annum over the ten years. Driven by subsidies and starting from a low absolute level, solar grew at 107.5% per year and wind at 33.8%. Hydropower generation varies year on year, and in 2015 it was 10.4% lower than in 2005.

More recent data on Belgium’s electricity generation are always available on the web site of ELIA, though only the production of plants connected to the ELIA grid (voltage of 30 kV or more) is taken into account.

TABLE 3. INSTALLED CAPACITY, ELECTRICITY PRODUCTION AND CONSUMPTION

		1980	1990	2000	2005	2010	2015*	Average annual growth rate (%) 2000 to 2015*
Capacity of electrical plants (GWe)[1]	G/N							
- Thermal	N	8.21	7.24	8.55	8.71	9.52	8.51	-0.03
- Hydro	N	1.13	1.40	1.41	1.41	1.43	1.42	+0.04
- Nuclear	N	1.67	5.50	5.71	5.80	5.93	5.91	+0.22
- Wind	N	0.00	<0.01	0.01	0.17	0.91	2.18	—
- Geothermal	N	0.00	0.00	0.00	0.00	0.00	0.00	—
- other renewable	N	0.00	0.00	0.00	<0.01	0.90	3.12	—
- Total	N	11.01	14.14	15.69	16.10	18.69	21.15	+1.88
Electricity production (TWh)[2]	G/N							
- Thermal	G	40.26	27.30	34.14	37.33	43.47	34.04	-0.02

- Hydro	G	0.83	0.90	1.70	1.60	1.67	1.42	-1.12
- Nuclear	G	12.55	42.72	48.16	47.60	47.94	26.10	-3.76
- Wind	G	0.00	<0.01	<0.01	0.23	1.29	5.57	—
- Geothermal	G	0.00	0.00	0.00	0.00	0.00	0.00	—
- other renewable	G	0.00	0.00	0.00	0.27	0.82	3.52	—
- Total**	G	53.64	70.92	84.01	87.03	95.19	70.65	-1.08
Total electricity consumption (TWh)[3]		51.02	67.56	79.82	83.64	85.92	83.14	+0.26

* Latest available official data.

** Electricity transmission losses are not deducted.

[1] Net maximum electrical capacity.

[2] Gross production.

[3] Final consumption (observed).

Source: FPS Economy — Energy Observatory.

Yearly electricity demand demonstrated a steady increase from 1990 until 2006, where demand stabilized around 83 to 85 TWh. The demand for electrical power, that is, net consumption plus pumping power and grid losses, amounted to 92.0 TWh in 2010, 89.7 TWh in 2011, 90.3 TWh in 2012, 90.2 TWh in 2013, 87.9 TWh in 2014 and 88.4 TWh in 2015. The maximum offtake in 2015 was 13 765 MW.

Electricity consumption by large industrial consumers connected to the ELIA transmission network increased by 2% to 27.3 TWh. Electricity consumption by the tertiary and residential sectors and SMEs reached 52.6 TWh in 2015, a rise of 1% compared to 2014, but 3% less than in 2013.

Production in Belgium connected to the ELIA grid dropped by 10% in 2015 to 47.7 TWh.

In general, Belgium has been a net power importer since the beginning of the 1990s. In 2016, net imports totalled 6.2 TWh, 70.6% lower than in 2015 (21 TWh), covering 7% of total electricity consumption in Belgium. Electricity imports reached a record in 2015 at 23.8 TWh (+9% compared to 2014), due to a low availability of nuclear power plants, while exports fell by 35% to 2.7 TWh.

TABLE 4. ENERGY RELATED RATIOS

	1980	1990	2000	2005	2010	2015*
Energy consumption per capita (GJ/capita)	206.8	206.2	240.4	237.7	233.22	198.97
Electricity consumption per capita (kWh/capita)	5 448.8	7 109.1	8 205.1	8 330.9	7 926.1	7 417.6
Electricity production / Energy production (%)	64.37	56.74	53.06	54.97	54.35	56.85
Nuclear / total electricity (%)	23.40	60.24	57.33	54.47	50.40	36.95
Ratio of external dependency (%)**	88.73	82.61	86.59	91.13	90.38	95.39

* Latest available official data.

** Net import / Total energy consumption.

Source: FPS Economy — Energy Observatory.

2. NUCLEAR POWER SITUATION

2.1. Historical Development and Current Organizational Structure

2.1.1. Overview

Nuclear power development in Belgium began after the conclusion of World War II, when uranium production began in the mines of the Belgian Congo and when Belgium signed a nuclear technical cooperation agreement with the United States of America. Belgium was a groundbreaker in adopting nuclear technology for peaceful purposes in the early 1960s. For many years, the Belgian nuclear industry covered almost all activities in the nuclear fuel cycle.

The world famous Belgian Nuclear Research Centre SCK•CEN was created in 1952. The Belgian Reactor 3 (BR3) in Mol was the first PWR in Western Europe; BR3 went critical for the first time on 19 August 1962. On 25 October of the same year, BR3 was connected to the electricity grid. On 30 June 1987, BR3 was also the first pressurised water reactor in Europe to be shut down.

In the neighbouring town of Dessel, the EUROCHEMIC spent fuel reprocessing pilot plant was in operation from 1966 to 1974.

After the commissioning of the pilot PWR reactor BR3 at SCK•CEN in 1962 and an early 305 MW PWR designed by Westinghouse in cooperation with France (Chooz A) in 1966, development of nuclear power for commercial utilization took off in Belgium with the decision to build the NPPs Doel (in Flanders) and Tihange (in Wallonia).

Doel 1 and 2 were ordered in 1968, and Tihange 1 was ordered in 1969. Commercial development was accelerated by the 1970s oil crisis which led to the construction of four more nuclear reactors in 1974. By 1985, 7 nuclear power units — all pressurized water reactors — had been connected to the electricity grid, with a total net generating capacity of (then) 5 824.5 MW.

Main Historical Milestones

1949	Government of Belgium grants purchasing priority of the uranium resources in Congo to the governments of the United Kingdom and the United States of America.
1952	The Belgian Government establishes STK-CEAEN, the Research Centre for Nuclear Energy Applications [Studiecentrum voor de Toepassingen van Kernenergie — Centre d'Etudes pour les Applications de l'Energie nucléaire; the name will be changed to SCK•CEN in 1957].
1956	Commissioning of Belgian Reactor 1 (BR1) by STK-CEAEN.
1957	Belgian engineers takes part in the commissioning of the first commercial nuclear plant in the United States of America.
1957	SCK•CEN (Studiecentrum voor Kernenergie — Centre d'Etude de l'Energie Nucléaire — Belgian Nuclear Research Centre).
1957	Foundation of BELGONUCLEAIRE (MOX production and radwaste treatment and conditioning).
1957	Foundation of EUROCHEMIC, international cooperation by 13 European countries sharing their knowledge in recovering and reprocessing spent fuel.
1960	Franco-Belgian convention and creation of SENA (Société Nucléaire franco-belge des Ardennes): the principle was that everything from funding to studies and energy production should be shared equally.
1960	Start of the construction of the EUROCHEMIC reprocessing plant.
1960	First supply of plutonium to Belgium by the United States of America.
1961	Commissioning of BR2 (Belgian Reactor 2) by SCK•CEN.
1962	Commissioning of the BR3 (Belgian Reactor 3) PWR prototype plant (11 MWe) for SCK•CEN. This reactor was the first PWR built outside the United States of America.
1963	Researchers introduce plutonium enriched fuel rods into BR3.
1964	Commissioning of the VENUS research reactor (Vulcan Experimental Nuclear Study).
1965	Creation of SYNATOM (Syndicate for the design of large capacity nuclear power plants).
1966	Commissioning of the Franco-Belgian Chooz A NPP, then the world's most powerful PWR (305 MW).
1966	Decision to build Doel and Tihange NPPs (Doel 1 and 2 ordered in 1968, Tihange 1 in 1969).
1966	Startup of the installations of EUROCHEMIC.
1969	A Nuclear Safety Department (AVN) was set up within the Association Vinçotte, immediately put in charge of the regulatory control of the nuclear power plants Doel and Tihange.
1971	Creation of the Institute for Radioelements (IRE).
1972	Joint fast breeder programme with Germany and the Netherlands (Kalkar Nuclear Power Plant).
1973	Creation of FBFC (Franco-Belge de Fabrication du Combustible), nuclear fuel production company.
1973	Oil crisis and decision to build four more nuclear units: Doel 3 and 4, Tihange 2 and 3 (ordered in 1974).
1974	End of the reprocessing activities of EUROCHEMIC.
1974	SCK•CEN launches a research programme on storing radioactive waste deeply underground.
1974	Commissioning of Doel 1 (Unit 1 of Doel NPP).
1975	Commissioning of Doel 2 and Tihange 1 nuclear power units.
1976	Take-over of EUROCHEMIC by the Belgian Government with the intention for it to provide supply for domestic needs only.
1977	SYNATOM becomes a nuclear fuel management company (Belgian company for nuclear fuel).
1980	Creation of ONDRAF/NIRAS, the National Agency for Radioactive Waste and Enriched Fissile Materials (Law of 8 August 1980, amended by the Law of 11 January 1991).

1981	The Belgian Nuclear Safety Authority, made up of two services, the SSTIN and the SPRI, is created by Royal Decree.
1982	Commissioning of Doel 3 and Tihange 2 nuclear power units.
1984	Foundation of BELGOPROCESS (which at the time stood for Belgium reprocessing), as a subsidiary of SYNATOM.
1985	Government decision to shut down EUROCHEMIC for good.
1985	Exhaustive back-fitting process for Doel 1 and 2 and Tihange 1 nuclear power units. Commissioning of Doel 4 and Tihange 3 nuclear power units.
1986	Architect–engineering companies ELECTROBEL and TRACTIONEL merge to create TRACTEBEL.
1986	SCK•CEN is involved in the measurements following the Chernobyl nuclear disaster.
1986	Transfer of the BELGOPROCESS shares to ONDRAF/NIRAS.
1986	Beginning of industrial production of MOX fuel by BELGONUCLEAIRE at the Dessel plant.
1987	Start of decommissioning studies for EUROCHEMIC.
1987	The BR3 pressurised water reactor is closed down. This leads to the immediate launch of the first Western European research programme into the dismantling of this type of nuclear reactor.
1988	The construction of an 8th unit (N8) of 1400 MW (50% EDF) indefinitely postponed by Government.
1989	Start of the decommissioning of EUROCHEMIC.
1989	Construction of a centralized treatment facility to process low level Belgian radwaste (CILVA).
1990	Construction of a storage unit for conditioned high and medium level waste (Building 136).
1990	Private electricity producers INTERCOM, EBES and UNERG merge to create ELECTRABEL.
1991	Decommissioning (by EDF) of Chooz A NPP.
1993	First steam generator replacement in Belgium at Doel 3 NPP.
1993	The first Belgian Parliament debate on reprocessing and use of MOX fuel led to the suspension of the reprocessing contract signed between SYNATOM and COGEMA in 1991. The active reprocessing contract signed in 1978 could be further carried out, but no new reprocessing contracts could be signed. From 1993, both options for the back end of the fuel cycle are to be considered on an equal basis and must be assessed in detail during the next five years. The authorization to use MOX in Belgian NPPs is granted in order to consume plutonium obtained from past and active reprocessing contracts for Belgian spent fuel.
1994	Royal Decree authorizing the loading of MOX fuel in Doel 3 and Tihange 2 reactors.
1994	Promulgation of the Law with respect to the Federal Agency for Nuclear Control (FANC/AFCN).
1995	First loading of MOX fuel in Tihange 2 (March) and Doel 3 (June) NPPs.
1995	Commissioning of the dry interim spent fuel storage facility on the Doel NPP site.
1995	Creation of the cooperative company CPTE (Company for co-ordination and Transmission of Electrical Energy) by ELECTRABEL (91.5%) and SPE (8.5%).
1995	An Economic interest grouping (EIG PRACLAY, later renamed as EIG EURIDICE) is created involving SCK•CEN and ONDRAF/NIRAS to carry out feasibility studies for the disposal of high level and/or long lived radioactive waste in clay layers.
1996	Belgian Reactor 2 (BR2) undergoes a major campaign of modernization and refurbishment.
1997	Commissioning of the wet interim spent fuel storage facility on the Tihange NPP site.
1997	In April, ONDRAF/NIRAS presents the various options for the final disposal of low level and short lived waste to the authorities. The Law of 12 December 1997 defines a new mission for ONDRAF/NIRAS, i.e. to establish the inventory of all nuclear facilities and sites containing radioactive waste and assess the decommissioning and site remediation costs.
1998	In January, the Belgian Government decided on a new approach for the search of disposal sites for low level and short lived radioactive waste based on participative methods; it limits the research to existing nuclear zones or areas where the municipalities have shown interest. In December, the Belgian Government ordered the cancellation of the reprocessing contract signed in 1991 between SYNATOM and COGEMA and which was suspended in 1993. It postponed the debate about spent fuel management for a year pending the results of ongoing technical and economic studies. The Government's decision doesn't ban further reprocessing of Belgian spent fuel, but forbids SYNATOM to conclude a new contract without its formal approval.
1998	The MYRRHA research project begins.
1999	In February, the Government appoints the expert commission AMPERE (Commission d'Analyse des Modes de Production d'Électricité et de Redéploiement des Énergies) to assess the electricity demand and the options for the future of power generation in Belgium in the 21st century.
1999	Law of 29 April 1999 on the organization of the electricity market ("The Electricity Act").
1999	In July, the new Government announces the closure of all Belgian nuclear power plants when they reach their 40 year lifetime and introduces a moratorium on reprocessing.

1999	SCK•CEN removes the reactor vessel from Belgian Reactor 3 (BR3).
2000	In April, the first 28 containers with vitrified high level radwaste, resulting from the reprocessing of Belgian spent fuel in La Hague (France), are returned to Belgium. The second repatriation takes place in November.
2000	In December, the Economic interest grouping EURIDICE (European Underground Research Infrastructure for Disposal of Nuclear Waste in Clay Environment) between ONDRAF/NIRAS and SCK•CEN was created to replace the EIG PRACLAY. The EIG EURIDICE is now responsible for the management and operation of the underground research laboratory HADES and the realization of the PRACLAY project.
2000	In December, the Commission AMPERE publishes its report of more than 1000 pages, containing among its key messages, its recommendations to keep the nuclear option open. The report will be evaluated by a group of five international experts selected by the Government.
2001	In February, repatriation of the third batch of containers with vitrified high level radwaste resulting from the reprocessing of Belgian spent fuel in La Hague (France).
2001	In May, the group of five international experts publish the conclusions of their evaluation of the report of the Commission AMPERE. The experts corroborate the standpoints of the Commission AMPERE on a large number of points, in particular the preservation of the national know-how regarding nuclear energy.
2001	During the outage of Tihange 2 fom 9 June to 11 August, the three steam generators are successfully replaced. The steam generator replacement itself is executed in the new record time of 17.5 days.
2001	In September, the Federal Agency for Nuclear Control (FANC/AFCN), established by the federal Law of 15 April 1994, becomes operational, incorporating the former SSTIN and the SPRI.
2001	SCK•CEN launches the “Master’s Degree Course in Nuclear Engineering” in collaboration with five Belgian universities.
2001	In December, an agreement is obtained between the Belgian Government and the electricity sector on financing the dismantling of old nuclear installations at the sites of EUROCHEMIC (BP1) and the former Waste Department of SCK•CEN (BP2), and on the management of the provisions for spent fuel disposal and dismantling of the Belgian nuclear power stations.
2002	In February and September, repatriation of the fourth and fifth batches of containers with vitrified high level radwaste, resulting from the reprocessing of Belgian spent fuel in La Hague (France).
2002	In July, the SAFIR 2 Report (Safety Assessment and Feasibility Interim Report) on high level radwaste disposal in Belgium is presented by ONDRAF/NIRAS to the competent federal authorities. The report confirms Boom clay as a potential host formation, as well as the technical feasibility of the construction of an underground repository in this clay. The report is peer reviewed by the OECD/NEA.
2002	BELGONUCLEAIRE passed a cumulative production of 500 tons MOX fuel.
2003	Law of 31 January 2003 on the gradual phasing out of nuclear energy for the industrial production of electricity.
2003	ONDRAF/NIRAS submitted to the Government the first inventory report of all nuclear sites or facilities containing radioactive substances on the Belgian territory.
2003	Law of 11 April 2003, regulating the provisions for decommissioning of Belgian nuclear power plants and for the management of spent fuel from those nuclear power plants.
2003	In the same month, the general assemblies of ELECTRABEL and SPE agreed to split their joint venture CPTE with retroactive effect to 1 January 2003.
2003	In September, repatriation of the sixth batch of containers with vitrified high level radwaste, resulting from the reprocessing of Belgian spent fuel in La Hague (France).
2005	Decision to close the MOX factory (BELGONUCLEAIRE) in Dessel.
2006	SCK•CEN undergoes a reorganization process which leads to the creation of three scientific institutes. Each institute researches a specific field of nuclear applications. A fourth institute becomes responsible for communications, support services and administration. •The Institute for Nuclear Material Sciences conducts research into materials and fuels for current and future nuclear systems. •The Institute for Advanced Nuclear Systems develops technological knowledge on innovative nuclear reactors. •The Institute for Environment, Health and Safety safeguards the health and safety of humans and the environment for various applications of radioactivity, including the back end of the fuel cycle.
2006	The last fabrication campaign at BELGONUCLEAIRE is completed on 15 August 2006.
2007	In September 2007, the FANC/AFCN creates a subsidiary, a foundation of private law, called Bel V.
2008	On 14 April 2008, the regulatory activities of AVN, as well as the concerned staff, are transferred to Bel V. Since that day, this subsidiary of the FANC/AFCN constitutes the Technical Safety Organization of the Belgian Nuclear Safety Authority.
2008	Completion of the first phase of the decommissioning of EUROCHEMIC.
2008	The BR3 reactor chimney is demolished: an important step in the dismantling process.
2009	SCK•CEN coordinates Belgian research on fusion within “the broader approach” to nuclear fusion.

2010	Start of dismantling work of BELGONUCLEAIRE (main contractors: TECNUBEL N.V., THV BELGOPROCESS/SCK•CEN and STUDSVIK GmbH; project manager: TRACTEBEL).
2010	GUINEVERE is inaugurated at SCK•CEN; one step forward in the research on accelerator driven systems. With the European GUINEVERE project, SCK•CEN realizes the world's first demonstration model of an accelerator driven system with a complete lead core. The federal Government announces financial support for the MYRRHA project. Europe views MYRRHA as a priority research infrastructure project for energy security and the fight against climate change.
2010	SCK•CEN celebrates 35 years of fusion research.
2011	In the aftermath of the nuclear accident in Fukushima, SCK•CEN offers support activities in areas such as analysis, measurements, technical advice, etc.
2011	Stoppage of FBFC (Franco-Belge de Fabrication du Combustible).
2012	At its 60th anniversary, SCK•CEN establishes the Academy for Nuclear Science and Technology. The Academy combines all education and training activities.
2012	Doel NPP, Unit 3: Temporary stoppage from 1 June 2012 until 5 June 2013. Tihange NPP, Unit 2: Temporary stoppage from 17 August 2012 until 7 June 2013.
2012	On 4 July 2012, federal Government decision on a timetable for the nuclear power phase-out between 2015 and 2025, providing for the extension by 10 years of the licence of Unit 1 of Tihange NPP.
2013	VENUS exploitation license for GUINEVERE published by Royal Decree.
2013	Law of 18 December 2013, amending the Law of 31 January 2003 on the gradual phasing out of nuclear energy for the industrial production of electricity, providing a timetable for the nuclear power phase-out between 2015 and 2025.
2014	Doel 3 and Tihange 2: Temporary stoppage from 26 March 2014 because of fault indications discovered in the steel reactor casings.
2014	Complete transposition of EU Directive 2011/70/EURATOM establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste by the Law of 3 June 2014.
2014	Doel 4: Temporary stoppage from 5 August 2014 to 19 December 2014 following an oil leak in its steam turbine.
2015	Law of 18 June 2015, amending the Law of 31 January 2003 on the gradual phasing out of nuclear energy for the industrial production of electricity in view of ensuring the security of electricity supply, on the long term operation (LTO) of Doel 1 and Doel 2 reactors until 15 February 2025 and 1 December 2025 respectively.
2015	The National Programme Committee drafts a National Programme for the Management of Spent Fuel and Radioactive Waste pursuant to the Law of 3 June 2014 which transposed Council Directive 2011/70 /EURATOM of 19 July 2011. It outlines the state of affairs at 31 December 2014 in the field of spent fuel and radioactive waste management.
2016	On 30 June 2016, a draft ministerial decree was approved, fixing the first National Programme for the Management of Spent Fuel and Radioactive Waste.
2016	In July 2016, the material testing reactor BR2 (Belgian Reactor 2) successfully restarted after thorough maintenance and refurbishment lasting 16 months. SCK•CEN takes advantage of the opportunity to invest in the extension of the irradiation capabilities of BR2, including the development of irradiation facilities allowing the irradiation of GenIV/MYRRHA candidate materials in representative conditions.

2.1.2. Current Organizational Structure

Policy related to the nuclear sector, the nuclear fuel cycle and nuclear R&D in both nuclear fusion and fission falls under the responsibility of the Federal Public Service (FPS) Economy, SMEs, Self-Employed and Energy.

Licensing, control and surveillance are the responsibility of the Federal Agency for Nuclear Control (FANC/AFCN) and is supervised by the federal Minister of the Interior.

The fuel cycle for Belgian nuclear plants is managed by SYNATOM. In addition, SYNATOM is entrusted by law with the management of the provisions for dismantling the Belgian nuclear power plants and is therefore mentioned twice in the chart below.

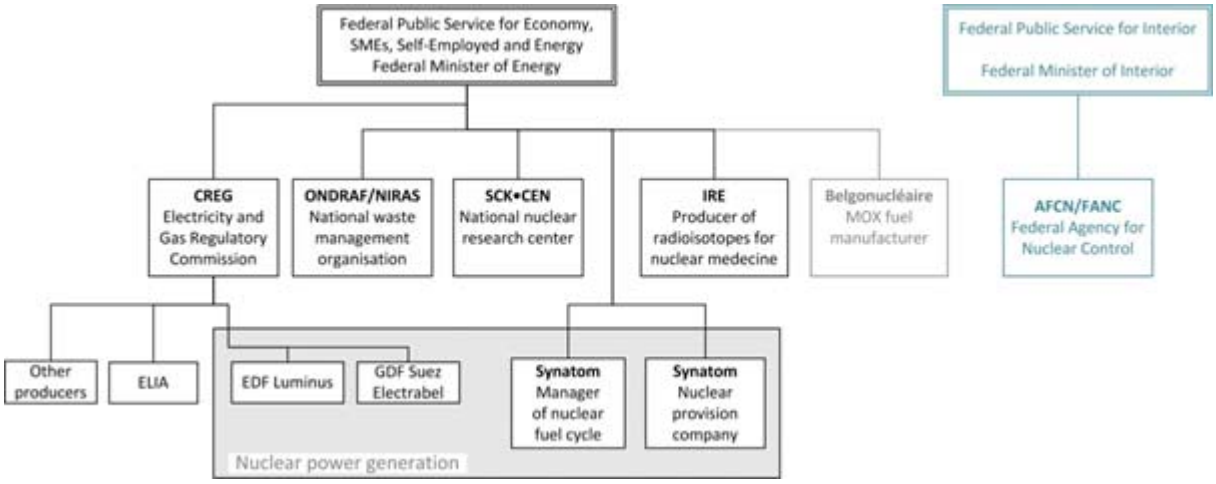

FIG. 1. Organizational chart.

FANC/AFCN

The Federal Agency for Nuclear Control FANC/AFCN (“Federaal Agentschap voor Nucleaire Controle” in Dutch or “Agence Fédérale de Contrôle Nucléaire” in French) is the Belgian Nuclear Safety Authority. It was established by the Law of 15 April 1994 on the protection of the public and the environment against the dangers of ionizing radiation and on the Belgian Federal Agency for Nuclear Control and became fully operational on 1 September 2001. The FANC/AFCN has legal duties in the field of radiation protection, nuclear safety and radiological surveillance, licensing and de-licensing, under supervision of the Minister of the Interior.

For more information on FANC/AFCN, see Section 3.1.1.

CREG

The federal Gas and Electricity Regulatory Commission CREG regulates and licenses electricity transmission above 70 kV, approves transmission tariffs and monitors the market.

Its main missions are:

To ensure that the electricity and gas market is transparent and competitive.

- To ensure that the market situation serves the public interest and fits into the overall energy policy;
- To represent essential consumer interests.

CREG also has an advisory role for the Belgian federal Government and is empowered by the Law of 29 April 1999 on the organization of the electricity market to perform investigations and studies on the electricity market, either on its own initiative or at the request of the Minister for Energy or a regional government.

ONDRAF/NIRAS

ONDRAF/NIRAS (“Organisme National des Déchets Radioactifs et des matičres Fissiles enrichies” in French or “Nationale Instelling voor Radioactief Afval en verrijkte Splijtstoffen” in Dutch) is the National Agency for Radioactive Waste and Fissile Materials entrusted by the Law of 8 August 1980 with the safe transportation, treatment, conditioning, storage and disposal of all radioactive waste produced in the country. The Royal Decree of 30 March 1981 defined its missions and duties, which were extended by way of a law enacted on 11 January 1991 to include certain aspects of the management of enriched fissile materials and the decommissioning of nuclear facilities other than nuclear power plants, the procedures of which were defined in the Royal Decree of 16 October 1991.

The legislature assigned by law certain responsibilities in the field of decommissioning to ONDRAF/NIRAS.

ONDRAF/NIRAS sees to it that the owners/operators create the necessary provisions for the financing of the future dismantling programme.

ONDRAF/NIRAS must work at cost price and charge those using its services — radioactive waste producers — no more or less than the amounts necessary to ensure the safe management of their waste, in accordance with the “polluter pays” principle.

ONDRAF/NIRAS also has the main responsibility for R&D on radioactive waste management and its disposal.

ONDRAF/NIRAS operates under supervision of the federal Minister in charge of Energy and the federal Minister in

charge of the Economy.

BELGOPROCESS

Since 1986, ONDRAF/NIRAS has an industrial subsidiary, BELGOPROCESS, which also runs commercial activities, representing less than ten percent of its turnover.

BELGOPROCESS was founded in 1984 as a subsidiary of SYNATOM. At the time the name stood for “Belgium reprocessing”, as the Belgian Government intended to restart the EUROCHEMIC reprocessing plant, but in 1986 the decision was made to close the factory and BELGOPROCESS was transferred to ONDRAF/NIRAS. (The demolition of the EUROCHEMIC reprocessing plant was completed in 2014.)

Since 1986, the site of BELGOPROCESS in Dessel (adjacent to Mol) serves as ONDRAF/NIRAS’ central processing and conditioning facility as well as a storage facility for conditioned waste of all categories.

BELGOPROCESS is active in three areas:

Industrial activities in the field of radioactive waste management (processing, conditioning and intermediate storage awaiting the final disposal of radioactive waste);

- Dismantling of decommissioned nuclear plants, remediation of contaminated buildings and sites, decontamination of materials and structures;
- The retention and development of new knowledge and know-how, the execution of projects and the commercial use of the know-how within these areas.

SCK•CEN

As a foundation of public utility, the Belgian Nuclear Research Centre SCK•CEN conducts research into the safety of nuclear installations, the management of radioactive waste and human and environmental protection against ionizing radiation, safeguards of strategic materials and social implications of nuclear energy.

According to its statutes and besides the research activities, it also guarantees the maintenance of a centre of competence in the domains of nuclear energy and ionizing radiation, and has a role in communication, education and training. In 2012 it created its Academy for Nuclear Sciences and Technology. It also offers services in the scope of its competences.

SCK•CEN’s material testing reactor BR2 (Belgian Reactor 2), which has been in use since 1963, is amongst the most powerful and flexible research reactors in the world and plays a prominent role in the production of medical radioisotopes (BR2 is responsible for 20 to 25% of the world’s total production of the most important radioisotopes) and the doping of silicon used in renewable energy systems. SCK•CEN decided to invest in the extension of the irradiation capabilities of BR2, including the development of irradiation facilities allowing for the irradiation of GenIV/MYRRHA candidate materials in representative conditions. In July 2016, BR2 successfully restarted after thorough maintenance and refurbishment lasting 16 months. SCK•CEN took advantage of the opportunity to invest in the extension of the irradiation capabilities of BR2, including the development of irradiation facilities allowing the irradiation of GenIV/MYRRHA candidate materials in representative conditions.

Since 1998, SCK•CEN has developed the nuclear research infrastructure Multipurpose Hybrid Research Reactor for High-tech Applications (MYRRHA). MYRRHA is based on the concept of an Accelerator Driven System (ADS) for the necessary research into innovative solutions for high level radioactive waste, the qualification of fusion reactor materials and fundamental nuclear physics research. These tasks are carried out in an international context in collaboration with universities, research organizations and sister organizations. MYRRHA has been identified within the European ESFRI roadmap and within the European Sustainable Nuclear Industrial Initiative (ESNII) of the Sustainable Nuclear Energy Technology Platform (SNETP) in support of the SET-Plan.

IRE

The National Institute for Radioelements (IRE) is a public utility foundation whose main activity is the production of radioelements used in nuclear medicine for diagnostic and therapeutic purposes. Its R&D department contributes to research in the field of radioelement production, environmental protection and radioactive waste management.

Through its subsidiary, IRE ELiT, the Institute develops its service activities relating to environmental protection and its new radiopharmaceutical production activities.

SYNATOM

The fuel cycle for Belgian nuclear plants is managed by SYNATOM, a wholly owned subsidiary of ELECTRABEL. The Belgian Government holds a “golden share” and appoints two representatives to the Board of Directors.

SYNATOM is responsible for the fuel cycle front end management, i.e., supplying enriched uranium to the seven nuclear power units; as well as the fuel cycle back end management, i.e., the management of all activities in connection with spent nuclear fuel.

SYNATOM is the “exclusive owner” (as defined by EURATOM Treaty Article 87) of the nuclear fuel from its fabrication to its transfer to ONDRAF/NIRAS when declared as radioactive waste. Hence it is the most important owner and producer of irradiated fissile materials.

In addition, SYNATOM is entrusted by the Law of 11 April 2003 on the provisions made for the decommissioning of nuclear plants and the management of irradiated nuclear fuel in these plants, amended by the Law of 25 April 2007, with the management of the provisions for dismantling the Belgian nuclear power plants and for the costs related to their spent fuel.

The main characteristics of the methodology applied for dismantling provisions are the following:

The provision must be accrued over the long term operation (LTO) of the nuclear power plants (as defined by the Law of 31 January 2003, i.e. 40 calendar years). The current scenario is a dismantling approach based on the dismantling of each unit separately, but in series, and the decommissioning of the common facilities well after the decommissioning of the last unit on each site.

- The initial provision is equal to the net present value of all future decommissioning expenses (based on a study performed by an independent engineering company and the engineering office TRACTEBEL).

ELIA

ELIA System Operator is Belgium’s only transmission system operator (TSO) for electricity.

For more information on ELIA, see Section 1.3.1.

BELGONUCLEAIRE

BELGONUCLEAIRE S.A. was founded in 1957 and provided nuclear engineering services in the areas of studies concerning the behaviour of nuclear fuels, the back end of the nuclear fuel cycle, and manufacturing equipment for MOX plants. It operated a MOX fuel manufacturing facility in Dessel from 1986 to 2006. Dismantling work started in 2010 and is scheduled to finish in 2016.

2.2. Nuclear Power Plants: Overview

2.2.1. Status and Performance of Nuclear Power Plants

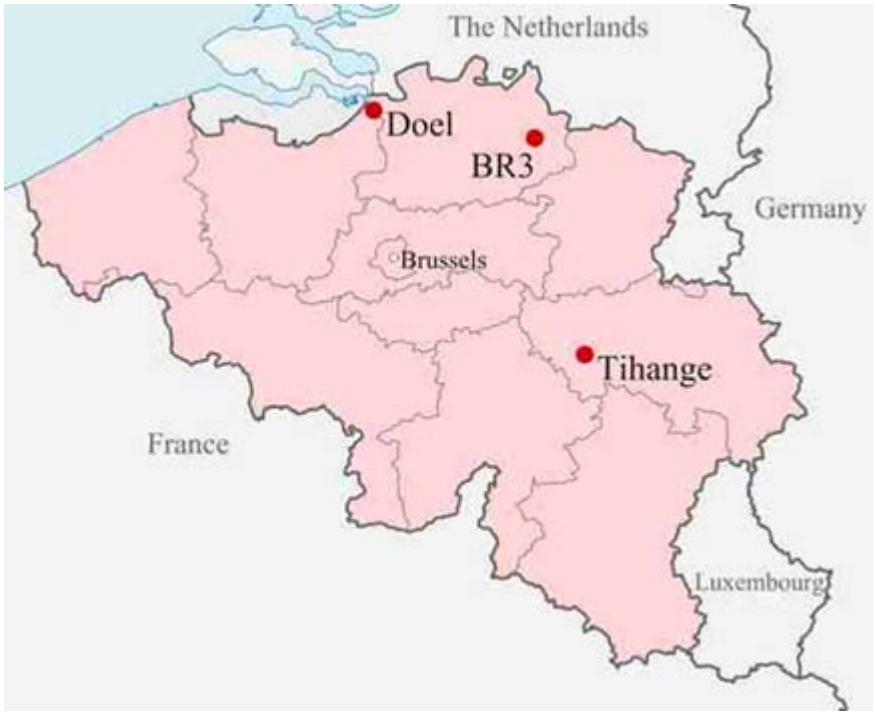

FIG. 2. Location of nuclear power plants in Belgium.(Licensed under Creative Commons Attribution-Share Alike 3.0 via Wikimedia Commons.)

The Belgian nuclear power plants are located in Doel (in Flanders) and Tihange (in Wallonia). All reactors are operated by ELECTRABEL, though EDF Belgium owns 50% of Tihange 1 and EDF LUMINUS — a 63.5% subsidiary of EDF Belgium — has a stake of 10.2% in four nuclear units (Tihange 2 and 3 and Doel 3 and 4). ELECTRABEL is 100% a subsidiary of GDF SUEZ S.A. The BR3 (Belgian Reactor 3), a prototype pressurised water reactor, was shut down on 30 June 1987.

On 31 January 2003, the federal Parliament passed a law codifying the national policy of Belgium to phase out nuclear energy for commercial electricity production. This law prohibits the construction of new nuclear power plants (NPPs) intended for the industrial production of electricity by nuclear fission in Belgium and sets a 40 year limit on the operational period of existing plants. This legislation does not apply to nuclear research reactors.

On 4 July 2012, the Belgian Government, while authorizing the LTO of Tihange 1 until 2025 (conditional on the approval by the FANC/AFCN), confirmed this decision and by the Law of 18 December 2013 it established a timetable for the nuclear power phase-out between 2015 and 2025. At the same time, the law eliminated the possibility to invoke force majeure to change the timetable for the nuclear power phase-out by Royal Decree if Belgium's security of supply is threatened.

On 18 December 2014, the current federal Government also confirmed the decision to phase out all nuclear power plants by 2025. However, in order to ensure security of supply of electricity, it would allow the Doel 1 and 2 reactors to continue operating for an additional ten years — conditional on the approval of the regulator FANC/AFCN and an agreement with the operator and owner of the reactors, ELECTRABEL — until 15 February 2025 and 1 December 2025, respectively. This decision was confirmed by the Law of 18 June 2015, amending the Law of 31 January 2003 on the gradual phasing out of nuclear energy.

Taking into account these amendments, the timetable for the nuclear phase-out is as follows:

Nuclear Phase-out Timetable

Reactor	Net capacity	Start of commercial operation	Off-line
Doel 1	433.0 MWe	15 February 1975	15 February 2025
Doel 2	433.0 MWe	1 December 1975	1 December 2025
Doel 3	1 006.0 MWe	1 October 1982	1 October 2022
Doel 4	1 033.0 MWe	1 July 1985	1 July 2025
Tihange 1	962.0 MWe	1 October 1975	1 October 2025
Tihange 2	1 008.0 MWe	1 February 1983	1 February 2023
Tihange 3	1 0.38.0MWe	1 September 1985	1 September 2025

Historically, nuclear power plants have operated effectively in Belgium, with availability and load factors between 85% and 90%. However, several independent events have resulted in prolonged unplanned shutdowns of nuclear reactors and in an overall reduction of their availability and load factors in recent years. In summer 2012, the units Doel 3 (on 2 June) and Tihange 2 (on 16 August) were taken offline by the operator because of fault indications discovered in the pressure vessels by specific in-service inspections (not required by procedures). Further analysis showed that the fault indications consisted of hydrogen flakes which were originated during steel manufacturing. The two units were restarted in June 2013, but were shut down again in March 2014 after the operator had performed additional tests requesting further investigations. Finally, after an international peer review by experts, in November 2015 the Belgian nuclear regulator FANC/AFCN authorized their restart based on safety case reports that provided an adequate demonstration of the structural integrity of Doel 3 and Tihange 2 for up to 40 years of operation (Final Evaluation Report 2015: Flaw indications in the reactor pressure vessels of Doel 3 and Tihange 2). The two units resumed operation in December 2015.

Furthermore, Doel 4 automatically shut down on 5 August 2014 following an oil leak in its steam turbine, hence in the non-nuclear part of the facility. Work to replace the reactor's turbine took almost 5 months. Doel 4 restarted on 19 December 2014.

Finally, Doel 1, the oldest nuclear power plant unit, was shut down in February 2015, in accordance with the phase-out legislation of 2003, limiting the operation of all Belgian nuclear power units to 40 years. This legislation was supposed to apply in December 2015 to Doel 2 as well, but the Belgian Parliament decided in June 2015 to extend the operation of both Doel 1 and 2 by 10 years, mainly out of concern for the security of the electricity supply.

At the end of 2015 and the beginning of 2016, Doel 1 and 2 resumed operation after two months of scheduled maintenance. All in all, for almost five months in 2014 and most of 2015, around half of the nuclear capacity in Belgium had been off-line.

TABLE 5. STATUS AND PERFORMANCE OF NUCLEAR POWER PLANTS

Reactor Unit	Type	Net Capacity [MW(e)]	Status	Operator	Reactor Supplier	Construction Date	First Criticality Date	First Grid Date	Commercial Date	S
DOEL-1	PWR	433	Operational	ELECTRAB	ACECOWEN	1969-07-01	1974-07-18	1974-08-28	1975-02-15	
DOEL-2	PWR	433	Operational	ELECTRAB	ACECOWEN	1971-09-01	1975-08-04	1975-08-21	1975-12-01	
DOEL-3	PWR	1006	Operational	ELECTRAB	FRAMACEC	1975-01-01	1982-06-14	1982-06-23	1982-10-01	
DOEL-4	PWR	1038	Operational	ELECTRAB	ACECOWEN	1978-12-01	1985-03-31	1985-04-08	1985-07-01	
TIHANGE-1	PWR	962	Operational	ELECTRAB	ACLF	1970-06-01	1975-02-21	1975-03-07	1975-10-01	
TIHANGE-2	PWR	1008	Operational	ELECTRAB	FRAMACEC	1976-04-01	1982-10-05	1982-10-13	1983-06-01	
TIHANGE-3	PWR	1038	Operational	ELECTRAB	ACECOWEN	1978-11-01	1985-06-05	1985-06-15	1985-09-01	
BR-3	PWR	10	Permanent Shutdown	CEN/SCK	WH	1957-11-01	1962-08-29	1962-10-10	1962-10-10	1

Data source: IAEA - Power Reactor Information System (PRIS).

Note: Table 7 is completely generated from PRIS data to reflect the latest available information and may be more up to date than the text of the report.

+ Date when first major placing of concrete, usually for the base mat of the reactor building, is done.

++ Date of the first connection to the grid.

* UCF (Unit Capability Factor) for the latest available year (only applicable to reactors in operation).

** ELECTRABEL.

Source: The data for Table 5 (list of nuclear power reactors that are operational, under construction, cancelled/suspended construction, and long term/permanent shut down) have been generated automatically and updated via the PRIS database. (www.iaea.org/pris/).

After the 11 March 2011 Fukushima accident, the European Council decided in March 2011 that the safety of all EU nuclear plants should be reviewed on the basis of a comprehensive and transparent risk and safety assessment. Following the specification proposal for such “stress tests” by the Western European Nuclear Regulator’s Association (WENRA) on 21 April 2011 and by the European Nuclear Safety Regulators’ Group (ENSREG) on 13 May 2011, the FANC/AFCN proposed on 17 May 2011 the specifications for “Belgian Stress tests” applicable to power reactors.

These specifications were adopted by the Belgian Parliament on 16 June 2011.

In the light of the report submitted by ELECTRABEL on 31 October 2011, the FANC/AFCN concluded that the Doel and Tihange nuclear power plants had an adequate level of protection under extreme conditions.

A similar stress test evaluation was performed at SCK•CEN, BELGOPROCESS and IRE. FANC/AFCN also concluded that these installations have an adequate level of protection under extreme conditions. A follow-up plan with specific measures was implemented for all installations.

2.2.2. Plant Upgrading, Plant Life Management and Licence Renewals

The initial licences of the seven nuclear power plants were granted for an unlimited time.

The safety of the installations is continuously reviewed through different processes, the most important and systematic being the series of periodic safety reviews (PSRs).

In addition, many other projects with important modifications have been executed, including steam generator replacements at all units, in some cases accompanied by power increases. Such major modifications to the nuclear power plants are subject to license amendments following a procedure similar to the initial one.

2.2.3. Permanent Shutdown and Decommissioning Process

The BR3 (Belgian Reactor 3), a prototype pressurised water reactor, operational from 1962 to 1987, was shut down on 30 June 1987.

SCK•CEN is entrusted with its decommissioning. At present, the major components of the BR3 reactor are dismantled, and concrete cleaning work has started. The major remaining tasks are related to the demolition of the buildings. It will be the first complete decommissioning of a PWR in Europe.

2.3. Future Development of the Nuclear Power Sector

The Law on the nuclear power phase-out of 31 January 2003 progressively phases out the production of electricity using nuclear fission energy by limiting the operation of existing reactors to 40 years and prohibiting the construction of new nuclear units intended for the industrial production of electricity by nuclear fission in Belgium. Subsequently, successive governments have amended this law in order to ensure the security of supply of electricity, allowing for the LTO of the units Tihange 1 and Doel 1 and 2, while always confirming the decision to phase out all nuclear power reactors by 2025.

2.3.1. Nuclear Power Development Strategy

Not applicable.

2.3.2. Project Management

Not applicable.

2.3.3. Project Funding

Not applicable.

2.3.4. Electric Grid Development

Not applicable.

2.3.5. Sites

Not applicable.

2.3.6. Public Awareness

Not applicable.

2.4. Organizations Involved in Construction of NPPs

TRACTEBEL

TRACTEBEL is the engineering division of ENGIE. TRACTEBEL was the Architect Engineer/Owner's Engineer for the construction of the seven Belgian nuclear power units in Doel and Tihange.

A multicontract approach was applied for the construction of all the units. As Architect Engineer for utility plants, TRACTEBEL was closely involved in developing:

Pre-feasibility and feasibility studies;

- Project management and support during construction/erection and the commissioning/acceptance tests phases;
- Commissioning.

TRACTEBEL ensured the timely project implementation due to prompt coordination of all the contractors involved, about 3 000 contracts per unit.

WESTINGHOUSE Electric Belgium

The Westinghouse Electric Belgium office provides engineering support to nuclear power utilities in Europe and worldwide. Activities include structural and safety analysis, materials and fracture analysis, plant ageing management and life extension, repair or replacement of major components, systems power uprating and efficiency analysis. The centre supports Westinghouse Field Services efforts at European operating reactors. The Nivelles Service Centre, inaugurated in January 2010, has two fully licensed Class II nuclear facilities, including the 2 000 square meter European Pump and Motor Maintenance and Repair Centre. Westinghouse Electric Belgium employs a multinational workforce of approximately 200 employees.

2.5. Organizations Involved in Operation of NPPs

ENGIE ELECTRABEL

The "Elektriciteitsmaatschappij der Schelde" was established in 1905. After a series of mergers, it became the largest energy company in Belgium. In 1990, the name of the former incumbent electricity supplier became ELECTRABEL. It is

100% owned by ENGIE, formerly GDF SUEZ (formed in 2008 by the merger of Gaz de France and SUEZ) and is active in the production and selling of electricity, natural gas and energy services to retail and business customers. In November 2015, ENGIE announced that it would change the name of its daughter company to ENGIE ELECTRABEL in 2016.

ENGIE ELECTRABEL operates seven nuclear reactors: four in Doel and three in Tihange, with a total capacity of almost 6 000 MW. Moreover, ELECTRABEL owns 50% of Tihange 1, 89.8% of Tihange 2 and 3, 100% of Doel 1 and 2 and 89.8% of Doel 3 and 4.

EDF BELGIUM

EDF Belgium is active in electricity generation. It owns a 63.5% stake in EDF LUMINUS, Belgium's second largest gas and electricity supplier. EDF Belgium also holds a direct 50% stake in Unit 1 of the Tihange NPP.

EDF LUMINUS

In 2009, EDF acquired the majority stake of CENTRICA in SPE LUMINUS, which was originally established in 1978 as joint utility "Société coopérative de Production d'Electricité" (SPE). EDF Belgium now holds 63.5% of the shares, with the remaining 36.5% held by the historical Flemish and Walloon inter-municipal shareholders of SPE: PUBLILEC, PUBLILUM, SOCOFE, VEH, ETHIAS and NETHYS.

EDF Belgium merged its sales activities with SPE in September 2010 and renamed the company EDF LUMINUS on 23 of November 2011.

EDF LUMINUS has a stake of 10.2% in four nuclear power units (Tihange 2 and 3 and Doel 3 and 4).

2.6. Organizations Involved in Decommissioning of NPPs

FANC/AFCN

The Federal Agency for Nuclear Control FANC/AFCN, established by the Law of 15 April 1994, is the regulatory body in charge of nuclear safety, licensing and de-licensing, under supervision of the Minister for the Interior.

The classification of nuclear installations in classes I to IV is defined by Article 3 of the Royal Decree of 20 July 2001, executing the Law of 15 April 1994 and laying down the "General Regulations" regarding the protection of the public, workers and the environment against the hazards of ionizing radiation. The decommissioning of nuclear installations belonging to the Class I facilities, as well as some belonging to the Class II facilities, is subject to prior authorization by the FANC/AFCN.

For Class I installations, the decommissioning licence is granted by a Royal Decree, countersigned by the Minister responsible for nuclear safety and radiological protection, but the licence application must be submitted to the FANC/AFCN. For Class II installations, the licence is granted by the FANC/AFCN. The decommissioning strategy is specified by the licence applicant and submitted to the FANC/AFCN for approval.

ONDRAF/NIRAS

The legislature assigned certain responsibilities in the field of decommissioning to ONDRAF/NIRAS by law. Among others, the agency has to collect and to evaluate information related to the decommissioning programmes of nuclear installations, to approve those programmes, and to execute decommissioning programmes at the demand of third parties or in the case of failure of an operator. For the purpose of standardization of decommissioning planning, ONDRAF/NIRAS issued recommendations for the elaboration of decommissioning plans, following the IAEA Safety Requirements and Guides in the field of decommissioning. Further, under the law, the legislature assigned ONDRAF/NIRAS the elaboration of an inventory of all nuclear installations and all sites containing radioactive substances within the country, including the verification of the existence of sufficient financial provisions for the execution of decommissioning and remediation programmes.

ONDRAF/NIRAS also ensures that the owners/operators create the necessary provisions for the financing of the future dismantling programme.

ONDRAF/NIRAS must work at cost price and charge those using its services — radioactive waste producers — no more or less than the amounts necessary to ensure the safe management of their waste, in accordance with the "polluter pays" principle.

CREG

The Law of 24 December 2002 provided for the levy of an excise tax, called federal dues, which is calculated on the basis of kWh consumed. Part of these dues are paid to funds earmarked to finance nuclear liabilities resulting from the

decommissioning of the sites of the former EUROCHEMIC plant (BP1) and the former Waste Department of SCK•CEN (BP2), as well as the treatment, processing, storage and evacuation of accumulated radioactive waste. The Commission for Electricity and Gas Regulation (CREG) collects the amount owed as dues and transfers it to ONDRAF/NIRAS, which is responsible for the management and clean-up.

BELGOPROCESS

Founded in 1984, BELGOPROCESS was incorporated as a subsidiary of ONDRAF/NIRAS in 1986; it is in charge of decommissioning the shutdown nuclear facilities on the sites of the former EUROCHEMIC plant (BP1) and the former Waste Department of SCK•CEN (BP2).

BELGOPROCESS uses this operational expertise to offer waste management and decommissioning services to national and international clients on a commercial basis. These activities range from treating foreign waste in its installations, to decommissioning off-site obsolete nuclear facilities, to implementing plasma thermal technology.

SYNATOM

SYNATOM, a wholly owned subsidiary of ELECTRABEL, was entrusted by the Law of 11 April 2003 on the provisions for the decommissioning of nuclear power plants and the management of the irradiated nuclear fuel from these plants, amended by the Law of 25 April 2007, with the management of all the provisions for the nuclear liabilities, the dismantling of the nuclear power plants and the management of the spent fuel. SYNATOM is also the “exclusive owner” (as defined by EURATOM Treaty Article 87) of all nuclear fuel from its fabrication to its transfer to ONDRAF/NIRAS when declared radioactive waste. Hence it is the most important owner and producer of irradiated fissile materials in Belgium.

The main characteristics of the applied methodology for dismantling provisions are the following:

The provision must be accrued over the life expectancy of the nuclear power plants (as defined by the Law of 31 January 2003, i.e. 40 calendar years). The current scenario is a dismantling approach based on the dismantling of each unit separately, but in series, and the decommissioning of the common facilities well after the decommissioning of the last unit on each site.

- The initial provision is equal to the net present value of all future decommissioning expenses (based on a study performed by engineering company TRACTEBEL).

TRACTEBEL

TRACTEBEL offers a full range of integrated concepts to assist with the safe and cost effective decommissioning of nuclear installations and has executed the following projects:

Decommissioning plan and preparatory work for the shutdown and dismantling of the first NPP units in Doel (Belgium);

- Complete studies of two subsystems for final repository project CIGEO (France);
- Demolition, decontamination and dismantling plan of Bohunice V1 NPP (Slovakia);
- Architect Engineer for the dismantling of high activity waste tanks (Belgium);
- Studies for wet and dry spent fuel storage (Belgium, France, United Kingdom).

TECNUBEL

TECNUBEL is part of the Benelux Business Unit of ENGIE. Its expertise covers a wide range of services in the maintenance, decontamination and dismantling of nuclear installations and the rehabilitation of the surrounding sites. It played a key role as the main partner in the dismantling of the MOX fuel plant of BELGONUCLEAIRE in Dessel.

SCK•CEN

SCK•CEN has accumulated almost 25 years’ experience in decommissioning and decontamination of reactors, hot cells, radioactive contaminated laboratories and “exotic” installations.

SCK•CEN was entrusted with the decommissioning of the BR3 (Belgian Reactor 3), a prototype pressurised water reactor which was operational from 1962 to 1987. At present, the major components of the BR3 reactor have been dismantled, and concrete cleaning work is underway. The major remaining tasks relate to the demolition of the buildings. It will be the first complete decommissioning of a PWR in Europe. This expertise is now also being applied for the refurbishment of various laboratories on site.

SCK•CEN has also been strongly involved in the management of the dismantling of the Thetis research reactor at Ghent University and at the dismantling of the former MOX production plant of BELGONUCLEAIRE in Dessel.

The dismantling work on the Thetis reactor was completed in 2014 and measurements were performed for the release of the various rooms. During these measurements, it was found that part of the reactor vessel is lightly activated, so that it cannot be released directly. Due to the non-nuclear risks associated with the removal of the activated parts, subsequently the University of Ghent presented a proposal for in situ decay storage of the reactor vessel. After extensive inspections by the IAEA, EURATOM and the FANC/AFCN, the Thetis reactor was formally declared dismantled in 2015, its licence being ended with by the Royal Decree of 26 December 2015. On 1 January 2016, Thetis thus becomes the first nuclear reactor in Belgium to be declassified.

2.7. Fuel Cycle Including Waste Management

Mining and Milling

Uranium deposits were reported prior to 1977, and exploration was funded jointly by the European Commission and the (then) Belgian Ministry of Economic Affairs from 1979 to 1981. The results were published in 1983. A brief historical review of uranium exploration in Belgium can be found in the 2001 edition of the Red Book (p. 110). No further exploration or mining activities were attempted after that time. Belgian regulations concerning prospecting and the export of ores contain no special provisions regarding nuclear ores.

Uranium Conversion and Enrichment

The supply of enriched uranium for the Belgian nuclear power plants belongs is the responsibility of SYNATOM.

SYNATOM owned an 11% share in the EURODIF enrichment facility on the Tricastin site in France, which closed down in June 2012. SYNATOM does not participate in Georges Besse II.

In 2008, SYNATOM concluded a strategic partnership with POWERTECH Uranium Corp. of Canada, for the development of POWERTECH's uranium projects in the United States of America. SYNATOM sold its 18.6% participation in POWERTECH in 2013.

No conversion or enrichment activities take place in Belgium.

Fuel Fabrication

Belgian experience with MOX fuel goes back as early as 1963, with the loading of 12 MOX fuel rods in its pioneer PWR, the BR3 reactor at Mol, though MOX fuel was only introduced in NPPs Doel 3 and Tihange 2 in 1995, after authorization in 1994.

The material testing reactor (BR2) and the research laboratories of SCK•CEN are licensed and equipped to handle MOX fuels and have been involved in most of the international MOX research projects.

SCK•CEN and BELGONUCLEAIRE continued MOX fuel research and development. As a result, the MIMAS production process technology is applied for almost all of the MOX used in NPPs.

From 1986 to 2006, BELGONUCLEAIRE operated an industrial scale MOX fuel manufacturing facility in Dessel. The plant had a yearly production capacity of 32 tonnes of MOX fuel for commercial West-European light water reactors and has produced more than 600 tons of MOX for 21 NPPs worldwide. At the end of 2005, production was stopped after successive capacity increases of MOX plants in France and the United Kingdom. The last fabrication operation was completed on 15 August 2006, followed by a decommissioning licence being granted by Royal Decree on 26 February 2008 and decommissioning operations starting in 2010.

FBFC (Franco-Belge de Fabrication du Combustible), a subsidiary of AREVA, had a fresh fuel production capacity of 500 tonnes per year and a MOX fuel production capacity of 200 tonnes per year, to provide for fuel assemblies for pressurized water reactors as well as boiling water reactors. In May 2012, AREVA officially notified the FANC/AFCN to stop all its activities in the Dessel facility. The fresh fuel facility was shut down in 2012 and a dismantling license was granted by Royal Decree in October 2013. Decommissioning of this facility is in its final stages. The MOX fuel fabrication facility ceased activities at the end of 2015.

Interim Storage of Spent Fuel

Commercial spent fuel is separately stored in dedicated facilities on the sites of the nuclear power plants (pool storage in Tihange and dry storage in Doel). At the end of 2014, the dry storage building in Doel contained 90 containers in which 2 663 spent fuel elements were stored, while the wet storage building in Tihange contained 2 495 such elements.

Reprocessing

Reprocessing of spent fuel was carried out by AREVA (formerly COGÉMA) in France starting in 1978, when SYNATOM entered into a reprocessing contract with COGÉMA.

Also in 1978, the Belgian Government concluded an agreement about the takeover of the EUROCHEMIC reprocessing plant with the intention for it to supply and meet domestic needs only. The EUROCHEMIC pilot plant was established in December 1957 by an international consortium of 12 OECD countries, in partnership with the private sector. It had been EUROCHEMIC's mission to construct and operate an experimental reprocessing plant for the recycling of spent nuclear fuel and to conduct scientific research into new reprocessing methods, while offering training for future European nuclear scientists.

EUROCHEMIC's plant was in operation from 1966 until 1974. A total of 181.5 tonnes of natural and low enriched uranium was reprocessed. Of this material, 95.5 tonnes originated from commercial nuclear reactors. A total of 677 kg of plutonium was separated. In addition, 1 363 kilograms of high enriched uranium was recycled from 30.6 tonnes of fuel elements from European pilot reactors. When EUROCHEMIC was commissioned in 1966, it employed 378 people of thirteen different nationalities.

In 1984, the Belgian Government transferred EUROCHEMIC to BELGOPROCESS (which at the time stood for Belgium reprocessing), then a subsidiary of SYNATOM. However, in 1986, the decision was made to close the factory. The demolition of the EUROCHEMIC reprocessing plant was completed in 2014.

In December 1993, the federal Parliament imposed a moratorium for a period of five years on further reprocessing of the spent fuel. In 1998, the Council of Ministers requested SYNATOM not to sign any new reprocessing contract without formal approval.

Waste Management

Directive 2011/70/EURATOM imposed a major policy change with its special emphasis on the obligation to define national policies for the safe management of all radioactive waste and spent fuels as well as to define a national programme aiming at implementing these policies. It was transposed by the Law of 3 June 2014.

Radioactive waste generated during routine operations of nuclear facilities in Belgium is processed and conditioned on-site by the operator of the relevant facility or by the National Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS) in central processing and conditioning facilities located mainly in Dessel and managed by BELGOPROCESS, the industrial auxiliary subsidiary of ONDRAF/NIRAS.

It is responsible for the safe processing of radioactive waste produced in Belgium that cannot be handled by the producer, and for temporary storage of this waste, pending final disposal. Foreign waste can also be processed in BELGOPROCESS installations, but such waste should return to the country of origin.

The interim storage facilities for conditioned waste of all categories are centralised on the Dessel site operated by BELGOPROCESS. Low level solid waste is either incinerated or compacted in a EUR 57 million facility named CILVA, which began industrial operation in 1994 and was certified according to the ISO 9001 quality management standard of 1995.

Low level liquid waste is treated chemically by flocculation and precipitation. After processing, the waste is encapsulated in cement in 400 litre drums and then stored inside a building designed specifically for the purpose. Bitumen was also used for this purpose until 2004. Annually, an average of 500 mł of waste is supercompacted and 180 tonnes of waste is incinerated in the CILVA facility.

Since 2007, medium level and long lived alpha bearing waste as well as Pu contaminated gloveboxes are encapsulated in cement in 400 litre drums in the PAMELA installation. About 801 mł has been treated and about 433 mł of conditioned waste produced up to the end of 2012.

The HRA/Solarium facility (Building 280X), built on site 2 at BELGOPROCESS and put into operation at the end of February 2005, is intended for the processing and conditioning by compression and cementation of historical medium level waste and radium bearing waste. By the end of 2013, 133 mł of waste had been processed in the HRA/Solarium facility.

A simplified representation of the organization of radioactive waste management in Belgium is sketched below:

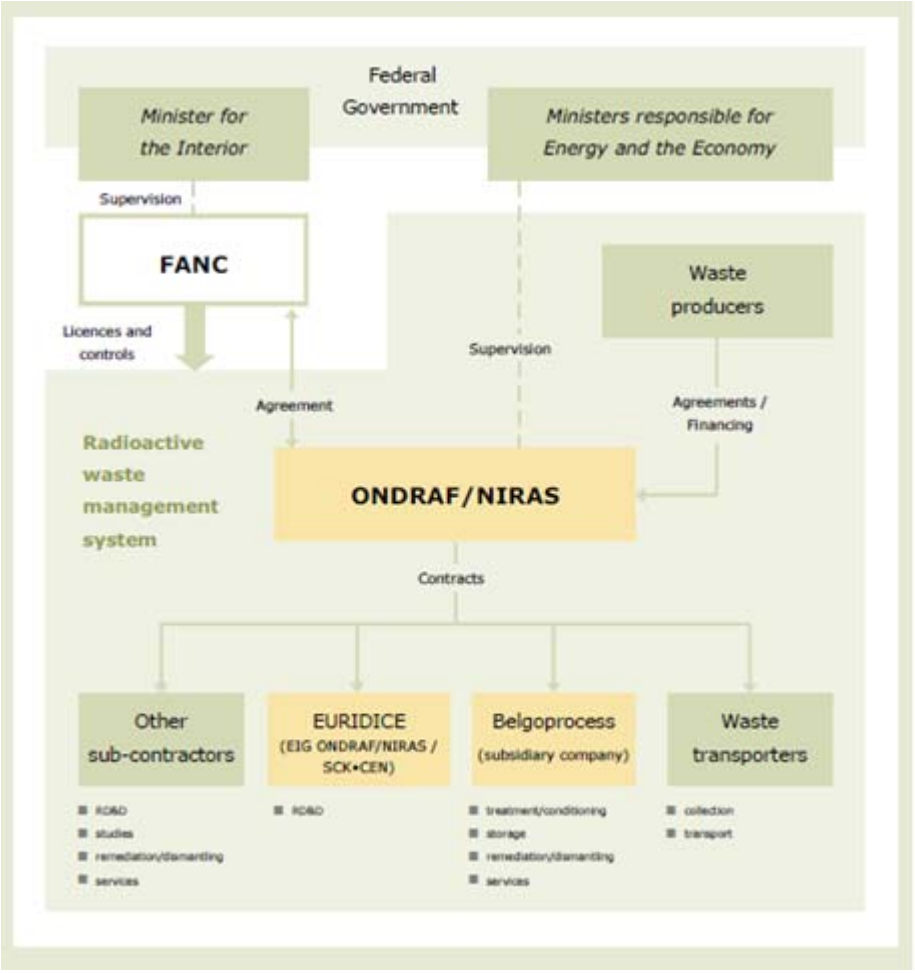

FIG. 3. Organization of radioactive waste management.(*Source:* http://www.ondraf-plandechets.be/*)*

Storage of Low Level Waste

Building 150 was commissioned in 1986 after Belgium joined the international moratorium on sea disposal of conditioned low level waste. Capable of holding 1929 mł, it has been filled to near capacity since the end of the 1980s. At the end of 2016, it contained 1922 mł of conditioned waste, or 3330 packages.

Building 151 was commissioned in 1988. This is a modular building, initially featuring two storage halls. Two more halls were added in 1993, increasing the total capacity from 6 300 mł to 14 700 mł. The drums are stored by means of a remotely controlled roller bridge. By the end of 2016, building 151 housed 13 878 mł of conditioned waste (34 179 packages).

While building 151 is almost filled to capacity, building 155 is actually being used to accommodate conditioned low level waste until a new building is constructed. Sufficient storage capacity is hence ensured until the end of 2020.

Storage of Medium Level Waste

Building 127 was commissioned in 1978. This building has undergone two phases of extension and adaptation, the last of which was in 1988. Since then, its total capacity has been 4 650 mł, split between 4 bunkers of the same size with reinforced concrete walls 80 cm thick. The drums are stored by means of a remotely controlled roller bridge. At the end of 2016, 3 890 mł of conditioned waste (15 923 packages) were housed in building 127.

Building 155 is a storage facility specially designed to store low level radium and plutonium bearing waste following processing and conditioning. Commissioned in 2005, it consists of two separate storage rooms: one for housing radium bearing waste and the other for plutonium bearing waste. Although it would be possible to extend its storage rooms, its capacity should be adequate for all the drums of radium and plutonium bearing waste currently in existence and for those whose production is forecast. At the end of March 2016, building 155 housed 3019 mł of conditioned waste (7282 packages).

Building 270 used to be a buffer storage facility on site 2 of BELGOPROCESS. In 2016 no conditioned waste was stored in this building, as it is planned to be dismantled by the end of 2017.

Storage of Medium Level and High Level Waste

Building 129 was commissioned in 1985. This building has a capacity of 250 mł, split between two shielded bunkers with reinforced concrete walls 1.2 m thick. The containers, which are handled remotely from a shielded control room, are placed in vertical steel shafts. The building contains 195 mł of conditioned high level waste from the vitrification in the PAMELA facility of liquid waste derived from the reprocessing of spent fuel in the former EUROCHEMIC reprocessing plant. Since 1995, it also houses medium level and high level cemented waste from SCK•CEN's BR2 and BR3 reactors and from the operation and partial decommissioning of PAMELA. Ever since, building 129 has contained 215 mł of conditioned waste (2335 packages). Although heat emitted by waste stored in building 129 is quite low, the storage shafts are ventilated to accelerate the dissipation of whatever heat is being generated.

Building 136 was constructed between 1990 and 1994 and is capable of accommodating 590 containers of high level vitrified waste and about 1000 mł of medium level cemented or compacted waste (additional modules may, if necessary, increase its capacity). The high level waste containers, which are handled remotely from a shielded control room, are placed in vertical steel shafts equipped with a constant ventilation system designed to dissipate the generated heat. This building is designed to resist extreme external disturbances such as earthquakes, explosions, or the crash of a military aircraft. It was built for the storage of medium level and high level waste resulting from the reprocessing (by AREVA) of spent fuel from Belgian nuclear power plants. Medium level waste arising from the reprocessing (in Dounreay) of spent fuel of the SCK•CEN research reactor BR2 is also stored in building 136. The project of returning the cemented waste from Dounreay (21 shipments) was successfully completed at the end of 2015.

At the end of March 2016, 390 containers (70.20 mł) of high level vitrified waste, 432 containers (77.76 mł) of compacted medium level waste (hulls and end fittings) — repatriated from France — as well as 123 drums (68.9 mł) of waste from Dounreay were stored inside this building.

The very high level waste will remain stored in the building for at least 60 years. The amount of heat initially released by this waste is such that it has to be left to cool down sufficiently before deep final disposal can take place, to prevent the risk of altering the properties of the surrounding geological environment.

Disposal of Category A Waste

In accordance with the conditions laid down in the decision of the federal Government of 23 June 2006 to build a surface disposal infrastructure for waste on the territory of the municipality of Dessel, ONDRAF/NIRAS prepared a safety case in order to obtain a construction and operation licence for the facility from the safety authorities. In 2011, Belgium requested that the Nuclear Energy Agency (OECD/NEA) organise a peer review of key aspects of the safety case. The review was completed in September 2012 and the key findings were presented to Belgian stakeholders. The main conclusion was that the long term safety strategy and the safety assessment methodology are, in general, credible and robust. A number of recommendations were formulated with respect to future R&D activities, design improvements and the presentation of the safety results. The safety case was adapted taking into account the recommendations and submitted to the safety authorities at the beginning of 2013. ONDRAF/NIRAS is currently formulating answers to the 270 questions and remarks expressed by FANC/AFCN, according to a strict methodical and systematic process. This procedure is still ongoing. Once a license for the surface storage of category A waste in Dessel has been granted, the repository could be in operation after four years. Disposal and closure operations would last about 100 years. The disposal project is integrated into a broader project that offers added value for the region, taking into account the concerns and aspirations of the local community.

To this end, the local partnerships STORA in Dessel and MONA in Mol participate in all further steps in the decision making process and in the development of all aspects of the integrated disposal project. This integrated project includes the disposal project itself (the Installation for the Production of Monoliths (IPM) facility for the conditioning of category A waste into concrete boxes to produce disposal packages called "monoliths", surface disposal concrete infrastructure, control and drainage systems, auxiliary buildings) and the associated socioeconomic aspects (prior importance to be placed on safety, health and the environment, communication centre, local fund to achieve social, economic and cultural added value for the municipalities concerned, etc.). Negotiations with all the parties concerned (radioactive waste producers, the federal, regional and local authorities) with a view to financing the socioeconomic aspects have led to the creation of a special dedicated fund.

A project team established by ONDRAF/NIRAS in Dessel is elaborating the various constituents of the global integrated disposal project. During the detailed study phase, which covers the period 2007–2016, all the components of the disposal project will have to be elaborated upon and settled in view of the project's implementation and realization phase scheduled to start in 2017. ONDRAF/NIRAS is preparing the necessary applications and authorizations, as the agency will act as nuclear operator of the disposal site. The plan calls for putting the disposal site into operation by the year 2020.

The safety case prepared by ONDRAF/NIRAS for the licence application successfully passed the international peer review that was organized in 2012 by the NEA. The peer review concluded that the safety strategy and methodology employed were credible and founded on solid principles and that the project has achieved the technical maturity to proceed to the next steps of construction and storage. Based on the commentaries of the peer review, the safety file was further elaborated and the licence application prepared for submission to the Federal Agency for Nuclear Control in

January 2013.

On 31 January 2013, the procedure leading to the issuance of a “building and operations permit” for the surface storage of category A waste in Dessel was initiated with FANC/AFCN; this will constitute a new nuclear Class I facility.

Long-Term Management of Category B&C Waste

In the 1970s, an inventory of potential deep geological formations for the disposal of conditioned high level and alpha bearing waste was drawn up by SCK•CEN and the Belgian Geological Survey. One of the promising potential host rocks was Boom clay, also present at the SCK•CEN site at a depth of about 200 m. More detailed investigations on that site started in 1974. Geophysical investigations led to the decision to build an underground research laboratory, called the High Activity Disposal Experimental Site (HADES), in the Boom clay layer of the Mol-Dessel area. It is located on the SCK•CEN site, at a depth of 220 m, and comprised in 1984 an access shaft and two galleries in which numerous measurements and in situ experiments took place.

In the early 1980s ONDRAF/NIRAS took over the responsibility of managing RD&D towards geological disposal; the SCK•CEN remained the principal actor (including through the SCK•CEN–ONDRAF/NIRAS joint venture EIG EURIDICE in charge of the HADES operations).

The principal areas of research include the geology and hydrogeology of the clay formation; the definition of the deep underground repository concept; the backfilling material; the interaction between the waste, the engineered barriers and the host rock and, in particular, the retention of radionuclides by clay minerals; the assessment of spent fuel disposal techniques; the improvement and definition of the various disposal scenarios; and the safety and performance assessment of a potential repository in the deep clay. Several of these experiments are conducted in cooperation with other research organizations and universities, both national and international. An important experiment, conducted in close collaboration with the French waste disposal organization ANDRA, deals with the lining of the galleries of a future repository.

In 1999, as part of the PRACLAY project (a preliminary demonstration test of high level radioactive waste disposal in clay), a second access shaft to the Boom clay was built. This was followed, in 2002, by the excavation of an 80 meter-long gallery connecting the new shaft to the HADES underground research laboratory. For the excavation, the so-called wedge block system was used. This is a tunnelling technique that uses a drilling machine equipped with a segment erector and enables the collecting of important data on clay convergence. It was an innovative experiment, since it was the first time anywhere that the technique had been used at a depth of 225 m in poorly indurated clay such as the Boom clay at Mol. It proved very successful, with an excavation rate of 2 to 3 m/day.

In July 2002, the SAFIR 2 report (Safety Assessment and Feasibility Interim Report), was published. It presents the results of R&D on disposal of high level and long lived waste performed in the period 1989–2000. The three main objectives of the report were:

To provide a structured synthesis of the technical and scientific studies carried out on the disposal of categories B and C waste in a poorly indurated argillaceous formation.

- To promote interaction with the nuclear safety authorities in order to reach closer agreement on the outstanding requirements for R&D on the principles of safety assessment.
- To offer a technical and scientific base for dialogue with all stakeholders in the long term management of radioactive waste.

The report concluded that there are no fundamental problems that put the safety and feasibility of disposal of high level waste in the Boom clay into question. It reinforced confidence in the concept studied and confirmed that, for the waste considered, disposal in poorly indurated clay could be a viable option. It recommended further enhancing confidence in the concept studied by establishing an interdisciplinary R&D programme incorporating all aspects of social sciences. The SAFIR 2 report was peer reviewed, at the request of the Belgian federal Government, by the OECD/NEA in October 2002 and the results were published in March 2003 (“SAFIR 2: Belgian R&D Programme on the Deep Disposal of High-level and Long-lived Radioactive Waste — An International Peer Review by NEA”). This review highlighted the potential of clay formations for confining waste and the absence of major scientific or technical obstacles to disposal in clays. The review also highlighted the need for a long term management policy for category B&C waste.

The underground laboratory was extended in 2007 to include a representative-scale disposal gallery (45 m long), the so-called PRACLAY gallery. The basic objective of the PRACLAY experience remains the study of the response of the clay formation to heat, but the original PRACLAY experience has been redefined and reorganised into five in-situ components including the large scale heater test and three on-surface activities aimed at testing the feasibility of building important elements of the engineered barriers (buffer, overpack, plug, backfill etc.) and verifying and confirming the behaviour and interactions of these elements.

The underground and surface facilities of HADES and PRACLAY and the research performed in them are now managed

by the European Underground Research Infrastructure for Disposal of radioactive waste in a Clay Environment (EIG EURIDICE), a European economic interest grouping of which ONDRAF/NIRAS and SCK•CEN are the founding members. EIG EURIDICE successfully installed the PRACLAY heater test device, finalised operational procedures and backup systems and started a test at the end of 2014. Given the positive outcome of this startup, it was decided to continue the test without any further interruption. It is scheduled to last for a period of 10 years (2015–2025).

The on-surface preliminary backfilling test of a disposal gallery within the scope of the European project ESDRED has been a success. The EIG EURIDICE, SCK•CEN and ONDRAF/NIRAS also have been, and are, involved in many other European projects and international collaborations in order to increase scientific knowledge and facilitate collaboration with different experts worldwide.

The R&D team is preparing a first Safety and Feasibility Case, the SFC-1, to integrate all existing scientific and technical arguments in order to increase the confidence of all stakeholders in the possibility of building, operating, and securely closing a geological disposal in clays (Boom clay or Ypresian clays) for categories B and C waste that will remain safe during hundreds of thousands of years after closure. If the waste plan exercise leads to the confirmation of the deep disposal option for the long term management of category B&C waste, the SFC-1 report will support the decision of the Government to move forward.

To prepare the SFC-1, ONDRAF/NIRAS released its RD&D Plan in December 2013 for the geological disposal of high level and/or long lived radioactive waste including irradiated fuel, if considered as waste.

Whatever the Federal Government's decision based on the Waste Plan may be, the implementation of the chosen technical solution is bound to be a lengthy, drawn out process that will probably take a few decades before the selected solution becomes operational.

R&D activities related to geological disposal are carried out in an extensive international and bilateral framework. ONDRAF/NIRAS is active in a number of international nuclear organizations including the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD). In particular, ONDRAF/NIRAS is heavily involved in the European Technology Platform "Implementing Geological Disposal" (IGD-TP).

Policy for Ultimate High Level Waste Disposal

ONDRAF/NIRAS is legally obliged to prepare a plan for the long term management of the radioactive waste under its responsibility. According to the Law of 13 February 2006 (which transposes EC Directives 2001/42/EC and 2003/35/EC into Belgian legislation), this plan has to be accompanied by a strategic environmental assessment (SEA) and submitted to public consultation.

Although an extensive R&D programme assessing the use of clay formations as potential host rock for the disposal of categories B and C waste started in 1974, no national policy decision relating to the long term management of those waste categories has been taken yet. In this context, ONDRAF/NIRAS has taken the initiative to compile in an integrated document, the "waste plan for the long term management of high level and/or long lived radioactive waste", all elements necessary to enable the Government to take, with full knowledge of the facts, a decision in principle regarding the long term management of categories B and C waste. The waste plan is accompanied by a SEA (Strategic Environmental Impact Assessment) in which alternative long term management options to disposal in clay have been assessed. The assessment not only covers environmental impacts but also the scientific and technical bases of the various options, the economic aspects and attendant ethical and societal considerations.

The final waste plan, including the results of the public consultation and the accompanying documents, was adopted by the Board of Directors of ONDRAF/NIRAS on 23 September 2011.

Moreover, ONDRAF/NIRAS committed itself to:

Ensure the reversibility of the disposal facility's operations and examine such measures as are likely to facilitate the potential recuperation of the waste after complete or partial closure of the disposal unit;

- Maintain control functions over the proper operations of the disposal system that will be additional to the regulatory control;
- Prepare as efficiently and effectively as possible the transfer to future generations of the knowledge linked to the disposal facility and the waste contained in it.

ONDRAF/NIRAS also recommended creating an independent monitoring body to ascertain that the decision making procedure progresses as scheduled.

The waste plan will form the basis for establishing the national policy and the national programme on the long term management of categories B and C waste, as requested by the Law of 3 June 2014 transposing the EU Directive 2011/70/EURATOM (see below).

Whatever the option for the long term management of categories B and C waste, the implementation of the technical solution chosen is bound to be a long, step by step, open and participative process that will probably take several decades before the selected solution becomes operational.

From a scientific and technical perspective, the construction of a geological repository facility would take 10 to 15 years after the granting of a licence. In all likelihood, it will take up to a century from the start of construction of the repository to its complete closure.

SCK•CEN launched an R&D programme on partitioning and transmutation of high level waste through the Accelerator Driven System route in a European framework. The purpose is to analyse the feasibility from technical, economical and industrial points of view of such a technology within an EU strategy.

EU Directive 2011/70/EURATOM

EU Directive 2011/70/EURATOM of 19 July 2011, establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, was completely transposed by the Law of 3 June 2014, amending Article 179 of the Law of 8 August 1980 on the budgetary proposals for 1979–1980.

Article 6 of the Law of 3 June 2014 created the National Programme Committee (CPNPC), whose members are:

Directorate-General for Energy, Federal Public Service for Economy, SMEs, Self-Employed and Energy;

- ONDRAF/NIRAS, the National Agency for Radioactive Waste and Enriched Fissile Materials;
- 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 the “exclusive owner” (as defined by EURATOM Treaty Article 87) of the nuclear fuel from its fabrication to its transfer to ONDRAF/NIRAS when declared as radioactive waste.

In 2015, the National Programme Committee drafted a National Programme for the Management of Spent Fuel and Radioactive Waste pursuant to the Law of 3 June 2014. It outlines the state of affairs at 31 December 2014 in the field of spent fuel and radioactive waste management.

The FANC/AFCN gave its advice on the draft on 10 April 2015, and the SEA (Strategic Environmental Impact Assessment) Committee of the Federal Public Service Health, Food Chain and Environment, provided its advice on 11 September 2015.

On 30 June 2016, a draft ministerial decree was approved, fixing the first National Programme for the Management of Spent Fuel and Radioactive Waste. This instrument serves as a strategic scoreboard for the short, medium and long term management of the various families of radioactive waste and spent fuel in Belgium.

An English courtesy translation of the October 2015 version of the National Programme for the Management of Spent Fuel and Radioactive Waste is available on the web site of the FPS Economy, SMEs, Self-employed and Energy.

2.8. Research and Development

Policy related to the nuclear sector, the nuclear fuel cycle and nuclear R&D in both nuclear fusion and fission is the exclusive responsibility of the Belgian federal Government. Although deciding to phase out the production of electricity by nuclear fission energy, the Belgian Government acknowledges the importance of continuing to invest in nuclear research to support the safe operation of nuclear power plants in Belgium and in Europe, the development of sustainable solutions for the management of radioactive waste, the future decommissioning and dismantling of nuclear power plants and the research on nuclear medical applications.

Nuclear research and development in Belgium is coordinated by the FPS Economy, SMEs, Self-employed and Energy.

Federal Government funding for nuclear fission and fusion research more than doubled in the last five years, rising to an estimated EUR 107 million in 2015. Despite the nuclear phase-out policy, the federal Government acknowledges the importance of nuclear fission research. Almost a third of funding centres on light water reactors (SCK•CEN), and one fifth each on nuclear waste management (ONDRAF/NIRAS), nuclear supporting technologies (SCK•CEN) and the multipurpose hybrid research reactor for high tech applications (MYRRHA, operated by SCK•CEN). Finally, close to EUR 6 million is dedicated to nuclear fusion. The MYRRHA project has been the single largest R&D investment programme in the country since 2009, with a budget of EUR 95.6 million for 2010–2015.

Belgium participates in the IEA Technology Collaboration Programmes (TCPs) focusing on fusion indirectly through the European Atomic Energy Community (EURATOM). As a member state of the European Union’s Joint Undertaking for the International Organization ITER and the Development of Fusion Energy and a voluntary contributor to the “Broader Approach” between the European Union and Japan, Belgium contributes to the development of fusion energy which aims

to start producing carbon free electricity in 2050, mainly through the Belgian Fusion Association.

2.8.1. R&D Organizations

Most of the nuclear research in Belgium is carried out at the National Nuclear Research Centre SCK•CEN, which also provides training and other services to the nuclear industry, the medical sector and the authorities, and promotes public awareness of nuclear technology. The nuclear research by SCK•CEN is mainly aimed at reactor safety experiments, innovative fuel cycles and partitioning and transmutation, advanced nuclear systems, radioactive waste disposal, decommissioning, radiation protection, and health physics and medical and space applications. Research on the safety of nuclear power plants is performed in collaboration with FANC/AFCN and industrial partners such as ELECTRABEL and TRACTEBEL.

Research and development for the support of both nuclear and non-nuclear power plant operations is carried out by ENGIE LAB (previously LABORELEC), a technical competence centre in electrical power and energy technology.

The research areas for SCK•CEN are authorized by Royal Decree. The first priority is to maintain the safety of the nuclear power plants. This involves research on the ageing of their main components and the safety aspects of fuel development. The research is carried out in cooperation with TRACTEBEL and the international research community. The second priority is to find an appropriate solution for the long term management of the long lived medium and high level radioactive wastes.

SCK•CEN's high performance material testing reactor BR2, which ranks among the world's top high neutron-flux reactors, plays a crucial role in support of the long term operation (LTO) of the Belgian nuclear power plants. Besides its basic missions — i.e. the development, qualification and surveillance of materials and components for use in nuclear installations — BR2 produces 25% of worldwide demand of the dominant medical isotope ^{99m}Tc, applied commonly in oncology and cardiology. A wide range of other radioisotopes applied in various medical diagnostic and therapeutic procedures are being produced at BR2. Furthermore it produces the ? and ? radioisotopes that have recently broken through for radiotherapeutic applications. The second main industrial application of BR2 concerns the highly homogeneous doping of silicon (covering also about 25% of the global demand) at use in renewable energy systems like hybrid/electric cars and electrical energy conversion and transmission systems essential in windmills and solar power.

To prepare the next 10 year licence period of BR2 (2016–2026), in conformity with the strategic note of the FANC/AFCN regarding the LTO of research reactors, an analysis on the design upgrades and advanced structural/functional maintenance and ageing management measures — in order to comply with modern safety standards — has been performed and approved by the safety authorities. In parallel with the implementation of the identified periodic safety review measures, the measures resulting from the stress test conducted in 2011–2012, to improve the robustness against external hazards of the SCK•CEN installations in general and the BR2-reactor in particular, will be implemented as well by 2016. Two essential points regarding the safe exploitation of BR2 are the reactor vessel and the beryllium (structural support) matrix of the reactor core. The condition of the reactor vessel is predicted on the basis of a surveillance programme that entails accelerated irradiation of representative material that is tested on its embrittlement resulting from the neutron damage. The results of these tests assure the resistance of the vessel material against brittle fracture up to doses experienced by the actual vessel well beyond 2026. The present beryllium matrix, in service since 1998, reached half of the maximal allowed irradiation dose in 2011. The maximum lifetime of the matrix would be reached in the second half of the 2016–2026 timeframe. Hence, the beryllium matrix was replaced as part of the refurbishment efforts which started at the end of 2014. SCK•CEN decided to invest in the extension of the irradiation capabilities of BR2, including the development of irradiation facilities that would irradiate GenIV/MYRRHA candidate materials in representative conditions. The refurbishment took place in 2015 and early 2016. The BR2 will restart operation during the last trimester of 2016.

SCK•CEN has a statutory mission to conduct research on the protection of humans and the environment against the harmful effects of ionizing radiation. In the field of life sciences, SCK•CEN has dedicated laboratories for specific research in radiobiology, microbiology and radioecology. The laboratory for radiobiology studies the effects of low dose ionizing radiation on developing mammalian organisms, the induction of cancer and non-cancer diseases and individual radiosensitivity. A new animal facility using state of the art technology has been operational since February 2014 to clarify the significance of short term biological responses to ionizing radiation for human health in the long term. The laboratory for microbiology investigates bacterial adaptation under extreme conditions, such as cosmic radiation, microgravity, heavily polluted soils and the geological disposal of radioactive waste. Radioecological research is performed in the unit biosphere impact studies. Its main focus is on understanding the behaviour of radionuclides in the biosphere for the protection of man and environment in normal and accident situations.

SCK-CEN is a major player in European Radiation Protection and Safeguards research and is a founding member and member of the management board/president of groups such as MELODI, ALLIANCE, NERIS, EURADOS and ESARDA.

The societal aspects of nuclear technology are also investigated with emphasis on public participation in the decision process. Research is performed in the context of decision support to add to the transparency of decisions. Three major areas are investigated: nuclear waste management, nuclear risk management and energy management.

ONDRAF/NIRAS, being responsible for the management of radioactive waste, is the central coordinator for the geological disposal RD&D programme over the past 30 years. In practice, ONDRAF/NIRAS determines the R&D objectives and entrusts the implementation to national and international scientific (universities and research institutes, SCK•CEN in particular), engineering and industrial partners. The large scale demonstration projects and experiments in the underground laboratory built in Boom clay were entrusted to EIG EURIDICE, the Economic Interest Group which was cofounded in 1995 by ONDRAF/NIRAS and SCK•CEN.

ONDRAF/NIRAS signed a trilateral agreement with ANDRA (France) and NAGRA (Switzerland), two agencies also studying argillaceous formations as host formations for the geological disposal of radioactive waste. In 2010, ONDRAF/NIRAS entered into a research and development agreement with COVRA, a Dutch counterpart, on the possibilities of storing radioactive waste in poorly indurated clay in their respective national territory.

From 23 to 26 March 2015, ONDRAF/NIRAS organised, in cooperation with ANDRA (France), COVRA (Netherlands), NAGRA (Switzerland), NWMO (Canada), POSIVA (Finland) and SKB (Sweden), the sixth international conference on “Clays in Natural and Engineered Barriers for Radioactive Waste Confinement”.

The conference gathered about 500 specialists in the different disciplines related to geological disposal of radioactive waste and gave participants the opportunity to evaluate the progress of the research conducted in that field, debate on it and intensify the knowledge for the implementation of a safe geological repository.

This conference was unique in the sense that it brought together all scientific and engineering fields of study related to the use of clay in geological disposal systems.

2.8.2. Development of Advanced Nuclear Technologies

SCK•CEN is developing the multipurpose nuclear research facility MYRRHA (Multipurpose Hybrid Research Reactor for High-tech Applications), identified within the European ESFRI roadmap and within the European Sustainable Nuclear Industrial Initiative (ESNII) of the Sustainable Nuclear Energy Technology Platform (SNETP) in support of the SET-Plan. MYRRHA will be a subcritical assembly driven by a high power proton accelerator that generates the primary neutrons by means of spallation reactions in the centre of the core to trigger fission reactions in the subcritical core. As well as being able to produce radioisotopes and doped silicon, MYRRHA’s research functions would be particularly well suited to investigate transmutation and to demonstrate the efficient operation of the concept of an Accelerator Driven System (ADS) at a pre-industrial scale.

In 2009, it was estimated that MYRRHA would require an investment of EUR 960 million, of which the Belgian Government could contribute 40%. MYRRHA is scheduled for operation in 2023, yet a reduced power model, GUINEVERE, became operational in February 2011.

In 2010, the Belgian Government granted SCK•CEN a budget of EUR 60 million over a five year period (2010–2014) for advancing the design of MYRRHA, securing its licensing and investment and operational costs.

In 2015, the Government extended its support for MYRRHA to 2016 and 2017 and efforts have since continued towards the realization of the project, including developing:

The necessary research and development work in order to reduce the financial risks and the technical uncertainties;

- A large number of detailed design activities;
- The preparation of the necessary files to introduce the safety case to the safety authorities in order to obtain the construction and operation licence;
- The necessary contacts with potential partners in view of the creation of the international consortium which is envisaged for the MYRRHA project.

At present, the Belgian federal Government and SCK•CEN are working towards setting up an international consortium to ensure additional financing of the project.

2.8.3. International Cooperation and Initiatives

Belgium is active in a number of international nuclear organizations, including: the International Atomic Energy Agency (IAEA), the Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD), as well as other bilateral and multilateral organizations such as the World Association of Nuclear Operators (WANO).

SCK•CEN is coordinator of the Belgian Support Programme to the IAEA for safeguards. It also executes most tasks of the Support Programme. Among these tasks, the most important contributions relate to the development of safeguards approaches for geological repositories and the Accelerator Driven System MYRRHA, currently in design at SCK•CEN. Moreover, SCK•CEN makes available its facilities and subject matter experts for calibration of IAEA equipment and

courses to IAEA safeguards inspectors, helping the IAEA to better perform the safeguards inspections in the framework of the Non-Proliferation Treaty and Additional Protocol.

SCK•CEN is a major player in European projects and has research collaboration on the peaceful use of nuclear applications with most “nuclear” countries/institutes throughout the world.

As a member state of the EU’s Joint Undertaking for ITER and the Development of Fusion Energy, Belgium contributes to the development of fusion energy which aims to start producing CO_2-free electricity in 2050.

2.9. Human Resources Development

Academic Learning

Belgium pioneered academic learning in the nuclear field through the creation of the Belgian Nuclear higher Education Network (BNEN) in 2002.

BNEN is a master-after-master academic programme in nuclear engineering, organized through a consortium of six Belgian universities and SCK•CEN.

The BNEN consortium was one of the very first in Europe to offer a nuclear engineering programme, where nationwide expertise is gathered and combined with the infrastructure and access to operating reactors. It served as a role model for the foundation of the European Nuclear Education Network (ENEN Association). BNEN facilitates networking between academia, research centres, industry and other nuclear stakeholders, and aims at developing and maintaining high level nuclear engineering competences. The condensed programme (60 ECTS in one year, including a Master’s thesis) allows students to acquire all necessary scientific and technical background and skills to develop a career in the field of nuclear applications. A modular approach also facilitates participation of foreign students. The lectures are taught in English, at the premises of SCK•CEN. The laboratory exercises make use of the nuclear facilities of SCK•CEN and are organised by SCK•CEN scientists. Various technical visits are organised to research and industrial nuclear facilities. Teaching blocks of one to three weeks for each module allows optimal time management for students and university lecturers, facilitates registration for individual modules, and allows easy access for international students through ERASMUS and ERASMUS-Mundus programmes.

The SCK•CEN Academy for Nuclear Science and Technology was founded in 2012.

Thanks to its thorough experience in the field of nuclear science and technology, in addition to its innovative research and the availability of large and unique nuclear facilities, SCK•CEN is an important partner for nuclear education and training (E&T) in Belgium as well as at international level. It is the specific task of the SCK•CEN Academy to foster the transfer of nuclear knowledge, skills and attitudes towards students and professionals who are active in the nuclear field.

In the interest of maintaining a competent workforce in industry, healthcare, research and policy, and of transferring nuclear knowledge to the next generations, the SCK•CEN Academy takes it as its mission to:

Provide guidance for young researchers: SCK•CEN experts are available to guide Bachelor’s and Master’s students, PhD candidates or any professional who wants to enrich his or her nuclear competences via an internship. Postdoc positions are also available. Research topics for these purposes can be found on the SCK•CEN Academy web site; candidates from all over the world are welcome to apply. The topics are all situated in the priority research domains of SCK•CEN. High school pupils and their teachers are welcome to visit the laboratories; several projects are available for this specific target group.

- Organize academic courses, training for professionals and scientific events: SCK•CEN Academy collaborates with several Belgian and foreign universities and contributes to academic learning. Examples are the BNEN master-after-master specialization in nuclear engineering and the Radiation Protection Expert course.

The postgraduate course for Radiation Protection Experts (20 ECTS) meets the requirements set in the Royal Decree of 20 July 2001 regarding the training for Radiation Protection Experts (Art. 73.2), and is therefore geared towards those who need to be formally recognized as RPE, as well as to all professionals working in the nuclear, radiology or the medical sector. The course focuses on the scientific and technological basis of radiological and nuclear techniques, with specific attention to radiation protection. This course is organised in Dutch by the SCK•CEN Academy and the University of Hasselt. An equivalent French course is run by ISIB and IRE.

Technical Training

In addition to academic learning, the SCK•CEN Academy also provides customized training courses aimed at improving the knowledge, skills and attitudes of nuclear workers from industry, the medical sector, research organizations and governmental institutions dealing with applications of radioactivity. These courses are modular, and tailored to the needs of the trainees in terms of content, duration, level, language (Dutch, French or English), venue, etc.

Available topics include those that are subject to SCK•CEN's R&D programme, for example: radiation protection, reactor technology, nuclear materials issues, nuclear safety and safety culture, emergency management, decommissioning and decontamination, waste and disposal, radiation biology, radiation ecology, microbiology, ethical aspects, nuclear technology assessment, etc. Some courses are specifically designed to fit into the CPD programmes endorsed by the FANC/AFCN.

Within the course programmes, lectures and practical sessions can be complemented with in-field experiences such as visits to several nuclear laboratories and research reactors. These technical visits enable trainees to enrich and illustrate their acquired academic knowledge with the practice of real-life situations. SCK•CEN facilities that can be visited include: three operating research reactors (BR1, BR2 and VENUS); one research reactor in dismantling phase (BR3); hot cells; the HADES underground laboratory for waste disposal research; the decontamination wing of the medical services; the laboratories for anthropogammametry (a means of assessing radioactive internal contamination) and low level alpha, beta and gamma measurements; the laboratories of the radiation biology, radiation ecology and microbiology groups; the dosimetry and nuclear calibrations laboratory, and more.

Furthermore, scientific events such as workshops and topic-specific days are organised in order to deepen the knowledge in very specific nuclear themes and make a contribution to innovative new research via interactive Q&A sessions and discussions. International experts are invited to contribute to the scientific programme.

2.10. Stakeholder Communication

The Belgian nuclear industry created a federation under the name "NUCLEAR FORUM". This federation has the mission to contribute to a quality discussion on the future of the nuclear industry. Its main goal is to provide factual and practical information on the nuclear industry and its many applications as well as to bring answers to the legitimate questions that are being asked.

BELGOPROCESS organizes visits to its processing, conditioning, and interim storage facilities for the press, professional visitors, and occasionally the public. It also publishes an annual report and information leaflets on its activities.

The Belgian Nuclear Research Centre SCK•CEN shares its expertise in an active way as an accessible and reliable source of (scientific) information for (local) authorities, the industry, the media and the general public. SCK•CEN offers information about its activities and the results of its research through a variety of publications and dedicated web sites for the general public, scientists, students and young people. Every year, SCK•CEN welcomes hundreds of visitors (both professionals and members of the general public) in its laboratories.

SCK•CEN also analyses the societal aspects of nuclear technology, in particular public participation in the decision making process. Every two to three years, SCK•CEN conducts opinion polls representative of the adult population living in Belgium, analysing the evolutions of its perceptions and knowledge in the field of nuclear technology.

EURIDICE has its own recently renovated communication space within the demonstration hall and organizes visits to both the demonstration hall and the underground laboratory.

In keeping with their mission to serve public welfare, the National Institute for Radioelements IRE and its subsidiary IRE-ELiT (Environment & Life science Technology), maintain an open and transparent dialogue with the various parties concerned: authorities, residents in the area, professionals, the general public, partners and clients. Conscious of its social and civic responsibility, the IRE mobilises the resources necessary to maintain a special relationship with the neighbouring population. The Institute prioritizes communications with residents in the area, neighbouring companies and the municipal administrative departments concerned. Various initiatives illustrate this commitment, such as organization of open-door days and information sessions, periodic circulation of the newsletter "Live from the IRE" to residents and the creation of a new web site www.ire.eu.

The web site of ONDRAF/NIRAS contains a subsite dedicated to the waste plan (in Dutch, French and German, but the waste plan is available in English. Technical publications deal more specifically with R&D concerning long term management of nuclear waste.

ONDRAF/NIRAS operates a radioactive waste information centre, called "ISOTOPOLIS", on the BELGOPROCESS site in Dessel. This centre, recently renovated, is open to the public but intended primarily for secondary school students.

The complete development of the 2010 Masterplan of the surface disposal project for category A waste, now called the "cAt-project", has been carried out in the framework of partnerships with the local communities (see MONA and STOLA below). This partnership approach not only keeps the public informed, but also allows direct participation of the local communities in the development and supervision of the project.

In the framework of the establishment of the ONDRAF/NIRAS waste plan for the long term management of B&C waste and its accompanying SEA, ONDRAF/NIRAS not only carried out a public consultation as prescribed by law, but also

requested the King Baudouin Foundation to set up a citizens' conference around this theme. The results of the consultation and of the citizens' conference were directly taken into account in finalizing the draft of its waste plan and in the definition of the proposed long term management solution.

STORA is a not-for-profit association composed of organizations and residents of the Belgian municipality of Dessel, which monitors all nuclear affairs in the municipality ("Study and Consultation Group Radioactive Waste in Dessel" or in Dutch: "Studie- en Overleggroep Radioactief Afval in Dessel"). One of STORA's major objectives is to involve the population of Dessel in all nuclear matters. Several nuclear companies have their head offices in Dessel, and Belgian radioactive waste is being processed and stored on the site of BELGOPROCESS.

The municipality of Dessel was a candidate for the disposal of low level and short lived waste, a project that was developed by STORA's predecessor, 'STOLA'. In June 2006 the federal Government decided that the waste will be disposed of in a surface disposal facility in Dessel. In this new phase, ONDRAF/NIRAS elaborated a complete disposal project together with STORA to come to a binding agreement that states the rights and duties of all parties concerned. STORA will keep monitoring the project and keep the residents of Dessel informed about all the nuclear affairs that are conducted within the region.

MONA is a not-for-profit association founded in 2000 to seek answers to the question: "Is the disposal of low level and short lived waste technically feasible and socially desirable in Mol?" ("Mol Consultation on Nuclear Waste" or in Dutch: "Mols Overleg Nucleair Afval"). Even after the Government's decision in this matter in 2006, this issue remains the main mission of the association.

MONA is primarily monitoring the development of the planned storage facility for low and intermediate level short lived waste (cAt-project). MONA ensures the continued involvement of the population of Mol in the technical development of this disposal project and ensures that the conditions imposed by Mol are respected.

MONA is maintaining open communication with the population of Mol and striving for optimal coordination and cooperation with other relevant agencies in the region.

2.11. Emergency Preparedness

Emergency preparedness and planning is a competence under the federal Minister of Home Affairs and his administrative services. The Law of 15 May 2007 defines Civil Safety and describes the roles and missions of the different entities involved. The Royal Decree of 16 February 2006 organises the planning and interventions during emergency situations. The Royal Decree of 17 October 2003 defines a nuclear and radiological emergency plan for the Belgian territory as well as notification criteria from the operators to the Government.

Off-site operations are directed by the "Governmental Centre for Co-ordination and Emergencies" (CGCCR), under the authority of the Minister of Home Affairs. The implementation of the actions decided at the federal level and the management of the intervention teams are conducted by the Governor of the Province concerned. In addition to the duties defined in the Royal Decree of 17 October 2003, the Federal Agency for Nuclear Control (FANC/AFCN) is a main actor within the emergency plan. Its role is defined in articles 15, 21 and 22 of the Law of 15 April 1994, creating the FANC/AFCN, and in articles 70, 71 and 72 of the GRR-2001 (General Regulations regarding the protection of the public, the workers and the environment against the hazards of ionising radiation, EURATOM Treaty, Article 37). These articles stipulate that the FANC/AFCN is responsible to survey, to control and to monitor the radioactivity on the territory and to deliver technical assistance to set up the emergency plan. It is also in charge of participating and/or organising operational cells (i.e. evaluation cell and measurements cell).

3. NATIONAL LAWS AND REGULATIONS

3.1. Regulatory Framework

3.1.1. Regulatory Authority

The Federal Agency for Nuclear Control (FANC/AFCN)

The regulatory authority in the field of radiation protection, nuclear safety and radiological surveillance is the Federal Agency for Nuclear Control, a public body with legal personality which is supervised by the minister for the Interior ("Federaal Agentschap voor Nucleaire Controle" (FANC) in Dutch or "Agence Fédérale de Contrôle Nucléaire" (AFCN) in French). It was established by the Law of 15 April 1994 on the protection of the public and the environment against the dangers of ionizing radiation and on the Belgian Federal Agency for Nuclear Control (FANC/AFCN) to ensure that the public and the environment are effectively protected against the hazards of ionizing radiation, but it only became fully operational on 1 September 2001.

By the Royal decree of 20 July 2001, laying down the General regulations for the protection of the population, workers and the environment against the dangers of ionizing radiation (GRR-2001), the regulatory responsibilities for radiological protection were transferred from the specialized offices of the Ministry of Public Health and the Environment and the Ministry of Labour and Employment to this Agency. On 2 April 2003 and 30 March 2011, this legislation was amended to include nuclear security. It must be noted that the general regulations deal with civil facilities and activities only. Military installations and activities are dealt with in the Royal Decree of 11 May 1971 laying down the general military regulations for protection against the hazards of ionizing radiation.

The FANC/AFCN is an independent governmental body. Its legal statute is in itself a guarantee that it can make independent regulatory judgements, within its legal competences. The FANC/AFCN can organize its internal decision making and can recruit its staff with sufficient autonomy from the political level. The FANC/AFCN has legal personality. This means that it can defend its position before court against other interested parties when needed.

The FANC/AFCN has been given its missions and enforcement powers directly by Parliament, guaranteeing its constitutional independence with respect to the Government.

In 2008, Bel V was created as a subsidiary of the FANC/AFCN following a Parliamentary resolution. On 14 April 2008, Bel V took over the regulatory activities, as well as the involved staff, of the former Authorized Inspection Organiation (AIO) AVN. Since that day, Bel V constitutes the Technical Safety Organization of the Belgian Nuclear Safety Authority.

An existing management contract between FANC/AFCN and Bel V delegates a number of tasks to Bel V, such as the control of nuclear facilities and the review and assessment activities for these facilities. Bel V is a founding member of the European Technical Safety Organisations Network (ETSON).

The missions attributed to the FANC/AFCN by the Law of 15 April 1994 and its associated royal decrees are allocated to different departments and sections. The only legal requirement regarding the organizational structure of the FANC/AFCN is the separation between regulation development activities and surveillance and inspection activities.

The FANC/AFCN is currently composed of five departments, with a total of about 150 people involved in:

Regulation, international affairs and development (RIAD);

- Facilities and waste;
- Security and transport;
- Health protection and environment;
- Support.

The regulatory function “development of regulation and guides” (Article 24 of Law of 15 April 1994) is ensured by the department “Regulation, International Affairs and Development (RIAD)”.

The regulatory function “licensing” (Art. 16 of Law of 15 April 1994) is ensured by the department “Facilities and Waste”; for nuclear facilities, industrial facilities and waste management facilities (including disposal facilities) and activities (including decommissioning).

The regulatory function “review and assessment” of facilities (Art. 15 & 16 of the Law of 15 April 1994) is performed by the departments responsible for the licensing of these facilities and by Bel V, for nuclear facilities, by delegation of the FANC/AFCN.

The regulatory function “inspection and enforcement” (Art 16§3) is performed by the same departments that are responsible for licensing and by Bel V for on-site inspections in nuclear facilities, with the support of FANC/AFCN nuclear inspectors when enforcement actions are needed.

Security matters (Art. 17 of the Law of 15 April 1994) are also included in the mission of the FANC/AFCN, and are entrusted to the department “Security and Transport”.

Other additional functions performed by the FANC/AFCN are:

Radiological surveillance of the Belgian territory and participation in the national nuclear emergency preparedness and response plan, which are allocated to the department “Health protection and Environment” (Art. 21 & 22 of the Law of 15 April 1994);

- Communication with the public and political authorities, allocated to the FANC/AFCN Management, the Communication Office and the RIAD department (Art. 26 of 1994).

The FANC/AFCN may propose laws and decrees to the Government and it has to implement laws and decrees to review licence applications, to propose licences or to grant licences, as applicable, to ensure compliance with the

regulatory provisions and the licence conditions.

The FANC/AFCN is also a founding member of the West European Nuclear Regulators Association (WENRA). Together with Bel V, it participates actively in the Reactor Harmonization Working Group (RHWG) and in the Working Group on Waste and Decommissioning (WGWD) and in particular in the working group developing reference levels for waste disposal facilities.

3.1.2. Licensing Process

Licensing takes place under the authority of the Minister of the Interior (Royal decree of August 7, 1995), who oversees the Federal Agency for Nuclear Control (FANC/AFCN). The Minister and the Agency are responsible for promulgating and enforcing regulations designed to protect the employees of the nuclear plants and the population against the hazards of ionizing radiation. The Agency is assisted in technical matters and advised by a Scientific Council of experts and representatives from various authorities responsible for nuclear safety. The Council gives recommendations by absolute majority. Bel V, the subsidiary body of the FANC/AFCN, carries out official acceptance procedures for nuclear installations prior to commissioning and exercises supervision over nuclear installations during operation. Ultimately, final authorization for nuclear plant commissioning rests with the King.

The main steps in the Belgian licensing procedure for nuclear installations (referred to as “Class I” installations in the Belgian regulations) are described in the GRR-2001 and are summarized below:

1. Filing of an application: the licence application is first sent to the Director General of the FANC/AFCN, together with the relevant information (characteristics of the installation, planned safety measures, an Environmental Impact Assessment, and a study of the premises and the demographic, geological, meteorological, etc. characteristics of the area of the installation). The application must contain a preliminary safety report and a report describing the possible impacts on the environment.

2. The Scientific Council is consulted for the first time. After the Council has given its preliminary advice, the decision is sent to the applicant. Then the European Commission is also consulted (if necessary) according to article 37 of the EURATOM Treaty, as well as all the municipalities in a radius of 5 km around the installation (who inform their population) and the province in which the project is involved. After the advice of the municipalities, of the province and of the European Commission have been received, the file is submitted to the Scientific Council once more, which then gives its definitive advice.

3. The Minister of the Interior then decides by submitting a Royal Decree to the King. This Royal Decree gives the construction and operation licence. It contains the conditions to be respected. These stipulate, among other things, the content of the safety report.

4. After the construction of the installation, and before the start of the operation, the FANC/AFCN or Bel V proceeds with the acceptance of the installation. This acceptance must establish the conformity of the installation with the general regulation, the stipulations of the construction and operation licence and the safety report. If the acceptance is favourable, the Minister of the Interior proposes to the King to confirm the construction and operation licence, which are granted for an unlimited period.

3.2. National Laws and Regulations in Nuclear Power

Main Laws in Nuclear Power

Nuclear Law, establishing responsibilities for different areas

- Law of 8 August 1980 on the budgetary proposals for 1979–1980, art. 179 §2 and §3 (as amended by the Acts of 11 January 1991 and 12 December 1997), establishing the “National Agency for Radioactive Waste and Fissile Materials” (ONDRAF/NIRAS) and entrusting ONDRAF/NIRAS with the safe transportation, treatment, conditioning, storage and disposal of all radioactive waste produced in the country. This law was modified by the Law of 11 January 1991, which also slightly changed the name of the agency to “Belgian National Agency for Radioactive Waste and Enriched Fissile Materials”.

- Royal Decree of 30 March 1981 defining the missions and duties of ONDRAF/NIRAS, as amended by the Royal Decrees of 16 October 1991, 4 April 2003, 1 May 2006, 18 May 2006, 2 June 2006, 13 June 2007, 3 July 2012 and 25 April 2014.

- Law of 15 April 1994 on the protection of the public and the environment against the dangers of ionizing radiation and on the Belgian Federal Agency for Nuclear Control. It constitutes the legal basis for the FANC/AFCN as regulatory body and sets out the basic elements for protecting the workers, the public and the environment against the adverse effects of ionizing radiation, repealing and replacing the Law of 29 March 1958.

- Law of 31 January 2003 on the gradual phasing out of nuclear energy for the industrial production of electricity.
- Law of 18 December 2013 amending the Law of 31 January 2003 on the gradual phasing out of nuclear energy for the industrial production of electricity.

Civil nuclear liability

- Law of 22 July 1985, as modified by the Law of 11 July 2000, on nuclear liability, which integrates the Paris Convention and the follow-up Convention of Brussels and their additional protocols. This law sets the maximum amount of the operator's civil liability for damages caused by a nuclear accident to about EUR 300 million (per accident and per site).
- Law of 10 February 2003 on the liabilities for staff employed by public entities.
- Royal Decree of 28 December 2011 laying down the maximum amount of the damage for which the operator or carrier may be held responsible in the case of transport within the meaning of Article 14 of the Law of 22 July 1985 on third party liability in the field of nuclear energy.

Establishing a regulatory body

- Law of 15 April 1994 on the protection of the public and the environment against the dangers of ionizing radiation and on the Belgian Federal Agency for Nuclear Control (FANC/AFCN), repealing and replacing the Law of 29 March 1958. This law constitutes the legal basis for the FANC/AFCN as regulatory body, its role being defined in articles 15, 21 and 22.
- Law of 22 December 2008 amending the Law of 15 April 1994 and allowing the FANC/AFCN to create Bel V in order to perform regulatory missions that can be legally delegated by the FANC/AFCN, without having to use a public tender procedure.

Implementing IAEA safeguards

- Law of 26 November 1996 approving the Convention on Nuclear Safety of 20 September 1994.
- Law of 5 June 1998 approving the Convention on Early Notification of a Nuclear Accident of 26 September 1986.
- Law of 5 June 1998 approving the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency of 26 September 1986.
- Law of 2 August 2002 approving the Joint Convention on the Safety of Spent Fuel Management and on the Safety of radioactive waste management of 5 September 1997.

Rules for environmental protection

- Law of 13 February 2006 on the assessment of the environmental consequences of certain plans and programmes and the public participation in the preparation of plans and programmes in connection with the environment.
- Law of 5 August 2006 on public access to environmental information.

Import and export controls of nuclear material and items

- Law of 1 June 2005 on the implementation of the Additional Protocol of 22 September 1998 to the International Agreement of 5 April 1973 in implementation of Article III, Paragraphs 1 and 4 of the Convention of 1 July 1968 on the nonproliferation of nuclear weapons.
- Law of 13 November 2002 approving the Additional Protocol to the Agreement in implementation of Article III, paragraphs 1 and 4 of the Treaty on the Non-proliferation of Nuclear Weapons and Annexes I, II and III of 22 September 1998.
- Royal decree of 24 March 2009 on the import, transit, and export of radioactive materials, transposing directive 2006/117/EURATOM (replacing directive 1992/3/EURATOM) on the supervision and control of shipments of radioactive substances between Member States and suppressing chapter IV of GRR-2001.

Security principles, including physical protection of nuclear material and facilities and protection of sensitive information

- Law of 11 December 1998 on classification and security clearances, certificates and advice.
- Law of 15 July 2008 approving the Amendment to the Convention on Physical Protection of Nuclear Material

(CPPNM) of 8 July 2005.

- Law of 10 September 2009 approving the International Convention for the Suppression of Acts of Nuclear Terrorism of 14 September 2005.
- Law of 1 July 2011 relating to the security and protection of critical infrastructures, partially transposing Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection.
- Royal decrees of 17 October 2011 on security, addressing categorization and protection of documents, physical protection of nuclear materials, nuclear installations and transport, categorization of nuclear materials and definition of security zones in nuclear installations and nuclear transport organizations, security clearances and certificates, and regulating access to security zones, nuclear material or documents in specific circumstances.

Roles of national government, local government, and stakeholders

- Special Law of 8 August 1980 on Institutional Reform, awarding federal and regional authorities joint responsibility for energy policy.
- Law of 8 August 1980 on the budgetary proposals for 1979–1980, art. 179 §2 and §3 (as amended by the Acts of 11 January 1991 and 12 December 1997), establishing the “National Agency for Radioactive Waste and Fissile Materials” (ONDRAF/NIRAS) and entrusting ONDRAF/NIRAS with the safe transportation, treatment, conditioning, storage and disposal of all radioactive waste produced in the country. This law was modified by the Law of 11 January 1991, which also slightly changed the name of the agency into “Belgian National Agency for Radioactive Waste and Enriched Fissile Materials”.
- Royal Decree of 30 March 1981 defining the missions and duties of ONDRAF/NIRAS, as amended by the Royal Decrees of 16 October 1991, 4 April 2003, 1 May 2006, 18 May 2006, 2 June 2006, 13 June 2007, 3 July 2012 and 25 April 2014.
- Law of 22 July 1985, as modified by the Law of 11 July 2000, on nuclear liability, which integrates the Paris Convention and the follow-up Convention of Brussels and their additional protocols.
- Law of 29 April 1999 on the organization of the electricity market (amended by the Law of 8 January 2012).
- Programme Law of 30 December 2001, modifying art. 179 §2, on the National Agency for Radioactive Wastes and Fissile Materials Management in the Law of 8 August 1980.
- Law of 1 June 2005 fully implementing EU Directive 2003/54/EC on the common rules for the internal electricity market.

Law of 8 January 2012 amending the Law of 29 April 1999 on the organization of the electricity market (and the Law of 12 April 1965 on the transport of gaseous and other products by pipeline).

Main Regulations in Nuclear Power

Provisions for authorization system, responsibilities of the operator, inspection and enforcement, radiation protection of workers, public and environment

- Law of 15 April 1994 on the protection of the public and the environment against the dangers of ionizing radiation and on the Belgian Federal Agency for Nuclear Control. This Law constitutes the legal basis for the FANC/AFCN as regulatory body and sets out the basic elements for protecting the workers, the public and the environment against the adverse effects of ionizing radiation, repealing and replacing the Law of 29 March 1958.
- Law of 4 August 1996 on the welfare of workers in the performance of their work.
- Royal Decree of 20 July 2001 (amended) laying down the “General Regulations” regarding the protection of the public, the workers and the environment against the hazards of ionizing radiation (GRR-2001, as amended) provides for the general principles set in the Law of 15 April1994, replacing the Royal Decree of 28 February 1963 (GRR-1963). The GRR-2001 scope is very wide and covers practically all human activities and situations which involve a risk due to the exposure to ionizing radiation.

  The GRR-2001 includes provisions for establishing an authorization system, responsibilities of the operator, inspection and enforcement, and site selection and approval within the licensing system.

  Article 3 of the Royal Decree defines the classification of nuclear installations (Class I to IV).
- Law of 5 August 2006 on access to environmental information by the general public, which also applies to the

nuclear sector.

- Law of 15 May 2007 defining the notion of Civil Safety and describing the roles and missions of the different entities involved.

Safety of nuclear installations

- Law of 15 May 2007 defining the notion of Civil Safety and describing the roles and missions of the different entities involved.
- Royal decrees of 17 October 2011 on security, addressing categorization and protection of documents, physical protection of nuclear materials, nuclear installations and transport, categorization of nuclear materials and definition of security zones in nuclear installations and nuclear transport organizations, security clearances and certificates, and regulating access to security zones, nuclear material or documents in specific circumstances.
- Royal decree of 30 November 2011 on the Safety Requirements for Nuclear Installations (SRNI-2011). This royal decree includes all reference levels developed by the Reactor Harmonization Group (RHWG) of the Western European Nuclear Regulators Association (WENRA). It also transposes the European Directive 2009/71 /EURATOM into the Belgian regulations.

Radioactive waste and spent fuel management, including storage and disposal

- Law of 8 August 1980 on the budgetary proposals for 1979–1980, art. 179 §2 and §3 (as amended by the Acts of 11 January 1991 and 12 December 1997), establishing the “National Organization for Radioactive Waste and Fissile Materials” (NIRAS) and entrusting ONDRAF/NIRAS with the safe transportation, treatment, conditioning, storage and disposal of all radioactive waste produced in the country.
- Royal Decree of 30 March 1981 defining the missions and duties of NIRAS, as amended by the Royal Decrees of 16 October 1991, 4 April 2003, 1 May 2006, 18 May 2006, 2 June 2006 and 13 June 2007.
- Law of 11 January 1991, modifying the Law of 8 August 1980, to include certain aspects of the management of enriched fissile materials and the decommissioning of nuclear facilities other than nuclear power plants in the responsibilities of NIRAS, also slightly changing the name of the institution to “Belgian National Agency for Radioactive Waste and Enriched Fissile Materials”.
- Royal Decree of 16 October 1991 defining the procedures for the Law of 11 January 1991 and the responsibilities of ONDRAF/NIRAS: the qualification of installations for treatment and conditioning of radioactive waste; the establishment of acceptance criteria for conditioned and unconditioned radioactive waste based on General Rules to be approved by the safety authority.
- Law of 12 December 1997 extending the mission of ONDRAF/NIRAS to establish an inventory of all nuclear facilities and sites containing radioactive waste, and its financing.
- Ministerial letter of 10 February 1999 concerning General Rules for the establishment of acceptance criteria by ONDRAF/NIRAS for conditioned and non-conditioned waste.
- Programme Law of 30 December 2001, modifying art. 179 §2, on the National Agency for Radioactive Wastes and Fissile Materials Management in the Law of 8 August 1980.
- Royal Decree of 18 November 2002 regarding the practical implementation of the qualification of installations for the storage, treatment and conditioning of radioactive waste and installations for the radiological characterization of radioactive waste.
- Law of 13 February 2006 transposing EC Directives 2001/42/EC and 2003/35/EC into Belgian legislation, requiring that the plans for the long term management of the radioactive waste drawn up by ONDRAF/NIRAS must be accompanied by a strategic environmental assessment (SEA) and submitted for public consultation.
- Royal Decree of 26 May 2006, transposing directive 2003/122/EURATOM on the control of sealed radioactive sources and, in particular, of “orphan sources”, amending accordingly the GRR-2001.
- Law of 29 December 2010, modifying inter alia the Law of 8 August 1980, giving ONDRAF/NIRAS additional legal tasks with respect to activities and measures in the domain of the societal support for the integration of a disposal facility at the local level. This law entitles ONDRAF/NIRAS to create a fund to cover all of the costs related to the societal conditions for the integration of a disposal facility at the local level. The supply to this fund is by the waste producers on the basis of the total amount of the fund for a specific disposal project, and on the basis of the waste volumes to be disposed of.
- Royal decree of 14 October 2011 on orphan sources.

- Law of 3 June 2014, completely transposing EC Directive 2011/70/ EURATOM, the EU framework for the responsible and safe management of spent fuel and radioactive waste.
- Royal Decree of 25 April 2014, amending the Royal Decree of 30 March 1981 determining the tasks and functional modalities of the public body for the management of radioactive waste regarding the providing of resources for the medium and long term funds.
- Law of 3 June 2014, amending Article 179 of the Law of 8 August 1980 on the budgetary proposals for 1979–1980 and completely 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.

Decommissioning, including funding and institutional control

- Law of 8 August 1980 on the budgetary proposals for 1979–1980, art. 179 §2 and §3 (as amended by the Acts of 11 January 1991 and 12 December 1997), establishing ONDRAF/NIRAS and entrusting ONDRAF/NIRAS with the safe transportation, treatment, conditioning, storage and disposal of all radioactive waste produced in the country.
- Law of 11 January 1991, modifying the Law of 8 August 1980 which also slightly changed the name of ONDRAF/NIRAS to “National Agency for Radioactive Waste and Enriched Fissile Materials”.
- Law of 24 December 2002 providing for the levy of an excise tax, called federal dues, which is calculated on the basis of kWh consumed. These dues are paid to a fund earmarked to finance responsibilities resulting from the decommissioning of the sites of the former EUROCHEMIC plant (site 1 or BP1) and the former Waste Department of SCK•CEN (site 2 or BP2), as well as the treatment, processing, storage and evacuation of accumulated radioactive waste. The Commission for Electricity and Gas Regulation (CREG) collects the amount owed as dues and transfers it to ONDRAF/NIRAS, which is responsible for the management and cleanup.
- Law of 24 March 2003 creating the legal framework for a structural financing mechanism of the dismantling activities on the BP1 and BP2 sites until their completion by a levy on the transported kWh. For each period of five years, ONDRAF/NIRAS has to present a financing plan to its supervising minister.
- Royal Decree of 24 March 2003 laying down the detailed rules on the federal contribution for the financing of certain public service obligations and the costs related to the regulation and control of the electricity market.
- Royal Decree of 4 April 2003 determining that ONDRAF/NIRAS’ funds available in the medium and the long term must be invested in financial instruments issued by the federal Government. As a result, the board of ONDRAF/NIRAS has decided to invest the assets of the “Long-term fund” into Belgian Governmental bonds which will be passively managed.
- Law of 11 April 2003 regarding liabilities and provisions for the decommissioning and dismantling of nuclear power plants and the management of the spent fuel from these nuclear power plants, amended by the Law of 25 April 2007. This law also determines the management of funds built up by SYNATOM for the decommissioning of the nuclear power plants.
- Royal Decree of 19 December 2003 to determine the amounts allocated to the financing of the nuclear liabilities BP1 and BP2 for the period 2004 to 2008, in implementation of Article 4, §2 of the Royal Decree of 24 March 2003 laying down the detailed rules on the federal contribution for the financing of certain public service obligations and the costs related to the regulation and control of the electricity market.
- Law of 29 December 2010, modifying inter alia the Law of 8 August 1980, giving ONDRAF/NIRAS additional legal tasks with respect to activities and measures in the domain of the societal support for the integration of a disposal facility at the local level. This law entitles ONDRAF/NIRAS to create a fund to cover all of the costs related to the societal conditions for the integration of a disposal facility at the local level. The supply to this fund is by the waste producers on the basis of the total amount of the fund for a specific disposal project, and on the basis of the waste volumes to be disposed of.

Emergency preparedness

- Royal Decree of 17 October 2003, defining a nuclear and radiological emergency plan for the Belgian territory as well as notification criteria from the operators to the Government. Emergency planning is a competence belonging to the federal Minister of Home Affairs and his administrative services.
- Royal Decree of 24 November 2003 setting the emergency planning zones relative to the direct actions to protect the population (evacuation, sheltering, and iodine prophylaxis). These evacuation and sheltering zones vary from 0 to 10 km radius depending on the nuclear plant concerned; the stable iodine tablet pre-distribution zones extend from 10 km up to 20 km around the nuclear plants.

- Royal Decree of 16 February 2006 organizing the planning and interventions during emergency situations.
- Law of 15 May 2007 defining the notion of Civil Safety and describing the roles and missions of the different entities involved.

Transport of radioactive material

- Law of 8 August 1980 on the budgetary proposals for 1979–1980, art. 179 §2 and §3 (as amended by the Acts of 11 January 1991 and 12 December 1997), establishing ONDRAF/NIRAS and entrusting ONDRAF/NIRAS with the safe transportation, treatment, conditioning, storage and disposal of all radioactive waste produced in the country. This law was modified by the Law of 11 January 1991, which also slightly changed the name of the institution to “National Agency for Radioactive Waste and Enriched Fissile Materials”.
- Royal decrees of 17 October 2011 on security, addressing categorization and protection of documents, physical protection of nuclear materials, nuclear installations and transport, categorization of nuclear materials and definition of security zones in nuclear installations and nuclear transport organizations, security clearances and certificates, and regulating access to security zones, nuclear material or documents in specific circumstances.
- Royal Decree of 28 December 2011 laying down the maximum amount of the damage for which the operator or carrier may be held responsible in the case of transport within the meaning of Article 14 of the Law of 22 July 1985 on third party liability in the field of nuclear energy.

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APPENDIX 1: INTERNATIONAL, MULTILATERAL AND BILATERAL AGREEMENTS

AGREEMENTS WITH THE IAEA

Statute of the International Atomic Energy Agency	Entry into force:	29 July 1957
Agreement on privileges and immunities	Entry into force:	26 October 1965
NPT related safeguards agreement INFCIRC No. 193	Entry into force:	21 February 1977
Additional protocol to the NPT safeguards agreement	Signature:	22 September 1998
Improved procedures for designation of safeguards inspectors	Rejected by EURATOM, but agreed to alternative solution.	16 February 1989

OTHER RELEVANT INTERNATIONAL TREATIES

Non Proliferation Treaty (NPT)	Entry into force:	2 May 1975
EURATOM	Member	
Convention on the physical protection of nuclear material	Entry into force: Ratification:	6 October 1991 6 September 1991

Amendment to the convention on the physical protection of nuclear material	Ratification:	22 January 2013
Convention on early notification of a nuclear accident	Entry into force: Ratification:	4 February 1999 4 January 1999
Convention on assistance in the case of a nuclear accident or radiological emergency	Entry into force: Ratification:	4 February 1999 4 January 1999
Vienna convention on civil liability for nuclear damage		Non-party
Paris convention on nuclear third party liability	Ratification:	3 August 1966
Joint protocol relating to the application of the Vienna and the Paris conventions	Signature:	21 September 1988
Brussels convention on supplementary compensation	Ratification:	20 August 1985
Convention on nuclear safety	Entry into force: Ratification:	13 April 1997 13 January 1997
Joint convention on the safety of spent fuel management and on the safety of radioactive waste management	Entry into force: Ratification:	4 December 2002 5 September 2002
International convention for the suppression of acts of nuclear terrorism	Entry into force: Ratification:	7 July 2007 2 October 2009
Zangger Committee	Member	
Nuclear export guidelines	Adopted	
Acceptance of NUSS Codes	Summary: codes can be used as guidelines when formulating national regulations. Belgium often goes beyond code requirements.	8 November 1988
Nuclear Suppliers Group	Member	

BILATERAL AGREEMENTS

Belgium has nuclear bilateral agreements which are currently in force with The United States of America (1962, 1983), India (1965), France (1966, 1981, 1984, 2014), Luxembourg (1970, 2002, 2004), Romania (1974), Lithuania (1978, 1998), Republic of Korea (1981), the Netherlands (1984 and 1990), China (1985) and the Russian Federation (1993).

The BELGO-LUXEMBOURG ECONOMIC UNION (BLEU) concluded bilateral agreements with Poland (1973) and the People's Republic of China (1979).

APPENDIX 2: MAIN ORGANIZATIONS, INSTITUTIONS AND COMPANIES INVOLVED IN NUCLEAR POWER RELATED ACTIVITIES

GOVERNMENT	
Federal Public Service Economy, SMEs, Self-Employed and Energy Directorate-General for Energy Nuclear Applications Boulevard du Roi Albert II, 16 B-1000 Brussels	tel.: +32-2-277 89 81 or +32-2-277 61 85 fax: +32-2-277 52 06 email: nuclear@economie.fgov.be web site: http://economie.fgov.be/
Federal Public Service Foreign Affairs, Foreign Trade and Development Cooperation Rue des Petits Carmes, 15 B-1000 Brussels	tel.: +32-2-501 81 11 contact: http://diplomatie.belgium.be/en/Contact/ web site: http://diplomatie.belgium.be/en/

Federal Public Service Interior Rue de Louvain, 1 B-1000 Brussels	tel.: +32-2-500 21 11 fax:+32-2-500 20 39 email: info@ibz.fgov.be web site: http://www.ibz.be/
NUCLEAR SAFETY AUTHORITY	
Federal Agency for Nuclear Control FANC/AFCN Rue Ravenstein, 36 B-1000 Brussels	tel.: +32-2-289 21 11 fax: +32-2-289 21 12 email: info@fanc.fgov.be web site: http://www.fanc.fgov.be/
WASTE MANAGEMENT ORGANIZATION	
ONDRAF/NIRAS Avenue des Arts, 14 B-1210 Brussels	tel.: +32-2-212 10 11 fax: +32-2 218 51 65 email: info@nirond.be web site: http://www.nirond.be/
COMMUNICATION	
ISOTOPOLIS Gravenstraat, 73 B-2480 Dessel	tel.: +32-14-33 40 31 email: isotopolis@belgoprocess.be web site: http://www.isotopolis.be/
R&D	
EIG EURIDICE Boerentang, 200 B-2400 Mol	tel.: +32-14-33 27 84 fax: +32-14-32 37 09 email: euridice@sckcen.be web site: http://www.euridice.be/
SCK•CEN (Belgian Nuclear Research Centre) (Registered Office Brussels) Avenue Herrmann-Debrouxlaan 40 B-1160 Brussels (Research Centre Mol) Boeretang, 200 B-2400 Mol	 tel. : +32-2-661 19 51 fax: +32- 2 661 19 58 tel.: +32-14-33 21 11 fax: +32-14-33 89 36 email: info@sckcen.be web site: http://www.sckcen.be/
OTHER BELGIAN NUCLEAR ORGANIZATIONS	
Belgian Association for Radioprotection Avenue Herrmann Debroux, 40 B-1160 Brussels	tel.: +32-2-289 21 27 email: office@bvsabr.be web site: http://www.bvsabr.be/
Belgian Nuclear Society c/o SCK-CEN Avenue Herrmann Debroux, 40 B-1160 Brussels	email: secretary@bnsorg.be web site: http://www.bnsorg.be

Fund for Scientific Research / Fonds National de la Recherche Scientifique (FNRS) / Fonds Wetenschappelijk Onderzoek (FWO) Rue d'Egmont 5 B - 1000 Brussels	tel.: +32-2-504 92 11 fax: +32-2-504 92 92 email: post@fwo.be contact: http://www.fnrs.be/en/index.php/contacts/ web site: http://www.fnrs.be/en/
Inter-University Institute for Nuclear Science / Institut Interuniversitaire des Sciences Nucléaires (IISN) / Interuniversitair Instituut voor Kernwetenschappen (IIKW) Rue d'Egmont 5 B - 1000 Brussels	tel.: +32-2-512 91 10 fax: +32-2-512 58 90
NUCLEAR FORUM Avenue des Arts 56 B-1000 Brussels	tel.: +32-2-761 94 50 contact: https://www.nuclearforum.be/contact/ web site: http://www.nuclearforum.be/
BELGIAN NUCLEAR INDUSTRY RELATED ORGANIZATIONS	
AGORIA Diamant Building Bd. A. Reyers, 80 B-1030 Brussels	tel.: +32-2-706 78 00 fax: +32-2-706 78 01 web site: http://www.agoria.be/
BELGIAN NUCLEAR INDUSTRY SECTOR	
Belgian companies provide products and services for a wide range of applications in the nuclear industry. The business app **Nuc Tec Bel** can help you find the right partner for your projects.	
AREVA See FBFC International	
Association Vinçotte Nuclear (AVN) Paepsemlaan, 20 B-1070 Brussels	tel.: +32-2-528 01 11 fax : +32-2-528 01 03 email: services@avn.be web site: http://www.avn.be/
Bel V Rue Walcourtstraat, 148 B-1070 Brussels	tel.: +32-2-528 02 11 fax:+32-2-528 02 01 email: info@belv.be web site: http://www.belv.be/
BELGONUCLEAIRE S.A. (in decommissioning) Avenue Ariane, 4 B-1200 Brussels	tel.: +32-2-774 05 11 fax: +32-2-774 05 47 email: communic@belgonucleaire.be web site: http://www.belgonucleaire.be/
BELGOPROCESS SA Gravenstraat, 73 B-2480 Dessel	tel.: +32-14-33 41 11 fax: +32-14-33 40 99 email: info@belgoprocess.be web site: http://www.belgoprocess.be/

EDF Luminus Markiesstraat 1 Rue du Marquis 1000 Brussels	tel.: +32-2-229 19 50 fax: +32-2-218 61 34 email: corporate@edfluminus.be web site: http://edfluminus.edf.com/
ENGIE ELECTRABEL Boulevard Simón Bolívar, 34 B-1000 Brussels	tel.: +32-2-518 61 11 web site: http://www.engie-electrabel.be/
FBFC International, S.A. (AREVA) (in decommissioning) Europalaan, 12 B-2480 Dessel	tel.: +32-14-33 12 11 fax: +32-14-31 58 45 email: info@fbfc.be web site: http://areva.com/
IRE ELiT (Environment & Life science Technology) Avenue de l'Espérance, 1 B-6220 Fleurus	tel.: +32-71-82 95 56 email: info@ire.eu web site: http://www.ire.eu/
LABORELEC (ENGIE LAB) Rue de Rhode, 125 B-1630 Linkebeek	tel.: +32-2-382 02 11 fax: +32-2-382 02 41 email: info@laborelec.com web site: http://www.laborelec.com/
SYNATOM S.A. (Nuclear Fuel Procurement) Boulevard Simón Bolívar, 34 B-1000 Brussels	tel.: +32-2-505 07 11 fax: +32-2-505 07 90 web site: http://www.synatom.be/
TECNUBEL S.A. (Decontamination) Avenue Ariane, 7 B-1200 Brussels	tel.: +32-14-34 69 11 fax: +32-14-32 00 90 email: info@tecnubel.be web site: http://www.tecnubel.be/
TRACTEBEL (Architect-Engineer and Contractor) Avenue Ariane, 7 B-1200 Brussels	tel.: +32-2-773 99 11 contact: http://www.tractebel-engie.com/contact-us/contact-business/ web site: http://www.tractebel-engie.com/
TRANSNUBEL, S.A. (Fuel Transportation) Zandbergen, 1 B-2480 Dessel	tel.: +32-14-33 11 11 fax: +32-14-33 11 10 email: info@transnubel.be web site: http://www.transnubel.be/
TRANSRAD, S.A. Zoning Industriel site IRE Avenue de l'Espérance, 1 B-6220 Fleurus	tel.: +32-71-82 97 59 email: info@transrad.be web site: http://www.transrad.be/
WESTINGHOUSE Electric Europe, sprl Rue de l'Industrie, 43 B-1400 Nivelles	tel.: +32-67-28 81 11 fax: +32-67-28 81 20 web site: http://www.westinghousenuclear.com/
BELGIAN NUCLEAR RELATED COMPANIES	

Belgian companies provide products and services for a wide range of applications in the nuclear industry.
The business app **Nuc Tec Bel** can help you find the right partner for your projects.

ABAY-TS (Contractor) Rue de Genčve 4, BTE 30 B-1140 Brussels	tel.: +32-2-729 61 11 fax: +32-2-729 61 61
AIB-VINÇOTTE CONTROLATOM vzw Jan Olieslagerslaan 35 B-1800 Vilvoorde	tel.: +32-2-674 51 20 fax: +32-2-674 51 40 email: av.controlatom@vincotte.be web site: http://www.controlatom.be/
AIB-Vinçotte Group (Safety Services) Avenue A. Drouart, 27 B-1160 Brussels	tel.: +32-2-674.57.11 fax: +32-2-674.59.59 web site: http://www.aib-vincotte.com
ALSTOM Belgium SA (Grid) Rue des Ormes, 109 B-4800 Verviers	tel.: +32-87-32 02 88 web site: http://www.alstom.com
ALSTOM Belgium SA (Power) Rue Chapelle Beaussart, 80 B-6030 Charleroi	tel.: +32-71-44 34 48 web site: http://www.alstom.com
ALSTOM Belgium SA (Transport) Rue Cambier Dupret, 50-52 B-6001 Charleroi	tel.: +32-71-44 54 11 web site: http://www.alstom.com
Asea Brown Boveri (ABB) Hoge Wei, 27 B-1930 Zaventem	tel.: +32-2-718 63 11 fax: +32-2-718 66 66 email: contact.center@be.abb.com web site: http://www.abb.com
Ateliers de la Meuse (Mechanical Equipment) Rue Ernest Solvay, 107 B-4000 Sclessin (Ličge)	tel.: +32-4-252 00 30 fax: +32-4-252 00 35 web site: http://www.alm.be/english
ENGIE FABRICOM (Electrical and Mechanical Contractor) Rue Gatti de Gamond, 254 B-1180 Brussels	tel.: +32-2-370 31 11 fax: +32-2-332 24 55 web site: http://www.engie-fabricom.be/
Ion Beam Applications (IBA) Groupe Chemin du Cyclotron, 3 B-1348 Louvain-La-Neuve	tel.: +32-10 47 58 11 fax:+32-10 47 58 10 web site: http://www.iba.be

OTHER BELGIAN NUCLEAR-RELATED COMPANIES

Anglo Belgian Corporation Wiedauwkaai 43 B-9000 Gent	tel.: +32-9-267 00 00 fax: +32-9-267 00 67 email: info@abcdiesel.be web site: http://www.abcdiesel.be/
ASCO Industries SA (Mechanical Engineering) Weiveldlaan 2 B-1930 Zaventem	tel.: +32-2-716 06 11 fax: +32-2-716 07 70 email: asco@asco.be web site: http://www.asco.be/
Balteau NDT (Manufacturer of X-Ray Generators) Rue Voie de Liege, 12 B-4681 Hermalle-sous-argenteau	tel.: +32-4-374 75 75 fax: +32-4-374 75 85 web site: http://www.balteau.com
Berthold Technologies NV/SA Vaartdijk 22 B-1800 Vilvoorde	tel.: +32-2- 251 60 10 fax: +32-2- 251 56 99 email: leo.demey@berthold.com web site: http://www.berthold.com
Canberra Packard Benelux (Instrumentation) Z. 1. Researchpark 80 B-1731 Zellik	tel.: +32-2-481 85 30 fax: +32-2-481 85 50 email: info.be@canberra.com web site: http://www.canberra.com/be
CG Power Systems Belgium Pauwels Trafo Belgium (Transformers Supplier) Antwerpsesteenweg, 167 B-2800 Mechelen	tel.: +32-15-28 33 33 fax: +32-15-28 33 00 web site: http://www.cgglobal.com/be/
CMI (NSSS Components Manufacturer) Avenue Greiner, 1 B-4100 Seraing	tel.: +32-4-330 24 44 fax: +32-4-330 25 82 web site: http://www.cmigroupe.com
ECS Industrielaan 42 B-2900 Schoten	tel.: 03/360 29 11 fax: 03/877 07 74 email: info@e-c-s.be web site: http://www.e-c-s.be/
ENI (Electrical Contractor) Kontichsesteenweg, 25 B-2630 Aartselaar	tel.: +32-3-870 12 11 fax: +32-3-887 12 98 web site: http://www.eni.be
ISI NV/SA **(**Isotopes Services International) Maanstraat 17-19 B-2800 Mechelen	tel.: +32-15-56 90 60 fax: +32-15-56 90 80 email: info@isotopes.be web site: http://www.isotopes.be
Kabelwerk Eupen AG (Cable Supplier) Malmedyer Strasse, 9 B-4700 Eupen	tel.: +32-87-59 70 00 fax: +32-87-59 71 00 email: info@eupen.com web site: http://www.eupen.com

Lepage Euronucléaire (Mechanical Contractor) Rue de l'Aurore, 2A B-6040 Jumet (Charleroi)	tel.: +32-71-28 57 00 fax: +32-71-28 57 01 web site: http://www.lepage-jumet.be
M.P.E. - Mécanique de Précision pour Equipements (Mechanical Equipment Supplier) Avenue de Tyras, 51 B-1120 Brussels	tel.: +32 2 262 1010 fax: +32-2-262 0241 web site: http://www.mpe.be
Phibo Industries bvba A.Z. Nieuwe Pontstraat, 23 B-9600 Ronse	tel.: +32-55-21 98 99 fax: +32-55-21 77 69 email: sales@phibo.be web site: http://www.phibo.be/
Sarens NV (Head Office) Autoweg 10 B-1861 Wolvertem	tel.: +32-52-31 93 19 fax: +32-52-31 93 29 email: info@sarens.com web site: http://sarens.com
Six Construct (Civil Works Contractors) Avenue des Communautés, 100 B-1200 Woluwe-Saint-Lambert	tel.: +32-2-402 62 11 fax: +32-2-402 62 00 email: communication@besix.com web site: http://www.sixconstruct.com
Stork Mec (Mechanical Contractor) Haven 269 Oosterweelsteenweg 57 B-2030 Antwerpen	tel.: +32-3-540 15 11 fax: +32-3-540 15 00 web site: http://www.storktechnicalservices.com
Technem S.A. Rue de la Métallurgie, 25 B-4530 Villers-le-Bouillet	tel.: +32-4-273 77 00 fax:+32-4-273 81 31 email: info@technem.be

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