

RADIOACTIVE WASTE MANAGEMENT PROGRAMMES IN OECD/NEA MEMBER COUNTRIES

BELGIUM [2013]

NATIONAL NUCLEAR ENERGY CONTEXT

Introduction

With a population of over 10.5 million people living on 30 528 m², Belgium is among the most densely populated countries in the OECD.

Belgium is a federal parliamentary democracy under a constitutional monarch. As a result of several constitutional revisions in the 1970s and the 1980s, Belgium has become a federalist state with three levels of government — federal, regional, and linguistic community— with a complex division of responsibilities.

Each of the Belgian three regions (Flanders, Wallonia and Brussels-Capital) and each of the three linguistic communities has its own parliament and government. The responsibilities for economic and energy policy are distributed between the federal state and the regions. The communities are primarily responsible for cultural and linguistic affairs and education.

The federal responsibilities in energy policy include security of supply, tariff regulation and the nuclear fuel cycle and related R&D. The regions of Flanders, Wallonia and Brussels-Capital are principally responsible for energy efficiency, renewables, non-nuclear energy R&D, and distribution and supply of electricity and gas.

Nuclear Power in Belgium

Policy related to the nuclear sector, the nuclear fuel cycle and nuclear R&D is the responsibility of the Belgian federal government. The FPS for Economy, SMEs, Self-Employed and Energy is responsible for nuclear policy within the Belgian government. 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.

After the operation of the pilot PWR reactor BR3 at SCK•CEN from 1962 onwards, commercial utilisation of nuclear power in Belgium started in 1974 and, by 2012, 7 nuclear power units – all pressurised water reactors – had been connected to the electricity grid, with a total generating capacity of 5 824.5 MW_e net. The nuclear power plants are located in Doel and Tihange. In 2011, they generated 45.9 TWh of electricity, about 53 % of all electricity generated that year in Belgium.

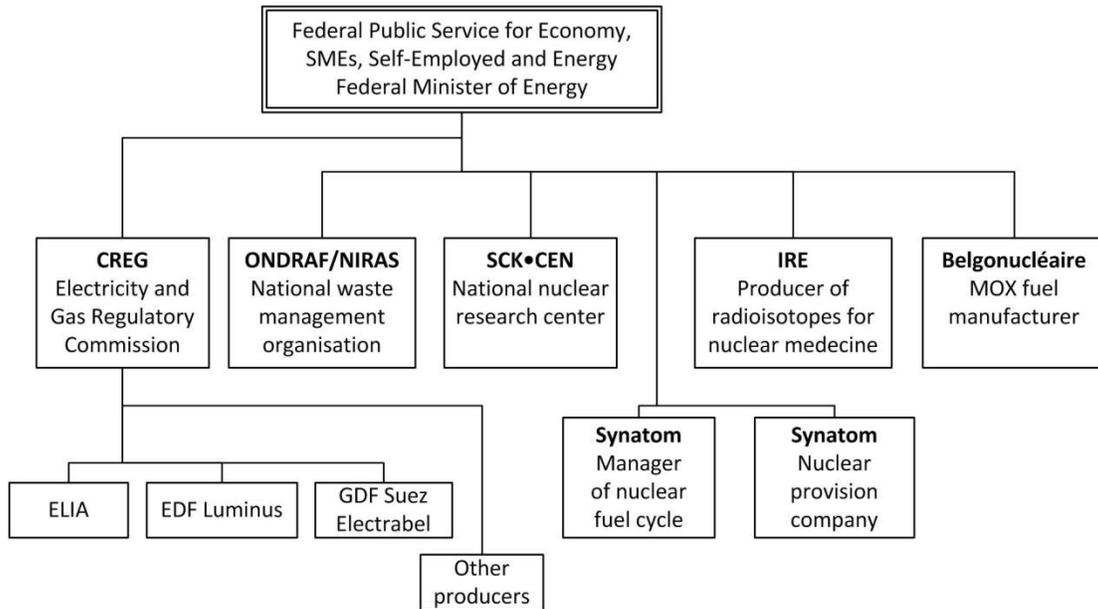


Figure 1: Federal Nuclear Policy Institutions

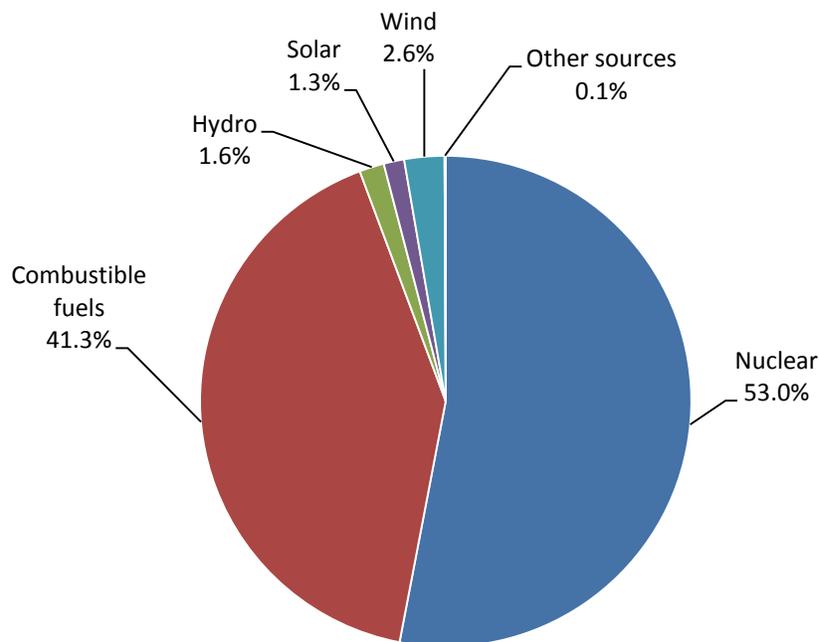


Figure 2: Net electricity production in Belgium (2012)

Source: Observatoire de l'Énergie - FPS Economy, SMEs, Self-Employed and Energy

On 16 January 2003, the Belgian federal parliament voted a law that promulgates the gradual phase-out of nuclear fission energy for commercial electricity production. The law prohibits the construction of new nuclear power plants and set a 40-year limit on the operational period of existing plants. The Belgian Government decided on 4 July 2012 to postpone by 10 years the shutdown of Tihange 1. This decision has not yet been confirmed by law. The first reactor to be shut down will be Doel 1 in February 2015 followed by Doel 2 in December 2015.

Nuclear R&D in Belgium

Most of the nuclear research in Belgium is carried out at the National Nuclear Research Centre, SCK•CEN, located in Mol. Being a research centre for nuclear energy and ionising radiations, SCK•CEN also provides training and other services to the nuclear industry, the medical sector and the authorities, and promotes public awareness of nuclear technology.

The research areas for SCK•CEN are authorised by Royal Decree. The first priority is to maintain the safety of the nuclear power plants. This involves research of the ageing of their main components and the safety aspects of fuel development. The work is carried out in cooperation with Tractebel Engineering, the nuclear engineering company of GDF Suez Electrabel, and to a large extent as well in cooperation with the international

research community, and at the service of the international legislation and safety authorities and industry. Regarding the integrity of structural reactor systems, structures and components, thorough and advanced scientific sound evaluation methodologies are continuously being elaborated, leading to thorough and improved surveillance practices. Regarding nuclear fuel safety, comprehensive qualification programmes are being performed, both to support and validate the proper and safe operation of the ever evolving fuel, and to assess its back-end aspects such as the ultimate source term and thermal-mechanical performance. The second priority is to find an appropriate solution for the long-term management of the long-lived medium- and high-level radioactive wastes.

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 risks management and energy management.

SOURCES, TYPES AND QUANTITIES OF NUCLEAR WASTE

Sources

About 70% of the radioactive waste produced today in Belgium derives from the nuclear power generation activities. Nuclear industry waste is generated during nuclear power plant operations, the reprocessing of spent fuel as carried out by Areva (formerly Cogema) in France, uranium and MOX fuel fabrication, and decommissioning.

Currently, 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). End of 2012, the dry storage building in Doel contained 82 containers in which 2424 spent fuel elements were stored, while the wet storage building in Tihange contained 2267 such elements.

The remaining 30% of Belgian radioactive waste is generated by nuclear research, production of radioisotopes by the National Institute for Radioisotopes (IRE), the use of such isotopes in medicine, industry and in private laboratories, and the European Joint Research Centre's Institute for Reference Materials and Measurements (IRMM).

Types and quantities

Radioactive wastes are classified in three categories:

1. **Category A: Low- and medium-level short-lived waste.** This waste contains small amounts of mainly beta and gamma emitters with half-lives shorter than 30 years and traces of longer-lived emitters. It arises mainly from the operation of nuclear power plants, but also from reprocessing, research, production of radioisotopes and their use in nuclear medicine and industry. Seventy-four per cent of the estimated total volume of category A waste will be produced by the decommissioning of nuclear facilities.

The estimated total volume of conditioned waste of this category is 69,900 m³.

2. Category B: Low- and medium-level long-lived waste. This waste contains mainly alpha emitters with half-lives exceeding 30 years, together, in some cases, with intermediate amounts of beta and gamma emitters. It is derived mostly from the fabrication of nuclear fuels, from nuclear research and the reprocessing of spent nuclear fuel. Twenty-two percent of the estimated total volume of category B waste will be produced by the decommissioning of nuclear facilities.

The estimated total volume of conditioned waste of this category is 10,430 m³ in the non-reprocessing scenario and 11,100 m³ in the full reprocessing scenario.

3. Category C: Long-lived high-level waste. This waste contains substantial amounts of beta and gamma emitters with short and medium half-lives, together with longer-lived alpha emitters. One of its major characteristics is the considerable heat emission. It derives mostly from the reprocessing of spent nuclear fuel and from research.

The estimated total volume of conditioned waste of this category is 600 m³ (full reprocessing scenario) or 4,500 m³ in the non-reprocessing scenario.

The projected total volumes of waste in each of these three categories are estimated on the basis of assumptions about the continuing operation of nuclear power plants (shut down after 40 years of operation), reprocessing of all spent fuel, and nuclear facility decommissioning by 2050. The Belgian Government in July 2012 decided to postpone by 10 years the shutdown of the Tihange 1 reactor. The first estimations of the impact of this decision is estimated to be of the order of

- an increase of 300 m³ of category A and B waste and 150 m³ of category C waste in the non-reprocessing scenario;
- an increase of 330 m³ of category A and B waste and 30 m³ of category C waste in the full reprocessing scenario.

RADIOACTIVE WASTE MANAGEMENT POLICIES AND PROGRAMMES

Waste management policies

Operational activities

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 (North-East of Belgium). The Dessel site also accommodates central facilities for interim storage of all conditioned Belgian waste, of all categories, awaiting disposal. The associated operations are carried out by Belgoprocess, the industrial auxiliary company of ONDRAF/NIRAS, which manages these central processing and interim storage facilities.

Long-term management of low-level and short-lived radioactive waste

On 23 June 2006, the Belgian federal Government selected the municipality of Dessel for the location of a surface repository for low- and medium-level short-lived radioactive waste. The Government also allowed ONDRAF/NIRAS to pass from a pre-project disposal phase to the proper project phase and instructed the agency to continue the development of the technical integrated disposal project in Dessel, to carry on the local partnership participation process, to develop a legal and regulatory framework to guarantee the project's safety and financing, and to provide for the financing of the associated socio-economic aspects.

A document titled Master Plan, published in March 2010, describes all the components of the integrated disposal project in Dessel. It expresses the vision shared by ONDRAF/NIRAS and the local partnerships of the project's content and execution.

Since end of January 2013, ONDRAF/NIRAS has entered the licensing phase as the safety case for the surface disposal was submitted to the Federal Agency on Nuclear Control (FANC).

More information about the project's development can be found under Programmes and projects infra.

Waste Plan: towards a decision in principle on the long-term management of high-level and/or long-lived radioactive waste (also called categories B and C waste)

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, almost 40 years ago, a long-term management policy is still absent for those waste categories.

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 (that translates into the Belgian legislation the EC Directives 2001/42/EC and 2003/35/EC), this plan has to be accompanied by a strategic environmental assessment (SEA) and submitted for public consultation.

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, i.e. a general policy decision or general guidance decision relating to 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.

In preparation of the legally required public consultation process that must precede the presentation of the Waste Plan to the authorities, ONDRAF/NIRAS has organized, on its own initiative, a voluntary public consultation and information process through public dialogues and a citizen's forum.

The final Waste Plan, including likewise the results of the public consultation and the accompanying documents, was adopted by the Board of Directors of ONDRAF/NIRAS on 23 September 2011. Since the Waste Plan's implementation must be ratified by a decision in principle of the Federal Government, ONDRAF/NIRAS presented the whole file to its supervisory authority on 26 September 2011. Awaiting a decision in principle, and in order to ensure the continuity of the public service missions of ONDRAF/NIRAS, the supervisory authority, in its response of 3 October 2011, tasked the agency with the implementation of a series of recommendations specifically to ensure the continuity of the agency's work for the long-term management of category B and C waste.

The long-term management solution recommended by the Waste Plan is intended to be a final document. It concerns the geological disposal in poorly indurated clay (Boom Clay or Ypres Clay) within one underground facility constructed on a single site located on Belgian territory.

The development and the realization of the recommended technical solution fits into the framework of a decision-making process that integrates the technical and social aspects and that progresses step by step, ensures continuity, and is adaptable, participative, as well as transparent.

Furthermore, ONDRAF/NIRAS has added to the recommended solution a series of conditions arising from the societal consultations. These conditions ensue from the concerns widely shared by the public and official bodies consulted. The exact impact of these conditions will have to be defined in consultation with all the stakeholders, considering the need to satisfy the safety and technical-financial feasibility imperatives.

As such, ONDRAF/NIRAS commits 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 recommends creating an independent monitoring body to ascertain that the decision-making procedure progress as scheduled.

Among the questions raised by the Waste Plan, special attention ought to be given to the issue of the long-term management of important radium-bearing waste volumes on the Umicore site in Olen resulting from historical radium-production activities. The definition of a long-term management strategy for radium-bearing wastes in general, and particularly those from Umicore, must start with the elaboration of a complementary plan. In the coming years, ONDRAF/NIRAS will establish a plan dedicated to this specific issue.

The Waste Plan and its accompanying documents provides the Belgian Government with all the necessary elements enabling it to take a decision in principle regarding the orientation to be given to the long-term management of these wastes.

Inventory of Nuclear Liabilities

ONDRAF/NIRAS' missions were extended by law on 12 December 1997. Under this new legislation, the organisation is entrusted with the task of drawing up, every five years, the Inventory of Nuclear Liabilities, listing all nuclear facilities and sites containing radioactive substances on the Belgian territory. This inventory is a public-interest undertaking aimed at guaranteeing the availability of the necessary financial means for the safe management of radioactive substances and facilities and sites containing radioactive substances. The Inventory of Nuclear Liabilities involves:

- drawing up a register specifying the location and condition of all nuclear facilities and all sites containing radioactive substances on the Belgian territory;
- estimating the cost of decommissioning and cleaning up these facilities and sites;
- evaluating the availability of sufficient funds to carry out these future or on-going operations.

A first Inventory report, covering the period 1998-2002, was published in January 2003; the second Inventory report, covering the period 2003-2007, in January 2008, and the third Inventory report, covering the period 2008-2012, in January 2013. These Inventories allow the Belgian Government to gain greater insight into the existing situation and to define future policy.

Before their submission to the competent federal authorities, the Inventories are evaluated by an international assessment committee composed of experts from IAEA, OECD/NEA, European waste agencies, and Belgian safety authorities. The recommendations of the committee are appended to the final report of the Inventory.

The major concern expressed in the recommendations in the second Inventory report focussed on what steps producers had devised to ensure the practical availability of provisions when needed. By letter dated 9 January 2009, the two supervising ministers of ONDRAF/NIRAS entrusted the agency with a new mission, namely to propose changes in the Belgian legislation in order to improve the robustness and availability of the nuclear provisions.

The main recommendations in the third Inventory Report suggest:

- establishing a general obligation to constitute provisions to cover the nuclear costs;
- establishing a mechanism of regular evaluation of the nuclear costs by the operators;
- establishing a mechanism that will ensure the continuity, in all circumstances, of the financing of radioactive waste management;
- establishing an institutional control on nuclear cost financing.

Policy agreement for orphan sources

On 19 October 2007, ONDRAF/NIRAS and the Federal Agency for Nuclear Control (FANC) signed an agreement with the professional confederations of the non-nuclear sector defining the policy to be implemented for the management of so-called orphan sources. Orphan sources can be described as radioactive substances and objects, the owner or holder of which cannot be traced. The agreement provides that ONDRAF/NIRAS be called upon for the collection and management of such sources once they have been declared radioactive waste by the Federal Agency for Nuclear Control. The costs for the collection and management of these sources can be recovered by ONDRAF/NIRAS from the legally founded “insolvency fund” to which the various radioactive waste producers contribute. Between 2007 and 2012, the Federal Agency for Nuclear Control drew up 222 certificates attesting the discovery of new orphan sources.

Programmes and projects

Details of existing plants for waste treatment and conditioning

Low-level solid waste is either incinerated or compressed in a facility named CILVA which began industrial operation in 1994. 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 in the past. The last bituminization campaign took place in 2004 and no further use of bitumen is planned. The CILVA facility cost EUR 57 million, and its operation was certified according to the ISO 9001 quality management standard of 1995. By the end of 2012, a volume of 27,884 m³ of waste had been treated in the CILVA facility and a total volume of 5,437 m³ of conditioned waste produced.

In 2011, the Board of Directors of NIRAS and its supervisory authority gave their consent to the incineration at the CILVA facility of some 120 tonnes of low-level waste originating from Germany. The processing of this waste will take several years.

Medium-level and long-lived alpha-bearing waste as well as Pu-contaminated glove-boxes have since 2007 been encapsulated in cement in 400-litre drums in the PAMELA-

installation. About 801 m³ has been treated and about 433 m³ of conditioned waste produced up to the end of 2012.

The HRA/Solarium facility (G280X), 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 certain radium-bearing waste. Most of this waste is old waste stored on the site of the former *Waste* department of SCK•CEN (see first chapter: "historical activities"). By 21 December 2012, 129 m³ had been processed in the HRA/Solarium facility.

Reprocessing of Belgian spent fuel by Areva (formerly Cogema) in France generates both medium-level waste and high-level waste. Medium-level waste is compacted (hulls and end fittings) or vitrified (process sludge). High-level waste is vitrified. The existing contracts for the reprocessing of 631.5 tHM Belgian spent fuel provide that reprocessing waste must be returned to Belgium. The interim storage facilities for conditioned waste of all categories are centralised on the Dessel site operated by Belgoprocess.

Storage of low-level waste

Building 150: commissioned in 1986 after Belgium joined the international moratorium on sea disposal of conditioned low-level waste. Capable of holding 1,929 m³, it has been filled to near capacity since the end of the eighties (it is filled with 1,914 m³ of conditioned waste, or 3,317 packages at the end of 2012).

Building 151: 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 m³ to 14,700 m³. The drums are stored by means of a remotely controlled roller bridge. By the end of 2012, building 151 housed 13,851 m³ of conditioned waste (34,627 packages). According to the most recent predictions, its total capacity should be enough to accommodate Belgium's conditioned low-level waste until the beginning of 2016.

Storage of medium-level waste

Building 127: 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 m³, 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 2012, 3,827 m³ of conditioned waste (15,812 packages) were housed in building 127.

Building 155: a storage facility specially designed to store low-level radium and plutonium-bearing waste following processing/conditioning. Commissioned in 2005, it consists of two separate storage rooms each: one for housing radium-bearing waste and the other for plutonium-bearing waste. Although it would be possible to extend the storage rooms, building 155's 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 2012, building 155 housed 1,110 m³ of conditioned waste (2,775 packages).

Building 270: a simple buffer storage on site 2 of Belgoprocess, used to temporarily store conditioned waste waiting for its transfer to the appropriate storage facilities on site 1 of Belgoprocess. At the end of 2012, 550 conditioned waste packages (235 m³) were stored.

Storage of medium-level and high-level waste

Building 129: commissioned in 1985, this building has a capacity of 250 m³, 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 m³ 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 m³ of conditioned waste (2,335 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: the construction of building 136 started in 1990. Five years later, the building was issued its operating licence. It is designed for the storage of medium-level and high-level waste resulting from the reprocessing by the French company Areva (former Cogema) of spent fuel from Belgian nuclear power plants. Medium-level waste arising from the reprocessing in Dounreay of the SCK•CEN research reactor BR2 spent fuel will also be stored in building 136. Building 136 is capable of accommodating 600 containers of high-level vitrified waste and about 1,000 m³ of medium-level cemented or compacted waste (additional modules may, if necessary, increase its capacity). The 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.

At the end of 2012, 390 containers (70.20 m³) of high-level vitrified waste, 336 containers (60.48 m³) of compacted medium-level waste (hulls and end fittings) repatriated from France, and 12 containers (6.72 m³) of medium-level 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, this to prevent the risk of altering the properties of the surrounding geological environment.

Inspection programme for the drums stored on the Belgoprocess site

In 2003, ONDRAF/NIRAS started an inspection programme for the conditioned waste drums stored on the Belgoprocess site. This programme was completed in 2011. The drums are inspected one by one by means of a semi-automatic control system. By 31 December 2011, 44,010 drums had individually been inspected, of which 1,678 show defects. Most of the defective drums are old drums dating from the eighties and represent no danger either for Belgoprocess workers or for neighbouring residents.

Disposal of category A waste

In accordance with the conditions laid down in the decision of the Belgian Government of 23 June 2006 to build a surface disposal infrastructure for the waste concerned on the territory of the municipality of Dessel, ONDRAF/NIRAS is pursuing its activities and efforts to realize the project in close cooperation with the local partnerships. The disposal project is integrated into a broader project that offers added value for the region, taking into account the concerns and values of the local community.

The local partnerships STORA (the original name STOLA has been changed into STORA) in Dessel and MONA in Mol have been prolonged and participate in the further steps of 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 “monolith”, surface disposal concrete infrastructures, control and drainage systems, auxiliary buildings) and the associated socio-economic 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, ...). Negotiations with all the parties concerned (radioactive waste producers, the federal, regional and local authorities) with a view to financing the socio-economic aspects have led to the creation of a special dedicated fund (see further description under Financing hereafter).

A project team ONDRAF/NIRAS established in Dessel is elaborating the various constituents of the global integrated disposal project. During the detailed study phase, which covers the period 2007-2015, 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 2015. 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 2018.

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 said 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, which will constitute a new nuclear Class I facility.

Long-term management of category B&C waste

In the 1970's, 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 the 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 have taken place.

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 (EBS) 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; the safety and performance assessment of a potential repository in the deep Clay. Several of these experiments are conducted in co-operation with other research organisations and universities, both national and international. An important experiment, conducted in close collaboration with the French waste disposal organisation 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 are:

- (1) to provide a structured synthesis of the technical and scientific studies carried out on the disposal of category B and C waste in a poorly indurated argillaceous formation.
- (2) 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.
- (3) to offer a technical and scientific base for dialogue with all stakeholders in the long-term management of radioactive waste.

The report concludes 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 reinforces confidence in the concept studied and confirms that, for the waste considered, disposal in poorly indurated Clay remains a viable option. By establishing an inter-disciplinary R&D programme that incorporates aspects of social sciences, it will be possible to further enhance confidence in the concept studied. In particular, paying due attention to management alternatives, developing repository designs, allowing for non-radiological environmental effects, and attention to societal aspects will increase confidence. The SAFIR 2 report was evaluated by an NEA peer review in October 2002 and its 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”).

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 (EURIDICE), a European economic interest grouping of which ONDRAF/ NIRAS and SCK•CEN are the founding members.

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 reorganized into five in-situ components including the large-scale heater-test and three on-surface experiences aimed at testing the feasibility of building important elements of the EBS (buffer, overpack, plug, backfill, ...) and verifying and confirming the behaviour and interactions of these elements.

The HADES underground facility and its development is now managed by EIG EURIDICE (European Underground Research Infrastructure for the Disposal of nuclear waste in Clay Environment) of which ONDRAF/ NIRAS and SCK•CEN are the founding members. EIG EURIDICE is now preparing the installation of the heater-test device. Commissioning of the heating test is planned to start in 2014.

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 have been, and are, also involved in many other European projects and international collaborations in order to increase the scientific knowledge and allow collaboration with different experts worldwide.

The R&D team is preparing a first Safety and Feasibility Case, the SFC-1, integrating 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 Clay unit for category B and C waste that will remain safe during hundred thousands of years after closure. If the Waste Plan exercise (see above in Waste management policies) 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 start the siting phase.

Whatever the 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.

RESEARCH AND DEVELOPMENT

ONDRAF/NIRAS

ONDRAF/NIRAS has been assigned the main responsibility for research and development on radioactive waste management and disposal in particular. The research is performed, under the responsibility of ONDRAF/NIRAS, by SCK•CEN, universities and other research institutes, as well as engineering companies.

Most of the R&D work pertains and relates to:

- providing convincing answers to still unresolved scientific questions about studies relating to the surface disposal of category A waste and, specifically, to the questions that will ensue from the study of the Safety Case by the Federal Agency for Nuclear Safety (see more description above under Programmes and projects)

the geological disposal of category B and C waste in Clay (see more description above under Programmes and projects).

SCK•CEN

Beside the R&D programme on geological disposal, SCK•CEN is studying the transmutation of high-level radioactive waste in order to reduce its volume and to shorten its lifetime. This research complements the research on geological disposal of

this type of waste. For this purpose, SCK•CEN is developing a multi-purpose research reactor, called MYRRHA, an accelerator-driven system (ADS) cooled with lead-bismuth. One of the purposes of MYRRHA is to pave the way towards the industrial demonstration of the transmutation of high-level radioactive waste. The Belgian Government decided in 2010 to allocate a budget of 60 M€ to cover the Front-End Engineering Design phase 2010-2014 to validate the technological choices, to obtain a positive pre-licensability statement and to prepare the international consortium.

In 2012, SCK•CEN successfully demonstrated the coupling of a sub-critical reactor to a particle accelerator, as a first step towards the realization of MYRRHA objectives. This world premiere is part of the GUINEVERE project, initiated in collaboration with the French Centre National de la Recherche Scientifique (CNRS), the Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA) and a dozen other European laboratories and the European Commission.

SCK•CEN acquired a large expertise in radioecology, both experimental and theoretical, including impact assessment studies, which is suitable for applications of existing exposure situations (e.g. NORM sites or post-accident), also largely embedded in European frameworks. Monitoring capacities are present for environmental routine monitoring, but also to trace back historical contaminations (airborne, carborne, handheld).

The safeguards issue related to spent fuel management, both during temporary storage situations and for deep repositories, including the potential impact of innovative fuel cycles, are studied.

DECOMMISSIONING AND DISMANTLING POLICIES AND PROJECTS

Programmes regarding the decommissioning of nuclear facilities have been ongoing in Belgium since 1987. They started with R&D and small pilot projects on dismantling and decontamination, with the aim of defining and developing suitable techniques and providing information on their performances and costs.

The first main project involved extensive preparatory work for the decommissioning of the former Eurochemic spent-fuel reprocessing pilot plant. Between 1966 and 1974, the plant was jointly operated by a consortium of 13 European countries but, after final shutdown, responsibility for its decommissioning, and the largest part of the attendant financing, passed solely to the Belgian State. The waste management and decommissioning company Belgoprocess, the subsidiary company of ONDRAF/NIRAS, started developing appropriate dismantling and decontamination techniques that could be used effectively by operators working in protective clothing under rigid conditions, which led to performance under real industrial circumstances.

The conventional demolition of the Eurochemic reprocessing plant will be carried out in three phases. Since 2004, the plant has been divided in an eastern, a western, and a

central part. The demolition of the fully decontaminated eastern part started in June 2008 and was completed in September 2008. During the demolition of the eastern part, decommissioning activities in the remaining and separated building were continued. The demolition of the central part was performed in 2010. Subsequently, the demolition of the western, and smallest part, follows. Demolition of this part should start in 2014.

In 1991, remediation and decommissioning of the former waste management site of the SCK•CEN started with the cleanup of historic waste. This site had become the property of ONDRAF/NIRAS, which also subcontracted the work to its subsidiary Belgoprocess. The industrial scale decommissioning of redundant process and storage facilities began in 1998 and some facilities have now been returned to green field status.

The decommissioning of the BR3 nuclear reactor on the SCK•CEN site in Mol started in 1989. The BR3 reactor was the first pressurized water reactor installed in Western Europe. It was commissioned in 1962 and definitely shut down in 1987. In 1989, the European Commission selected it as a pilot dismantling project within the framework of the European Union's third five-year research programme on the decommissioning of nuclear installations. In addition, several other buildings on the SCK•CEN site, in which physical, chemical and biological nuclear R&D had been carried out, were decontaminated and released from radiological surveillance in 1995-96. They are now used for conventional technological research by the Flemish institute for technological research VITO. The decommissioning activities on the BR3 reactor are expected to be completed in 2020.

Since then, SCK•CEN has accumulated almost 25 years' experience in decommissioning and decontamination (of reactor, hot cells, radioactive contaminated laboratories and "exotic" installations) and is now recognized internationally as leading partner in the field of decommissioning. Its experience is thus in the field of decommissioning licensing files, engineering studies, dismantling and decontamination technology, radioprotection applied to decommissioning and waste & material management.

In 2005, Belgonucleaire decided to close its facility in Dessel. The last production campaign ended on 15 August 2006. During more than 20 years, Belgonucleaire produced MOX fuel for nuclear reactors. Belgonucleaire received the licence for decommissioning the MOX Plant in March 2008. The three main decommissioning service contracts were awarded in March 2009. These contracts cover a period of 5 years, corresponding respectively to one year (2009) for the education and qualification of contractors' staff and operators, three years for the decommissioning of the glove boxes, and one year for the decommissioning of the main infrastructures and the release of the buildings. Decommissioning activities of the Belgonucleaire Plant started in 2009 and are expected to be completed in 2014-2015.

The research reactor Thetis (max. 250 kW) of the University of Ghent was in operation from 1967 until December 2003. The final decommissioning plan was drawn up by SCK•CEN and approved by ONDRAF/NIRAS in 2010. During the same year, the fuel

elements were removed from the reactor core to Belgoprocess (Dessel) for treatment & conditioning (Pamela-facility: cementation of the elements in a 400 l drum). The licence for the decommissioning activities was granted in May 2012 by the Federal Agency for Nuclear Control (FANC) and a team of Belgoprocess started the work at the beginning of 2013, under supervision of SCK•CEN. The decommissioning activities are expected to be completed in 2015 and the end status is to be a 'brown field' (remaining nuclear activities: radiochemistry and nuclear laboratories).

FBFC International, located in Dessel, produces uranium oxide and MOX nuclear fuel elements for nuclear power plants. During the initial phase, FBFC International decided to centralize the activities that were conducted in buildings 1, 2, 3, and 5 inside building 5M, this with the aim to optimize the safety conditions and the management of the nuclear materials present at the site. The idea was to continue operations inside building 5M until 2013 and to stop the operations in building 5 and the remaining installations only at a later date. The licence for decommissioning was issued in December 2010 by Royal Decree and the actual dismantling of building 3 started in September 2011. Building 1, 2, and 3 were scheduled to be fully dismantled by the end of the year 2013. However, in 2011, the Board of Directors of FBFC International decided on the gradual discontinuance of all activities of the plant in Dessel, planning for a full cessation of all operations in 2015. The scenario adopted is that of immediate decommissioning, without, however, proceeding to the restoration of the site to an undeveloped state.

On 1 August 2012, ONDRAF/NIRAS' supervisory authority charged the agency to undertake the remediation and decommissioning operations of the Best Medical Belgium S.A. facilities (Fleurus site), a company that went bankrupt. The Belgian law provides that ONDRAF/NIRAS is charged with the task of undertaking such operations in case of bankruptcy or failure of a nuclear operator.

Following the requests of its supervisory authority, ONDRAF/NIRAS drew up a work plan to take over these facilities in order to remediate and decommission them and submitted an operating licence application on 28 September 2012 to the Federal Agency for Nuclear Control (FANC). The licence granted on 5 October 2012 covers all activities required to restore the safety standards and maintain proper safety levels, to collect the waste, radioactive sources or materials, and to release the materials and the buildings from radiological surveillance. It does not yet include the decommissioning of the facilities, which is to be the target of a specific licence application. This will be covered later by a specific request for authorisation (licence for decommissioning).

ONDRAF/NIRAS took measures to integrate this new nuclear operator role into its management system, recruiting the needed people and adapting its internal organisation structure consequently. The Best Medical Belgium S.A.'s facilities taken over by ONDRAF/NIRAS are now called "ONDRAF - Site Fleurus".

The first priority of the ONDRAF-Fleurus site operational team is to carry on and complete the facilities' safety programme launched in August 2012 by the temporary administrators, and to implement the most urgent remediation tasks.

Waste resulting from these decommissioning projects is processed and conditioned in the same way as wastes resulting from the routine operations of nuclear facilities. During decommissioning, particular importance goes to minimizing the amount of radioactive waste produced. This involves techniques such as decontamination of concrete by removal of the contaminated surface layer and abrasive or chemical decontamination of metal items, so that the bulk of the residual materials may be released from regulatory control and need no longer be treated as radioactive waste.

TRANSPORT

The transport of radioactive substances in Belgium is governed by the Royal Decree of 20 July 2001 which sets out general regulations for the protection of the public, workers, and the environment against the hazards of ionizing radiation. All shipments, by whatever means, must be authorized in advance by the Federal Agency for Nuclear Control, under the supervision of the federal Minister of the Interior. In general, these regulations follow the technical requirements of the IAEA Regulations for the Safe Transport of Radioactive Substances but, for certain types of shipment, the transport licence may specify special conditions, such as the provision of escorts.

Non-conditioned radioactive waste, awaiting processing and conditioning, or conditioned waste, awaiting interim storage, are generally removed from the site where it was generated. Non-conditioned waste is transported to the central processing and conditioning facilities and conditioned waste to the central storage facilities, both on the Belgoprocess site in Dessel. These transport operations are mostly performed by Transnubel and Transrad, who act as subcontractors for ONDRAF/NIRAS. This type of transport is carried out exclusively by road. The type of transport container and vehicle used depends on the nature and radiation level of the radioactive waste. Specially shielded transport containers have been designed for the safe transport of waste packages.

Spent nuclear fuel elements have been transported by road and rail from the Belgian nuclear power plants to the Areva reprocessing plant in La Hague (France). The waste resulting from existing reprocessing contracts is shipped back to Belgium by road and rail using specially designed, shielded transport canisters. On 13 January and 3 April 2007, the last two transports returning vitrified high-level waste resulting from the reprocessing of 631.5 tHM Belgian spent-fuel by Areva (La Hague-France) to Belgium (Belgoprocess-Dessel) were conducted without any problem.

Vitrified medium-level waste (process sludge) and compacted hulls and ends (CSD-C) resulting from the 631,5 tHM Belgian spent fuel reprocessing from Areva and cemented waste resulting from reprocessing of SCK•CEN spent fuel in Dounreay will be returned to Belgium. The destination of all reprocessing waste is the interim storage building 136 on the site of Belgoprocess (see above in Storage of high-level and very high-level waste).

COMPETENT AUTHORITIES

National Organisation for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS)

The organisation and operation of radioactive waste management in Belgium is the responsibility of ONDRAF/NIRAS, a public body created by law and enacted in 1980. The Royal Decree of 30 March 1981 defined its missions and duties. It operates under supervision of the federal Minister in charge of the energy policy. Its mission was 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.

By taking over the management of the facilities of the bankrupt company Best Medical Belgium S.A. for remediation and decommissioning purposes, ONDRAF/NIRAS has become a class II nuclear operator. The organisation will become a class I nuclear operator once the category A waste surface disposal site has been made operational. The international IAEA safety standard GS-R-3 and the Royal Decree of 30 November 2011 stipulate that the requirements be fulfilled by an integrated management system as established within the scope of nuclear activities such as the management of radioactive waste. ONDRAF/NIRAS has started to revise its current management system, which is certified according to the ISO 9001:2008 standard, thus to transform it into an integrated management system in keeping with the requirements mentioned in the documents above.

It is also preparing a national programme in keeping with the requirements of the 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. This directive, which is being translated into Belgian law, establishes a common European framework for the responsible and safe management of spent fuel and radioactive waste.

Federal Agency for Nuclear Control

All nuclear activities in Belgium are subject to the general regulations for the protection of the public, workers, and the environment against the hazards of the ionizing

radiation. This includes the technical activities associated with processing, conditioning and interim storage of radioactive waste, and with the decommissioning of the nuclear facilities at the former Eurochemic pilot reprocessing plant in Dessel and the former Waste Department of SCK•CEN in Mol. Licensing, control, and surveillance under these regulations is the responsibility of the Federal Agency for Nuclear Control (FANC), which was created in 1994 and is supervised by the federal Minister of the Interior. The interface between the responsibilities of FANC and of ONDRAF/NIRAS is controlled by way of a formal protocol agreement. FANC is now preparing new regulations specific for the disposal of radioactive waste.

FINANCING

The law under which ONDRAF/NIRAS was created requires the costs associated with radioactive waste management to be paid by those who produce it. This law also stipulates that the costs of all ONDRAF/NIRAS activities, including applied research and investment, be estimated at cost price and financed by the radioactive waste producers in proportion to their share of the overall volume of radioactive waste generated. Long-term operations, mainly those associated with future radioactive waste disposal, is financed by way of a special fund, the long-term fund (LTF), to which waste producers contribute annually according to the volume and type of radioactive waste they produce.

The same law provides for the creation of an “insolvency fund” aimed to guarantee the necessary financial means for ONDRAF/NIRAS to take over responsibility for radioactive waste management from any waste producer who becomes bankrupt or insolvent. The radioactive waste producers also finance this fund.

The law of 29 December 2011 has established, in addition to the LTF, a second fund, the Medium-term Fund (MTF), which is independent of the former and intended to finance the socio-economic aspects of the category A waste surface disposal project. This Fund disposes of 130 million EUR. The MTF will be funded by an integrated contribution levied at Federal level on the radioactive waste producers. This contribution will be calculated on the basis of the total capacity of the disposal facility, on the one hand, and the total waste quantities produced and intended for the disposal facility, on the other. The Royal Decree of 3 July 2012 determines the modus operandi of both these funds (FLT and FMT).

ONDRAF/NIRAS' activities related to establishing and updating the inventory of nuclear facilities and sites in Belgium are financed by way of licence fees, paid by the owners or operators of these facilities or sites and imposed by Royal Decree of 31 May 2000. Its activities associated with decommissioning the nuclear facilities of the former Eurochemic pilot reprocessing plant in Dessel and the former Waste Department of SCK•CEN in Mol are financed by way of a federal charge on electricity supply, imposed by Royal Decree of 24 March 2003. R&D work on radioactive waste disposal is also

financed by the waste producers, mainly Electrabel, the owner and operator of the nuclear power plants in Doel and Tihange, and Synatom, a private company in charge of the nuclear fuel cycle of the Belgian nuclear power plants. These funding arrangements are agreed to with ONDRAF/NIRAS by way of contracts that span several years.

Decommissioning activities of SCK•CEN are financed by a special liability fund supplied by the Federal Government. Decommissioning activities of site 1 (former EUROCHEMIC plant) and site 2 (former Waste department of SCK•CEN) of Belgoprocess are financed by a federal allowance levied by the Government on the price of electricity charged to consumers.

PUBLIC INFORMATION

The website of ONDRAF/NIRAS contains a new sub-site dedicated to the Waste Plan, plus another one dealing with the category A disposal project. Technical publications deal more specifically with R&D concerning long-term management. ONDRAF/NIRAS also has a radioactive waste information centre, called "Isotopolis", on the Belgoprocess site in Dessel. This centre, recently renovated, is open to the public and intended primarily for secondary school students.

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

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

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 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.

For more information, the websites of the relevant authorities and organisations are listed below.

Government

Federal Public Service Economy, SMEs, Self-Employed and Energy - Brussels

Website: <http://economie.fgov.be>

E-mail: nuclear@economie.fgov.be

Federal Public Service Interior – Brussels

Website; <http://www.ibz.be/>

E-mail: info@ibz.fgov.be

Nuclear Safety Authority

Federal Agency for Nuclear Control (FANC) - Brussels

Website: <http://www.fanc.fgov.be>

E-mail: info@fanc.fgov.be

Waste management organisation

ONDRAF/NIRAS - Brussels

Website: <http://www.nirond.be>

E-mail: webmaster@nirond.be

R&D

SCK•CEN – Mol

Website: <http://www.sckcen.be>

E-mail: info@sckcen.be

Industry

Belgoprocess - Dessel

Website: <http://www.belgoprocess.be>

E-mail: info@belgoprocess.be

EIG Euridice - Mol

Website: <http://www.euridice.be>

E-mail: euridice@sckcen.be

Synatom – Brussels

Website: <http://www.synatom.be>

E-mail: info@synatom.be

Nuclear Forum – Brussels

Website : <http://www.nuclearforum.be>

Communication

Isotopolis - Dessel

Website: <http://www.isotopolis.be>

E-mail: isotopolis@belgoprocess.be