Country Profile Template

Contracting Party: Belgium

<u>Section 1: Summary document detailing</u>

- Relevant national authorities and responsibilities;
- National legislation and basis for regulation;
- Application of BAT/BEP in domestic legislation;
- Dose limit, constraints and discharge limit setting rationale;
- Regulation, surveillance and monitoring;
- Environmental monitoring programmes;
- Radiation dose assessment methods;
- Environmental norms and standards;
- Quality assurance.

1. SUMMARY DETAILING REGULATION, MONITORING, ASSESSMENT, NORMS AND STANDARDS

1.1 Relevant national authorities and responsibilities

All licensing and supervision activities concerning construction and operation of nuclear facilities is carried out by the regulatory authority of the federal state (FANC) with the co-operation of authorized inspection and controlling bodies (Bel V, Controlatom, …). This is also the case for authorisation of radioactive discharges to the environment. FANC is under the authority of the Ministry of Interior.

1.2 National legislation and basis for regulation, including the application and implementation of BAT/BET

The first law concerning protection of the population from ionising radiation dated from March 29th, 1958. The legislation with respect to radiological protection was based on the Royal Decree of February the 28th 1963. After some modifications by the Royal Decrees of May 17th 1966, May 22nd 1967, December 23rd 1970, May 23rd 1972, May 24th 1977, March 12th 1984, August 21st 1985 the legislation was thoroughly adapted by the Royal Decrees of January 16th and February 11th 1987 when the ICRP-26 and 30 (regarding the methodology for calculation internal radiation dose) were taken into account. Other modifications were made by the Royal Decrees of February 12th and September 6th 1991, June 17th 1992, September 7th 1993, October 2nd 1997 and May 3rd 1999.

The Federal Agency for Nuclear Control (FANC) was established by law of April 15th 1994 and according to its position it has a great independency, necessary to take up his responsibility to the society in an impartial way. It is led by a board of directors and the daily management is observed by a General-Director.

A new legislation was created by the Royal Decree of July 20th 2001 *(General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation - GRPIR*), which was necessary to harmonise the Belgian legislation with the European Directives (that take into account some recommendations of the ICRP-60). This Royal Decree attributes to the FANC the objectives of "protection of the population, workers and the environment against the dangers of ionising radiation" that consist to:

- propose, apply and improve law and regulations;
- control human (and non-human) activities responsible for exposure of man to radioactivity;
- ensure the surveillance of radioactivity on the territory (telerad automatic network - Radiological Surveillance Monitoring programme);
- co-operation to nuclear emergency plans;
- distribute neutral and objective information.

Law of August 5th, 2006 that gives right to the public in accessing information with regard to the environment, which transposes the EU directive 2003/4/CE of the European Parliament and council of January 28th, 2003 regarding the public access to information related to the environment, led to the diffusion of a note from the Belgian Safety Authority that regulates the periodical reporting of radioactive releases from nuclear installations (see §2.9).

Basis for national legislation/regulation:

The Belgian policy is based on EC Directives, on international conventions and on recommendations of appropriate international bodies like the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA). The major principles in these regulations are:

- justification of exposure: exposure to radiation is only allowed if the advantage is larger than the possible risk and damage of the exposure;
- optimisation: known as the ALARA-principle (As Low As Reasonably Achievable), exposure has to be as low as possible, taking social and economic factors into account;
- dose limits: exposure of individuals as result of the combination of different exposures, has to be subject to limits to prevent unacceptable risks.

1.3 Dose limit and constraints

The limits, which are given by the Belgian regulation *General Regulations for the Protection of the population, workers and the environment against the dangers of Ionising Radiation* (GRPIR), are the following.

Dose	Public art. 20.1.4	Workers art. 20.1.3	apprentices and students ≥ 18 years art. 20.1.5	 16≤ <18 years art. 20.1.5
Effective (whole body)	1 mSv/a	20 mSv/a *	20 mSv/a *	6 mSv/a
Equivalent for any individual organ or tissue	-	500 mSv/a *	500 mSv/a *	-
Equivalent for lens of the eye	15 mSv/a	20 mSv/a *	20 mSv/a *	15 mSv/a
Equivalent for skin **	50 mSv/a	500 mSv/a *	500 mSv/a *	150 mSv/a
Equivalent for hands, arms, feet and ankles	-	500 mSv/a *	500 mSv/a *	150 mSv/a

* for 12 consecutive months.

** average dose for each area of 1 cm^2 of skin

Remark: the above limits do not take into account medical exposure

Nuclear installations apply for their workers a dose constraint of 10 mSv/a.

1.4 Discharge limits

The annual limits for discharges and emissions are specified for a nuclear facility in such a way that the resulting doses to the population shall not exceed 1 mSv per year for all pathways combined (art. 20 of the Royal Decree of July 20th 2001).

The Royal Decree introduces also a notion of dose constraint (optimisation principle-ALARA): the discharge limits have to be based on a fraction of the public annual limit of 1 mSv. Dose constraints have been discussed with the FANC: the following table shows the dose constraint used by the nuclear sites.

	Dose constraint (mSv/a)			Evaluation of real committed dose (average over the last 10 years) (mSv/a)		
	Atmospheric discharge	Liquid discharges	Total	Atmospheric discharge	Liquid discharges	Total**
Belgoprocess (Site of Mol)	0.3	0.25	0.55	$9\ 10^{-3}$	$4\ 10^{-5}$	$9\ 10^{-3}$
NPP Tihange	0.185	0.081	0.22	$46.5\ 10^{-3}$	$2.17\ 10^{-3}$	$48.7\ 10^{-3}$
NPP Doel	0.17	0.23*	0.36	$19.1\ 10^{-3}$	$8.84\ 10^{-4}$	$19.7\ 10^{-3}$

* take into account a specific critical group

** maximum dose does not necessary correspond to the sum of doses due to atmospheric or liquid releases: the critical individual, even localised at the same place, is not always in the same age category

The model used to estimate the radiation exposure for a critical group caused by radioactive effluents of nuclear power plants was based on the NUclear REgulatory Guide (NUREG) 1.109 rev. 1, USNRC. Some conservative adaptations have been made by taking into account:

- Dose conversion factors (RD of July 20th 2001) based on the icrp 72;
- 6 classes of age (RD of July 20th 2001) : ≤ 1y, 1-2y, 2-7y, 7-12y, 12-17y and > 17y;
- Eventual adaptation of some parameters (e.g. consumption habit,…).

The dose is calculated at the most unfavourable receiving points, taking into account the relevant exposure pathways and living habits, e.g. the consumption rates of different foodstuffs. On the basis of these assumptions and parameters used in the models, the radiation exposure to individuals cannot be underestimated.

1.5 Regulation, surveillance and monitoring

Under the Royal Decree, the Federal Agency for Nuclear Control (FANC) is charged in particular with *monitoring the radioactivity of the territory and the doses received by the population* (Article 70) as well as organising the *monitoring of the population as a whole* (Article 71). It should also be noted that the Franco-Belgian co-operation agreement of September 8th 1998, relates to the Chooz nuclear power station situated on the Meuse in France close to the border with Belgium. This agreement ensures the full monitoring on Belgian territory of all radioactivity transfers around the nuclear site as well as the periodic exchange of results between states.

The Agency reviews its entire sampling and measurement programme each 4-years in order to stay harmonised with international requirements such as EURATOM.

Finally, the OSPAR Convention (OSlo-PARis Convention, 1998 – ratified by Belgium) on the protection of the marine environment of the North Sea and North-East Atlantic makes the development of monitoring and research programmes concerning the impact of radioactive discharges on the marine environment mandatory.

The nuclear installations are inspected several times each year by the federal authorities (FANC and authorised inspection and controlling bodies). The environmental monitoring programme is undertaken by special authorised laboratories under the co-ordination and the responsibility of the federal authority (FANC). Laboratories undertake analyses in accordance with internal Quality Control procedures also involving regular calibration of detectors and yearly comparison exercises. Therefore, the quality of environmental and discharge sample measurements, and the assessment of impact of discharges and emissions on members of the general public, is based on an independent national system of governmental bodies and experts.

Results of discharge measurements performed by operators are reported monthly to the federal authority (FANC) according the requirements of the EU recommendation 2004/2/Euratom and are available through annual reports on the FANC website.

Results obtained from the radiological surveillance programme of the territory (including TELERAD, food chain, nuclear sites discharges, NORM and legacy sites…) are also annually published on this website.

Furthermore, Belgium reports discharge data from nuclear installations annually to EURATOM (art. 35&36 of the treaty), to the OSPAR secretariat and hourly the dose rate data from the TELERAD network to the European Commission (EURDEP).

1.6 Environmental monitoring programmes

The programme for the radiological monitoring of the territory comprehends several domains.

It relies on about 4,350 samples annually, which are subjected to almost 20,500 alpha, beta and gamma radioactivity analyses. This radiological monitoring programme includes radioactivity measurements carried out in:

- the Meuse and Sambre basins;
- the Scheldt and Nete basins;
- the marine zone;
- a reference zone (Brussels Capital region).

For the major parts of the biosphere (air, soil, water and biocenosis) as well as in the main constituents of the food chain, supplemented by the follow-up of the atmospheric and liquid discharges of the main nuclear sites and through dose rate measurements around these facilities.

The discharges and environmental impact of some NORM and legacy sites are also monitored. This monitoring occurs either periodically or in the framework of a specific measurements campaign. These NORM sites belong to the phosphate and to the titanium dioxide production sectors. An environmental follow up of a legacy site related to a former radium extraction facility is also performed.

Wastes releases from hospitals are also (ad hoc) controlled in sewage purification plants by using submersible automatic gamma spectrometry probes. The goal is to qualify and quantify if possible the radioactivity that enters the environment at the outlet of the sewage plants. The in situ controls of the hospital practices conducted by nuclear inspectors will be also linked with the obtained results. The final aim being to minimize the radioactivity levels of the hospital releases.

1.6.1 Monitoring environmental impact of radionuclides water, sediment and fish

Several (fixed) sampling points have been chosen off the Belgian coast where sampling of sea water, sediments and fish living on the bottom is organised 4 times a year by the oceanographic vessel, the "Belgica" (photo on the right taken from the site of the North Sea Mathematical Model Management Unit). Sixteen samplings are carried out in a belt of 5 to 25 km offshore from the towns of Coxyde, Newport, Ostend and Blankenberge (one point is located 37 km directly below Wenduine near Blankenberge).

The measurements taken relate to monitoring the levels of alpha, beta and gamma emitting radioactive nuclides, as well as ^{40}K as far as natural radioactivity is concerned.

On the coast, because of their accumulation and concentration capacity, samples are essentially taken of seaweed, fish, molluscs and crustaceans to measure the main fission and activation products as well as Th, Pu and U.

The compartments monitored are:

- Atmosphere compartment: dust samples from the air (filters) near Coxyde;
- Land compartment: taking of soil samples (meadows) near Coxyde;
- Marine compartment: water sediments and samples of fauna (crustaceans, bivalves, fish) and flora (seaweed).

Samples of algae (Fucus vesiculosus) are taken on a pier in Ostend, shrimps (*Crangon sp.*) and mussels (*Mytilus edulis*) are also sampled.

Samples of sea water are taken with the help of "Niskin" bottles.

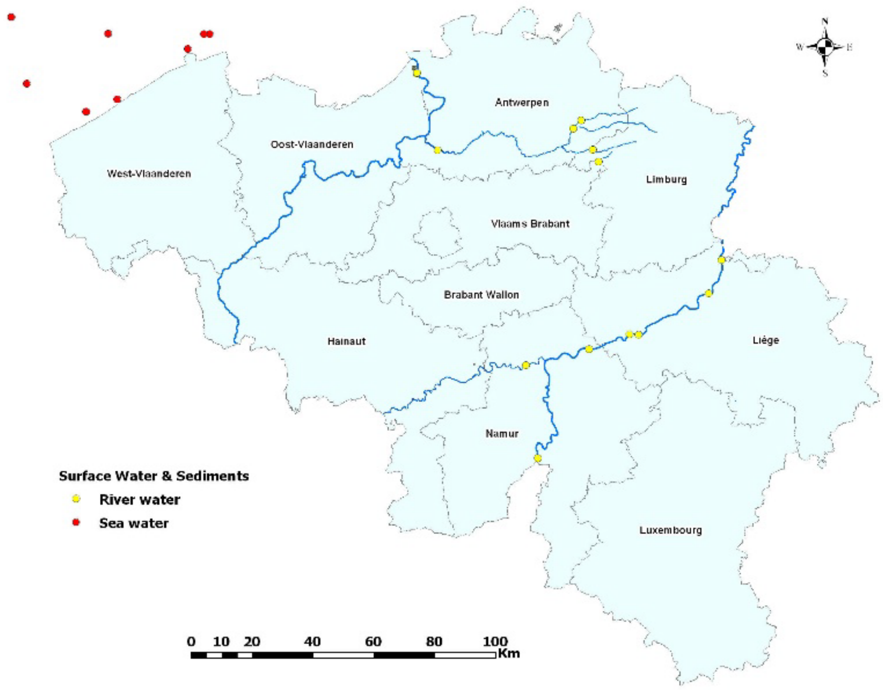
The sediments are brought to the surface using a "Van Veen" scoop (photo on the left), a sort of grapnel with an open jaw lowered to the sea bottom at the end of a steel cable.

As soon as the jaws touch the bottom, the spring which keeps the jaws open is released. Before returning to the surface, the jaws close and trap a quantity of sand or sediment from the sea bed.

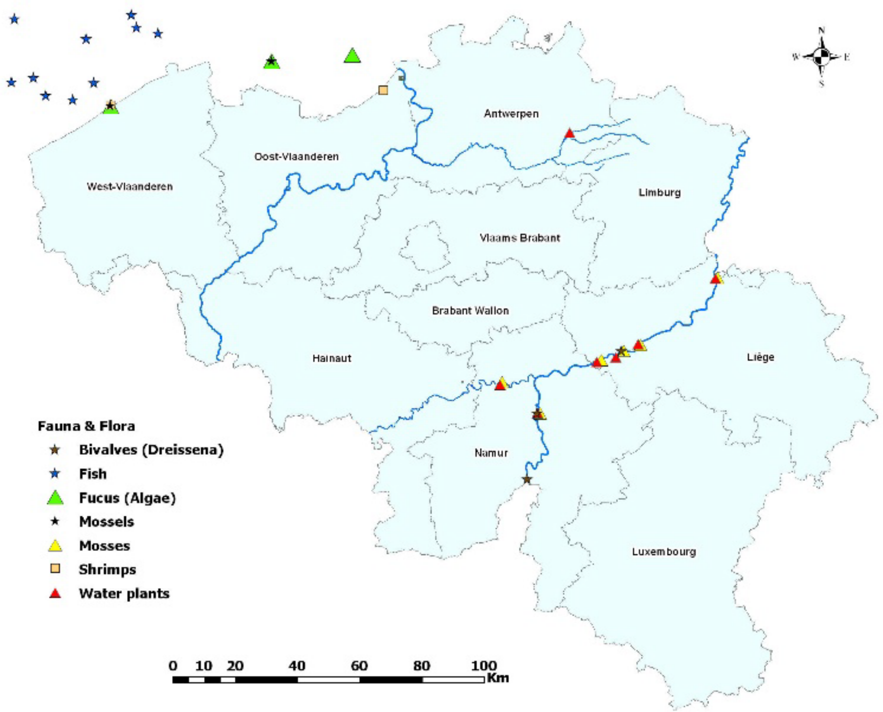
Samples of the fauna (fish) are collected for subsequent radioactivity analyses using a trawl net (photos to the right).

1.6.2 Frequency of sampling, organisms and or other types of environmental samples considered

Monitoring <u>surface water</u> and <u>sediments</u> in fresh – rivers (Sambre, Meuse, Grote Laak, Winterbeek, Grote Nete, Molse Nete and Scheldt) and marine water – North Sea;



Monitoring the <u>living environment</u> by searching for radioactivity in fauna in fresh and salt water (molluscs from fresh and salt water, shrimps and fishes) and in flora in fresh water (aquatic plants and mosses) and seawater (algae) who are <u>bio-indicators</u> of the presence of radioactivity;



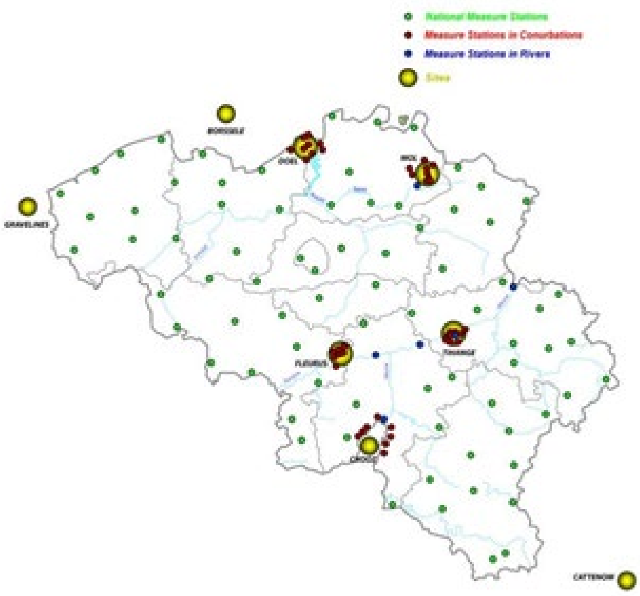
Radiological monitoring programme for the maritime zone (North Sea and Scheldt estuary)

Zone		Location of sampling points	Type of measurement	Frequency of sampling
North Sea	water	off the coast (Belgica campaign), 16 locations	Spectrometry γ: $^{134-137}Cs$, $^{57-58-60}Co$, ^{54}Mn ^{40}K Spectrometry β total & α total Spectrometry α: $^{238-(239+240)}Pu$	quarterly
	sediments	off the coast (Belgica campaign), 16 locations	Spectrometry γ: ^{7}Be, $^{134-137}Cs$, $^{(57)-58-60}Co$, ^{54}Mn, ^{65}Zn, ^{110m}Ag, ^{40}K, $^{226-228}Ra$, ^{228}Th Spectrometry α: $^{238-(239+240)}Pu$	quarterly
	seaweeds	Ostende – Belgian coast	Spectrometry γ: ^{7}Be, $^{134-137}Cs$, $^{(57)-58-60}Co$, ^{54}Mn, ^{65}Zn, ^{110m}Ag, ^{40}K, $^{226-228}Ra$, ^{228}Th ^{90}Sr, $^{238-(239+240)}Pu$, ^{241}Am, ^{3}H organic, ^{99}Tc	quarterly
	mussels & shrimps	Ostende – Belgian coast	Spectrometry γ: ^{7}Be, $^{134-137}Cs$, $^{(57)-58-60}Co$, ^{54}Mn, ^{65}Zn, ^{110m}Ag, ^{40}K, $^{226-228}Ra$, ^{228}Th ^{90}Sr, $^{238-(239+240)}Pu$, ^{241}Am, ^{3}H organic	quarterly
	fish	off the coast (Belgica campaign), 16 locations	Spectrometry γ: ^{7}Be, $^{134-137}Cs$, $^{(57)-58-60}Co$, ^{54}Mn, ^{65}Zn, ^{110m}Ag, ^{40}K, $^{226-228}Ra$, ^{228}Th ^{90}Sr, $^{238-(239+240)}Pu$, ^{241}Am, ^{3}H organic, ^{99}Tc	quarterly
Scheldt	shrimps bivalves, seaweeds	estuary downstream from Doel (Kieldrecht) estuary/North Sea (Hoofdplaat & Kloosterzande)	Spectrometry γ: ^{7}Be, $^{134-137}Cs$, $^{(57)-58-60}Co$, ^{54}Mn, ^{65}Zn, ^{110m}Ag, ^{40}K, $^{226-228}Ra$, ^{228}Th ^{90}Sr, $^{238-(239+240)}Pu$, ^{241}Am, ^{3}H organic, (^{99}Tc for seaweed)	quarterly

1.6.3 TELERAD network

The TELERAD network - automatic remote radioactivity measuring network in Belgium - has been modernised in 2010. The network comprises about 250 stations, which constantly measure the radioactivity of the ambient air and river waters. The stations are distributed throughout the entire country for nationwide monitoring, in rings around the nuclear sites at Tihange, Doel, Mol, Fleurus and Chooz to monitor the installations, as well as in the urban areas close to these installations (~ 5 km).

In addition, in ad hoc selected sewage purification plants the radioactivity of waters are controlled in situ with automatic (submerged) gamma spectrometry probes.



The modernisation comprised the replacement of all stations by stations with a new generation of modern data communication links. To improve the nuclear sites surveillance, the ring stations (situated around the sites on the fence) have been equipped with a gamma spectrometry detectors to assure a quick identification of nuclides present in the ambient air. In addition, existing river stations are also modified and are now equipped with a gamma spectrometry detectors with identification of present nuclides. Finally, new automatic gamma spectrometry probes are implemented upstream and downstream of the Doel NPP on the Scheldt river. The surveillance of the aquatic releases from NPPs are now directly done by automatic gamma spectrometry probes placed at the outlet of the release channels of the NPPs (Tihange and Doel).

In 2019 an optimisation has been carried out: 50% of the spectrometry stations located around the fence of the nuclear power plants, have been moved to the urban area. The ambient dose rate stations who were replaced by these spectrometry detectors in these urban areas made the other way. This gives the advantage of having online spectrometric information on atmospheric releases in a larger area to about 5 km around each NPP.

All stations are linked to a centralised system that is automatically alerted when detecting any abnormal rise in radioactivity levels or a nuclide is detected above a preset threshold on the ring stations. The central systems has a full redundant set-up at a disaster recovery site.

The TELERAD network is a measuring and early warning network and, as such, pursues the following two major objectives:

- The continuous recording of measurements to provide all necessary statistical information on the level of radiation found in the country;
- The setting off, without delay, of an alarm to signal the exceeding of a warning threshold.

TELERAD is thus an alarm network that enables the real-time detection of any abnormal situation, which may lead at its highest level of severity to the launching of the Emergency Plan for Nuclear Risks.

In the event of a nuclear accident, TELERAD will play an important role in the taking of decisions, optimising interventions and countermeasures implemented by the relevant authorities as well as keeping the country's citizens informed on an ongoing basis.

The measuring stations used in the TELERAD network for measuring radioactivity in the air are of four types:

The **dosimetry stations** for measuring the ambient gamma radioactivity, of which there are around 160 on the territory (including those around the boot of Givet for monitoring the Chooz nuclear site).

Each measuring station is equipped with a rain detector which provides information about the presence and duration of rainy periods. Following photographs show a station in the environment with a view on its electronics.

Gamma spectrometry stations (about 65) for measuring the ambient gamma radioactivity and the gamma radioactivity of certain radionuclides (10 predefined nuclides), are distributed on the fences around all nuclear sites and in the agglomerations (~ 5 km around the site) of the Nuclear powerplants Doel and Tihange. Photographs show a station in its environment.

Three spectrometric stations have been added around the BELGOPROCESS site in 2018. These stations have the particularity of being powered by solar panels and can be moved by means of a trailer.

The **aerosol stations** (ZnS detector), of which there are 7 for measuring the radioactivity of dusts suspended in the air (aerosols and fine particles), which determine the total alpha and total beta radioactivity.

The photograph on the left shows the alpha/beta measuring unit with a view of the unreeling filter tape which collects the dusts and particles impacted when the air is pumped.

These stations are supplemented by a unit measuring radioactive iodine on the aerosols and the air particles when a pre-determined threshold of beta radioactivity is exceeded (7 units in total coupled with alpha/beta measurement). The photograph on the right shows the detector in its casing (cylinder) and the parallelepipedal tube containing the active charcoal cartridges (on the right).

If the warning thresholds are exceeded, active carbon cartridges, intended to trap the radioactive iodine, are automatically measured after pumping the outside air in order to determine the level of radioactivity.

TELERAD also has 12 **river stations** which continuously measure the gamma radioactivity of river waters. These stations are of two types:

Retrofit : this type of station (6) is installed close to the three rivers receiving discharges from nuclear sites and waste water from major urban centres (combining research centres, universities and hospitals): the Meuse, the Sambre and the Nete.

These stations are large containers from which two inlet and outlet pipes allow river water to be pumped to the detector and returned after radioactivity has been measured – photograph on the right.

On the far left of the photograph, a programmable automatic sampler (Buhler type PP MOS) enables water to be pumped into flasks for gamma, alpha and beta spectrometry (for the programme for the radiological monitoring of the territory).

Inside is the gamma spectrometry unit housed in its own tank, surrounded by a strong lead screen protected by a stainless steel casing in which the water pumped from the river enters and leaves – photograph on the left. Ten radionuclides are defined in the recognition software.

The photograph here below shows the inside of the PP MOS with the pumping instruments in its upper section and all the 2.9-litre flasks (12 in all) at the bottom base.

This fully programmable unit enables pre-determined volumes of water to be collected over a fixed time period and frequency.

Above the PP MOS are the counting unit and the high voltage supply of the river station detector.

To the left of the gamma spectrometry unit is a large volume water sampler (SwedMeter type) which enables a sample of the water in the pipe to be taken automatically as soon as an alarm level is exceeded. This water is stored in a 25-litre flask for the purpose of subsequent gamma (and beta) spectrometry analyses in the laboratory.

BCI : these stations have their probe directly immersed in river water. They are two in number located in the Scheldt downstream and upstream of the Doel nuclear power plant.

TELERAD also has 6 stations (BCI) in the release channels of the nuclear power plants which continuously measure the gamma radioactivity of the releases: one in the release channel and one upstream/downstream of the nuclear power plant of Doel and three in the release channels of the nuclear power plant of Tihange. These stations allow to monitor the liquid discharges from the electricity producers with close attention.

Ten radionuclides are defined in the recognition software.

1.7 Radiation dose assessment methods

1.7.1 Nuclear Power Stations : Tihange and Doel

For both nuclear power stations, calculations made for liquid and atmospheric discharges under conservative assumptions show that the maximum effective doses to the population in the vicinity of the NPP's are well below the national limits of 1 mSv/y (maximum limit including all atmospheric and liquid contributions).

The model used to estimate the radiation exposure for a critical group caused by radioactive effluents of nuclear power plants is based on the NUclear REgulatory Guide (NUREG) 1.109 rev. 1, USNRC. Some conservative adaptations have been made by taking into account:

- Dose conversion factors (RD of July 20th 2001) based on the ICRP 72;
- 6 classes of age (RD of July 20th 2001) : ≤ 1y, 1-2y, 2-7y, 7-12y, 12-17y and > 17y;
- Eventual adaptation of some parameters (e.g. consumption habit,…).

Following the calculation of the radiological consequences in the EURATOM Article 37 Dossier, the principle of the "most vulnerable person" is implemented for all calculations; this most vulnerable person is part of different critical groups (by age category) in order to determine which individual in a specific age category is the most vulnerable. It means a person located at the place with the highest radionuclides concentration resulting from the dispersion of the releases in the air. Similar conservative assumptions are considered for the liquid releases. Information on nearby population was gathered for the Article 37 dossier.

The assumption of the most exposed person is conservative as regards exposure to releases (= exposed continuously at the point of maximum exposure). Critical person is an extremely pessimistic situation: it is a person living permanently near the nuclear power plant, eating food exclusively produced around the plant, swimming and practicing water sports in the river who's receiving these liquid discharges. Different age classes are taking into account : baby, child (1-2 years, 2-7 years, 7-12 years), teenager, adult.

Local meteorological conditions are taken into account in the meteorological model (Art. 37 §3.4.1) that was developed in the years 1968-1971 for the plant licensing studies.

Local habits were taken into account by age category (as defined in NUREG 1.109 and applicable ICRP publications) in the definition of the exposure pathways that are locally significant. Conservative assumptions are taken into account (such as no dilution of the liquid releases in the river, use of underground water coming from undiluted water from the river with a transfer period of 82 days…).

This approach is consistent with the US 10CFR50 which is an important regulatory basis for the Belgian NPPs.

Exposure pathway(s) considered

Total dose to the most vulnerable person is calculated for atmospheric and liquid pathways.

Dose from atmospheric releases:

- direct exposure to the noble gas cloud;
- contamination due to iodine releases, aerosols, gaseous tritium and C-14:
    - air inhalation;
    - body exposure to deposition on the surface/ground;
    - contamination by ingestion of contaminated food (milk, meat, vegetables, fresh vegetables).

Dose due to liquid effluent discharges:

- By ingestion:
    - drinking water;
    - fish;
    - aquatic food other than fish;
    - milk and meat from contaminated domestic animals by water watering;
    - Food contaminated by irrigation water.
- external irradiation:
    - swimming;
    - water sports;
    - professional navigation;
    - stay on the banks;
    - stay on dredging sludge/mud.

In 2002, a re-evaluation of the dose calculation was made, taking into account new parameters (e.g. new dose conversion factors, respiration rate, etc.) by the applicable ICRP publications. This document takes into account 6 age categories (instead of the 4 age categories used in NUREG 1.109[1]). The re-evaluation of the dose calculation was made in the framework of Council Directive 96/29/Euratom of the European Commission.

In the framework of the PSR, an actualisation of the impact study for radiological consequences is performed every ten years.

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[1] Calculation of annual doses to man from routine releases of reactor effluents for the purpose of evaluating compliance with 10 CFR part 50, Appendix I, Regulatory Guide 1.109 rev.1, USNRC-October 1977.

Quality assurance of processes involved in dose estimates

Quality Assurance is made of several steps:

- At the time of dose estimation, the applicable referential is assessed, meaning that up-to-date reference documents (regulatory, standards and guides) are used; a regulatory watch is conducted on legislative texts, regulations, standards and guides and their impact on the dose assessment process is checked regularly;
- Dose estimates are made by use of internationally approved methods (US Regulatory Guides, ICRP publications…). The ensuing calculation results are then compared for consistency with expert judgement and results on similar contexts;
- Use of a Quality Management System based on ISO-9001 for the overall process.

Dose estimates are produced every year for the actual routine releases and averaged on the last 10 years period. This is based among others on the NUREG 1.109 and applicable ICRP publications.

In the framework of the Periodic Safety Review, an actualisation of the dose estimation for routine releases has been done using state of the art modelling tools together with recent meteorological data and actualised local habits.

Similarly, dose estimates are reviewed at the light of recent knowledge in accident conditions. This process is driven by both the Corporate Nuclear Safety Department of the operator and the Safety Authorities.

1.7.2 Radioactive waste treatment facilities: Belgoprocess

For Belgoprocess nuclear site: adult, water pathway is calculated by a new model from the SCK•CEN (since 2020, previously by NRPB 231 from 1990 to 2019) and air pathway calculated by IMPACT (since 2019, previously by NUREG 1.109, DCF ICRP-72 from 2002 to 2019).

Model liquid discharge

Based on a mathematical model developed by NRPB (National Radiological Protection Board, before 2020) and on a new model developed by the SCK•CEN (since 2020). The doses calculated are the sum of the effective dose equivalent due to external radiation received in a year and the committed effective dose equivalent due to intakes of radionuclides in the same year.

The comparison of the results for the two models are summarized below:

Dosis calculated with…	2017	2018	2019
NRPB model	0.031 µSv	0.025 µSv	0.046 µSv
revised SCK•CEN model	0.759 µSv	0.544 µSv	0.862 µSv

These doses are insignificantly lower compared to the legal dose limit that a person of the public may incur as a result of operating a nuclear installation of 1 mSv on an annual basis and a dose limitation of 0.25 mSv/year.

The calculated doses according to the SCK model for the same discharge quantities are roughly a factor of 20 higher than those calculated with the NRPB model. This is mainly due to consumption of contaminated fish from the Molse Nete in the SCK model (21 kg of fish per year). This way of exposure was not considered in the NRPB model (no fish), where the dose is mainly caused by external radiation on the riverside and the ingestion of leafy vegetables, root crops and cow's milk.

Model atmospheric discharge

Since 2019 the model used for the calculations is IMPACT (Immission Prognosis Air Concentration Tool), successor of IFDM (Immission Frequenty Distribution Model) with updated meteo files. Those models calculate the dispersion of a pollution with a bi Gaussian dispersion model based.

The comparison of the results for the two models are summarized below:

Dosis calculated with…	**2018**	**2019**
IFDM	8 µSv	12 µSv
IMPACT	12 µSv	12 µSv

These doses are of the same order of magnitude and are insignificantly lower compared to the legal dose limit that a person of the public may incur as a result of operating a nuclear installation of 1 mSv on an annual basis and a dose limitation of 0.3 mSv/year.

Dose impact of liquid waste discharge

Two categories of potentially exposed people are considered in the assessment from SCK. The first is an extremely exposed population, consisting of a farmer/gardener's family whose diet consists 100% of local food (including fish and river water as drinking water) contaminated with radionuclides and who spends time on the riversides of the Molse Nete.

The second population group is an average exposed population group and is also composed of a farmer/gardener's family. The identification of this population is based on current river use and agricultural practices. It is assumed that 10% of the food consumed by this group (including fish) is radioactive. The use of the river water for human consumption is not considered, but the use for watering animals is. The time spent on contaminated fields by an individual of this average exposed population group is also lower than for the extremely exposed group. The individuals of this group are more close to the current radiation burden of the local population as a result of the discharges into the Molse Nete, although the assumptions regarding human living habits are still conservative.

Within the two categories of people six age groups are considered (0-1 year, 1-2 year, 2-7 year, 7-12 year, 12-17 year, >17 year).

Dose impact atmospheric

The calculation method based on the IMPACT model uses 6 age groups of exposed people with age distribution from baby to adults. Reference is the NUREG 1.109. IMPACT is the successor of IFDM met updated meteo files. IFDM uses meteorological data for the SCK mast in Mol for the years 1989 while IMPACT uses reference meteorological conditions from the RMI meteo-station of the year 2012.

Dose conversion factors and the 6 age groups are included in the national legislation "*General regulations for the protection of the population, workers and the environment against the dangers of ionising radiation (GRPIR)*".

Exposure pathway(s) considered

Exposure pathway liquid discharge

The calculated dose is based on a calculation model from SCK for the representative local people near the river Molse Nete.

It consists of 24 exposure pathways from which 22 have to do with internal contamination due to inhalation of contaminated dust particles and the ingestion of food that possibly could have come in contact with water from the river, the other 2 pathways comprise the direct external radiation from the waste water and the sediment of the river. It is assumed that the mean exposed group near the river spends 500 h/year near the riverside, spends 500 h/year in fields and meadows which may have been contaminated by irrigation with river water. It is also assumed that 10% of his food comes from plants and animals in the immediate vicinity of the river.

Exposure pathway atmospheric discharge

Exposure pathways are inhalation, ingestion and external exposure.

The most critical person is an adult who stays permanently near the fence of the site border. Additionally this person consumes vegetables, meat and milk from cows near the site border.

Quality assurance of processes involved in dose estimates

The processes involved in dose assessment comply with the ISO 9001 quality standards and as part of the integrated certification management system ISO 14001, ISO 9001, OHSAS 18001 and ISO 17025 (lab). That is to say that they are traceable and subject to verifications conducted by independent Q&A organisms.

1.8 Environmental norms and standards

The art. 34 of the Royal Decree of July 20th 2001 defines that liquid discharges in surface waters or sewer canalisations are forbidden when concentration in radionuclides, expressed in Bq/litre, exceeds one thousandth of the annual limit of intake by ingestion for an adult (annexe III D of the RD).

1.9 Quality assurance

The nuclear installations are inspected several times each year by the federal authorities (FANC and authorised inspection and controlling bodies).

The environmental monitoring programme is undertaken by special authorised laboratories under the co-ordination and the responsibility of the federal authority (FANC). Laboratories undertake analyses in accordance with internal Quality Control procedures also involving regular calibration of detectors and yearly comparison exercises. The selected laboratories must meet a series of standards such as:

- ISO/IEC 17025: General requirements for the competence of testing and calibration
- ISO 11929: Determination of the characteristic limits (decision threshold, detection limit and limits of the coverage interval) for measurements of ionizing radiation)
- ISO 5667: Water quality - Sampling - Preservation and handling of water samples.
- ISO 18589: Measurement of radioactivity in the environment - Soil - Sampling strategy, sampling and pre-treatment of samples.

- Determination of uncertainties on sampling based on scientific fundamental methods such as EURACHEM / CITAC Guides

Therefore, the quality of environmental and discharge sample measurements, and the assessment of impact of discharges and emissions on members of the general public, is based on an independent national system of governmental bodies and experts.

The different nuclear sites have to meet certain minimal quality assurance requirements. The QA is based upon General Safety Requirements and recommendations published by the IAEA e.g. GS-R-3 (nuclear safety) and WANO (World Association of Nuclear Operators). The integrated management systems are accordance with the international standards such as ISO-9001 (quality), ISO-14001 (environment), ISO-45001 / OHSAS-18001 (safety) and ISO-17025 (lab).

All liquid waste management and treatments are audited according to EMAS (Eco-Management and Audit Scheme) and ISO 14001 certifications.

Section 2: Nuclear Power Plants

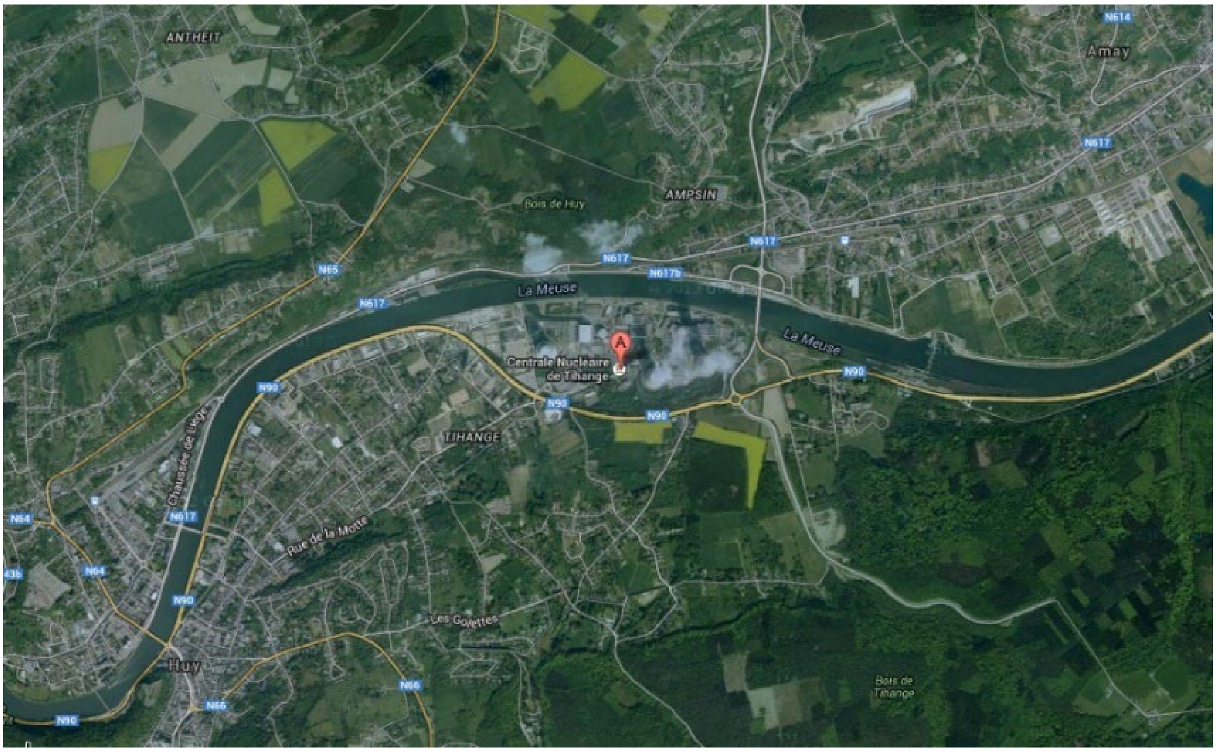
- Name of nuclear facility
- Location of nuclear power plant(s)
- Year for commissioning/licensing/decommissioning
- Receiving waters and catchment area
- Other voluntary relevant information that does not tend to change.

2 NUCLEAR POWER PLANTS

2.1 Tihange Nuclear Power Plant

2.1.2 Location

The site containing 3 PWR is situated on the right Meuse river side near of Huy and Tihange cities.



2.1.3 Year for commissioning/licensing/ planned decommissioning[2]

Tihange 1 : 1975/2015 => 2025;

Tihange 2 : 1983/2023;

Tihange 3 : 1985/2025.

2.1.4 Receiving waters and catchment area

Meuse river.

[2] According to the Belgian law on nuclear phase-out from 2003

2.1.5 Other voluntary relevant information that does not to change

2.1.5.1 System(s) in place to reduce, prevent or eliminate liquid discharges of radioactive substances

Origin: there are 3 reactors and for each reactor building there are 2 main categories of liquid wastes:

- Recyclable waste waters (primary waters known as hydrogenous waters) and;
- Non-recyclable waste waters (aerated primary water, drain floors, laundry, chemical such as lab decontamination components, resins regeneration solutions, and so on …).

Treatment:

- Ion-exchange resins, filtration, degassing and evaporation of waste waters (in degassers and evaporators, the tritium remains in the condensed distillate and released as a tritiated water).
- The concentrate phase is treated as solid waste according to ONDRAF/NIRAS[3] procedures.

Waste management:

Recycle effluents

- Are collected in their respective units (Tihange 1, 2 or 3) and then pumped to unit 2 where they are filtered (1 or 5 µm filters), demineralised (anionic, cationic and mixed bed resins), degassed (fission gas and hydrogen) and evaporated.
- The distillate (boric acid solution) is recovered, the distillate (containing tritium) is sent to one of the available RAR tanks (storage tanks before release to river, two tanks /unit).

Non-recyclable effluents

- Are identically collected in their respective units and are also pumped to unit 2. If the radioactivity is low, treatment will be conducted by filtration. If the radioactivity is higher, the effluents will be treated by evaporation only.
- The distillate (evaporation) is treated as a low level activity effluent, analysed and repumped to one of the available RAR tanks (storage tanks before release to river, 2 tanks/unit).
- In either case, solid residues (concentrate or filter) are treated as solid waste according to ONDRAF/NIRAS procedures.

All effluents from the RAR are analysed both chemically and radio-chemically prior to their release. In order to dilute the effluents, they are mixed first with waters from raw water cooling system before being released to the Meuse river. All the radioactive liquid releases into the river are under the approval of a Health Physician from the NPP .

In 2009, Tihange NPP decided to lower the limit for treatment of liquid effluents at ~1 MBq/m³ (gross gamma counting).

[3] National Agency for Radioactive Waste and enriched Fissile Material.

2.1.5.2 Systems abatement efficiency

Abatement systems and management:

Abatement system/ Management	Into operation (Year)		Efficiency of abatement system		Comments
	Existing	Planned	Decontamination Factor	Other measure of efficiency	
Discharges:					
delay tank(s**)** **Liquid** : storage tanks prior to release in the river Meuse) 2tanks /reactor **Gas** : on each unit , several gas tanks of different capacities and design pressures	**Liquid** **Ti 1**: 1986 **Ti 2**:1982 **Ti 3:** 1985 **Gas**: **Ti 1** 1975 (part of original design) and ca.1980 (two additional tanks) **Ti2 and Ti3:** part of original design of the plants		**Liquid** :See Ion exchange for typical figure **Gas** : delay policy is used on a regular basis in order to avoid short lived gas species releases (Xe-133) . gas release are mandatory filtered on PRE, HEPA and Active carbon filters		**Ti 1** : the 2 release tanks for liquid were added during the first 10 -years outage. **Ti 2 and Ti 3** : part of the basic design Discrepancies in storage capacities exist according to different ages and design
chemical precipitation	In operation in the late years 1980		Typical figures were poor (FD = about 20 but needed multi-step precipitation)	Gross gamma counting	One floculator (30 m³) in CNT2 Given up according to poor DF
centrifuging	NO	NO			
Hydro-cyclone	NO	NO			
cross-flow filtration					
ion exchange (with pre and post filtrations, coupled with thermal degasser and evaporator) for primary (recyclable) liquids , boric acid liquors are recycled , tritiated distillate are stored prior to release Evaporator alone : for non-recyclable liquids	Classical Filter/Ion exchange/ Filter /degasser/ evaporator process or evaporator only		Typical figures are … > 95 … 99 % for the whole treatment process of the primary effluents	Efficiencies of the ion exchange resins are checked by gross gamma counting / spec gamma, Efficiency of the single evaporation is measured by checking the distillate gross gamma activity	

osmosis	One semi-industrial unit in operation in TI3 in the mid-1990		DF measured by IN and OUT effluents activities	Gross gamma and spectro gamma counting's	Fused for Boraflex issue only , given up after the removal and the replacement of the Boraflex
ultrafiltration	NO	NO			
Emissions:					
electrostatic precipitation	NO	NO			
cyclone scrubbing	NO	NO			
chemical adsorption	NO	NO			
HEPA filtration	YES, part of the basic design of the 3 units		> 99 % (measured according to the technical specifications for classified filters or on a voluntary basis for the unclassified ones)		Discrepancies exist because the 3 unite are of different ages and designs
cryogenics	NO	NO			
Active carbon filter	See HEPA		> 95 % classified filter > 90 % for un-classified items		See HEPA

2.1.5.3 System(s) in place to reduce, prevent or eliminate atmospheric discharges of radioactive substances

Note that Tihange NPP air emissions are not within the scope of OSPAR, the data are mentioned for information only.

Origin:

1) Space between the reactor building itself and the second containment (“inter-space”), fuel building (spent-fuel pool), nuclear auxiliaries building (ventilation, machinery rooms, laundry building, demineralisation building, decontamination building, …);
2) Gaseous effluents from hydrogenous circuits (primary circuit, chemical and volumetric conditioning circuits); 3) atmosphere of each reactor building itself (70,000 m^3).

Treatment:

- All gas releases from 1) are continuously monitored, can be filtered (HEPA and charcoal) and released at rates from 150,000 to 250,000 m^3/h.
- Gas releases from 2) are sent to storage / decay tanks. Venting of the atmosphere of the reactor building is done after monitoring and filtration (charcoal) if necessary.

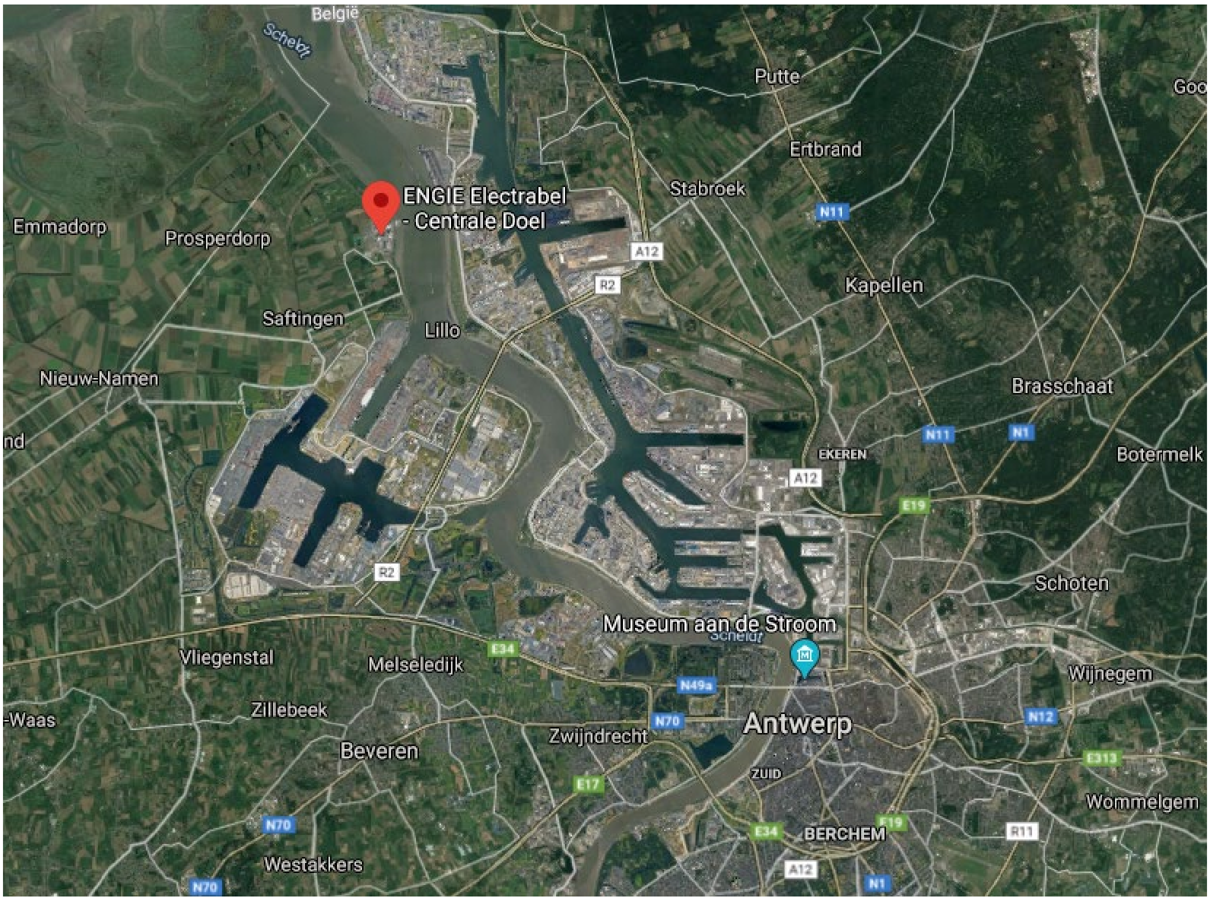
Waste management:

- Releases from 2) for each reactor (Tihange 1, Tihange 2 & Tihange 3) are sent to primary storage tanks. Once the radioactivity of a full storage tank has sufficiently decreased, effluents are released through the chimney at a maximum rate of 75 m^3/h (presence of filters and continuous monitoring).
- All gas (mostly Xe-133 and spurs of Kr 85 and other short lived species) from 1) are continuously released through stacks and monitored by on-line detectors. When "action" levels are exceeded, gas releases are by-passed through HEPA filters (High Efficiency Particulate Air filters) and active carbon filters. Filters and active carbon cartridges samples - trapping iodine and airborne (except for laundry and decontamination buildings) - are analysed weekly (determination of iodine concentrations by gamma spectrometry). Tritium and C14 are measured since 2018-2019 in Tihange 3 and Tihange 2. Tritium is determined by calculation taking into account flow rate and concentration in Tihange 1.

2.2 Doel Nuclear Power Plant

2.2.1 Location

The site containing 4 PWR is situated on the western side of the Scheldt river near Antwerp city.



2.2.2 Year for commissioning/licensing/ planned decommissioning[4]

Doel 1 : 1975/2015=>2025;

Doel 2 : 1975/2015=>2025;

Doel 3 : 1982/2022;

Doel 4 : 1985/2025

2.2.3 Receiving waters and catchment area

Scheldt river.

2.2.4 Other voluntary relevant information that does not to change

2.2.4.1. System(s) in place to reduce, prevent or eliminate liquid discharges of radioactive substances

Origin:

- There are 4 units at NPP Doel.
- The industrial waste waters of those units consist of: liquid effluents from controlled areas (‘GZ’; floor, laundry, lavatory, chemical drains, …) and liquid effluents from non-controlled areas (‘SEK’; floor, regeneration effluents from machinery, blow down of the steam generators).

Treatment:

- Ion-exchange procedures, filtration and evaporation of waste waters (in evaporators, tritium from the distillate is condensed and released as a liquid fraction).
- The concentrate phase is conditioned in the NPP itself as solid concrete waste.

Waste management:

- The GZ are always sent to the WAB (water and waste treatment building). Depending on their activity, the SEK will be treated in the WAB, directly sent via the GSL (building of secondary discharges) to the ELK (unique release collector to the Scheldt after dilution) or directly sent to the ELK. In WAB, all the liquid effluents are stored in tanks for intermittent release.
- All (treated) liquid effluents flow through the “L-Building” where an activity measurement may interrupt the discharge before going to the “Discharge Pavilion”where it is sent to the Scheldt. In the “Discharge Pavilion”, the industrial water (GZ or SEK) is mixed with tertiary cooling waters before being effectively released into the river Scheldt. An instantaneous limit of 0.1 MBq/m^3 drink water equivalent is applied for all liquids released through the discharge pavilion into the Scheldt.

2.2.4.2. Systems abatement efficiency

Abatement systems and management.

[4] According to the Belgian law on nuclear phase-out from 2003

Abatement system/ Management	Into operation (Year)		Efficiency of abatement system		Comments
	Existing	Planned	Decontamination Factor	Other measure of efficiency	
Discharges:					
Delay tank(s): ▪ Liquid: ○ the liquid effluents coming from the controlled areas (GZ) of the 4 reactor units are stored in 2 storage tanks in the WAB prior to release in the river Scheldt ○ the liquid effluents from the machinery buildings are stored in the GSL prior to release in the river Scheldt ▪ Gas: on each unit, several gas tanks of different capacities and design pressures	Liquid: 1982 Gas: D12: 3 tanks are part of original design, 2 additional tanks in place since end '80's D3, D4: part of original design of the plants		Gas: delay policy is used to avoid short lived gas species releases.		WAB = water and waste treatment building D12: prior to the startup of the WAB in 1982, liquid releases were handled by D12. Since 1982 all liquid releases from controlled areas are handled by the WAB.
chemical precipitation	NO				
centrifuging	NO				
hydrocyclone	NO				
cross-flow filtration	NO				

ion exchange: with pre and post filtrations, coupled with thermal degazifier and evaporator for primary (recyclable) liquids , boric acid liquors are recycled, tritiated distillates are stored prior to release. Evaporator alone: for non-recyclable liquids.				Efficiency of the ion exchange resins is checked by gross gamma counting / spec gamma. Efficiency of the single evaporation is measured by checking the distillate gross gamma activity.	
osmosis	NO				
ultrafiltration	NO				
candle filters for the laundry water	Yes				
Emissions:					
electrostatic precipitation	NO				
cyclone scrubbing	NO				
chemical adsorption	NO				
HEPA filtration	Yes, part of the basic design of the units.			>99,95%	
cryogenics	NO				
active carbon filtration	Yes, part of the basic design of the units.			Efficiency according to the Technical Specifications	
Bag filtration on the shredder	Beginning of 90's				

2.2.4.3. System(s) in place to reduce, prevent or eliminate atmospheric discharges of radioactive substances

Note that Doel NPP air emissions are not within the scope of OSPAR, the data are mentioned for information only.

Origin: reactor building, annular space between the reactor building itself and the second containment, fuel building, nuclear auxiliaries building.

Treatment:

- All gas releases from hydrogenous circuits of the four reactors (degasification of primary circuit, …) or the WAB are sent to storage decay tanks.
- All gases from other sources (leakages, airy ventilation of the nuclear buildings, non-condensable gas, …) are continuously released and monitored.

Waste management:

- Once the radioactivity of a full storage tank has sufficiently decreased, effluents are released through the chimney (continuous monitoring). All gas from other sources are continuously released and monitored. When “action” levels are exceeded, gas releases are by-passed through HEPA filters (High Efficiency Particulate Air filters) and/or active carbon filters (trapping iodine).
- The particulate filters and active carbon cartridges are analysed weekly (determination of iodine concentration and gamma spectrometry). Using monthly aliquots, beta and alpha measurements are conducted on filters; ^{85}Kr is determined on gas; tritium is determined on condensed gas, gamma spectrometry on noble gases.

Section 3: Reprocessing facilities

- Name of reprocessing facility
- Location of reprocessing facility
- Year for commissioning/licensing/decommissioning
- Receiving waters and catchment area
- Other voluntary relevant information that does not tend to change.

NOT APPLICABLE

Section 4: Fuel fabrication facilities

- Name of fuel fabrication facility
- Location of fuel fabrication facility
- Year for commissioning/licensing/decommissioning
- Receiving waters and catchment area
- Other voluntary relevant information that does not tend to change.

4. Fuel fabrication facilities

Belgium had two fuel fabrication facilities at the Mol-Dessel site but are both dismantled:

- Belgonucléaire (MOX fuel fabrication) stopped in 2006. The dismantling started in 2009 and has been completed in 2019.
- FBFC International (Franco-Belge de Fabrication de Combustibles International, fuel rod fabrication facility) stopped in 2015. End 2019, the dismantling was at 75% and is foreseen to be completed by end 2020.

All liquid waste from the former facilities were sent to the Belgoprocess site 1 for treatment. After treatment, eventual liquid discharges are released by the Belgoprocess site 2.

In fact, all the liquid discharges produced by the Mol-Dessel including the currently active facilities such as SCK•CEN site (Nuclear Research Centre) and JRC-Geel (Joint Research Center, Institute for Reference Materials and Measurements) are managed by the Belgoprocess facilities.

Section 5: Radioactive waste treatment facilities

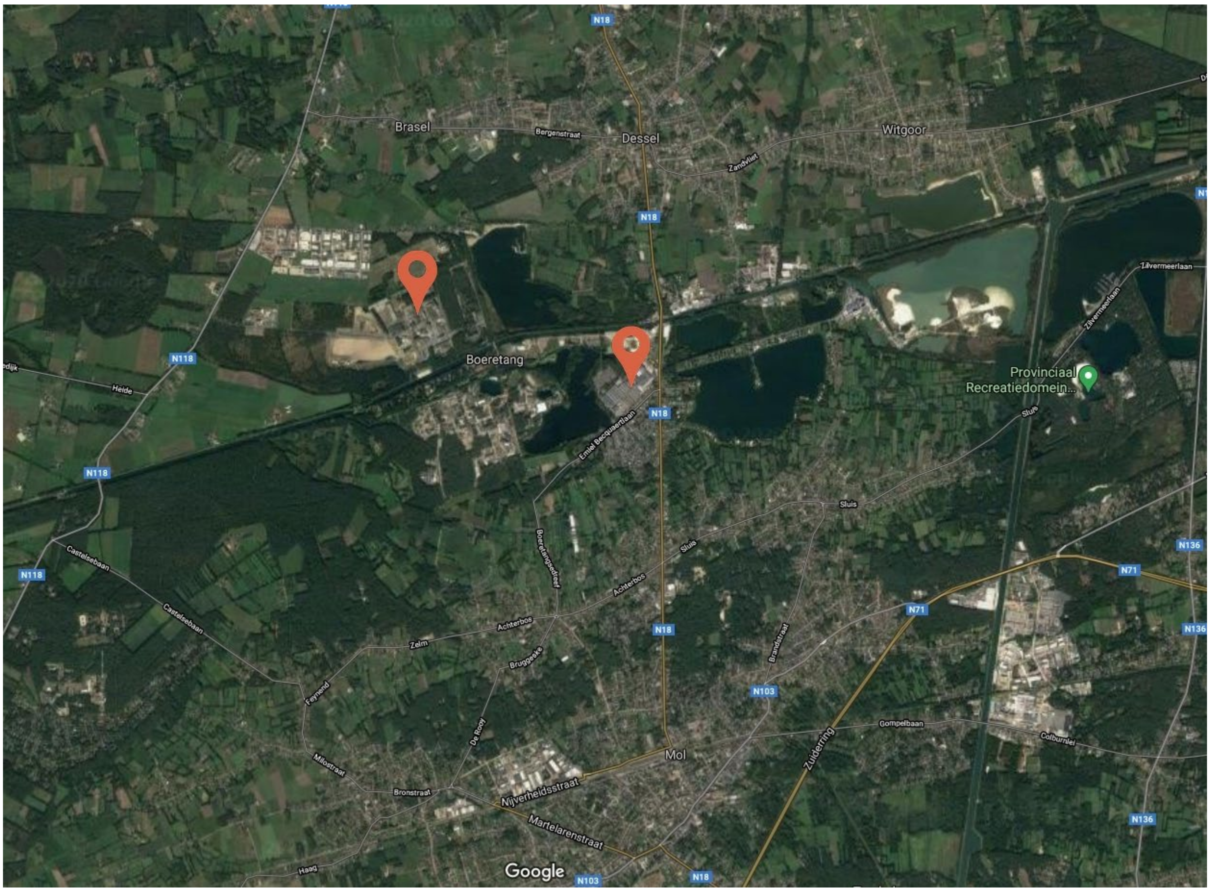
- Name of radioactive waste treatment facility(ies)
- Location of radioactive waste treatment facility(ies)
- Year for commissioning/licensing/decommissioning
- Receiving waters and catchment area
- Other voluntary relevant information that does not tend to change.

5. Radioactive waste treatment facilities

5.1 Belgoprocess (BP)

5.1.1 Location

The waste treatment and storage facility Belgoprocess site is situated in the Mol-Dessel region and liquid releases are discharged in the Molse Nete river by an underground pipe of 10 km long. On the right Belgoprocess 1 site; on the left Belgoprocess 2 site (liquid waste treatment and releases).



5.1.2 Year for commissioning/licensing/decommissioning

1984/-

5.1.3 Receiving waters and catchment area

Molse Nete river.

5.1.4 Other voluntary relevant information that does not to change

5.1.4.1 System(s) in place to reduce, prevent or eliminate liquid discharges of radioactive substances

Origin:

- Liquid wastes treated by BP are mainly produced by SCK•CEN and Belgoprocess installations.
- Besides that, there are also effluents coming from Doel and Tihange NPPs, Belgonucléaire (dismantled end 2019), FBFC International (dismantled end 2020), IRE, JRC-GEEL (formerly known as IRMM, production of calibrated/reference sources, cyclotron) sites and finally hospitals and research centres (universities, …).

Kind of effluents:

Relatively low activity effluents:

- *Suspicious* effluents where activity is < 400 kBq/m^3 for beta/gamma emitters and < 40 kBq/m^3 for alpha emitters;
- *Contaminated* effluents where activity is < 400 MBq/m^3 for beta/gamma emitters and < 800 kBq/m^3 for alpha emitters;
- *Higher radioactive* effluents where activity is < 40 GBq/m^3 for beta/gamma emitters and < 80 MBq/m^3 for alpha emitters.

Medium activity effluents:

- With activity < 40 TBq/m^3 for beta/gamma emitters (i.e. liquid wastes of medium activity from the IRE site).

Treatment:

- Effluents are treated by coagulation/flocculation followed by sedimentation in settling tanks, the phase above is sent over an ultrafiltration unit before collected in a storage tank prior to disposal.
- Depending on the radioactivity levels, the effluents can be evaporated by BP.

Waste management:

- Residues or solid phases are conditioned by BP cementation before storage (since 2005 bitumisation is no longer applied). Up to 1992, high activity wastes - coming from the former Eurochemic plant (dismantled now) - were vitrified and stored. Now these processes are stopped.
- Before liquid effluents are released into the Molse Nete river, the following limits have to be respected[5]: debit < $70 m^3/h$ and concentration < 5 MBq/m^3 and < 10 GBq/month or 50 GBq/year according to the weighting formula[6]:

$$4[^{241}Am + {}^{226}Ra] + \alpha + 1\ 10^{-4}\,[^{3}H] + [^{60}Co] + 3[^{134}Cs/^{137}Cs] + 0.3\ [\beta\ ]$$

With:

$[\alpha]=[\alpha\text{-total}] - [^{241}Am + {}^{226}Ra]$

$[\beta] = [\beta\ \text{total}] - [^{60}Co]\ - [^{134}Cs/^{137}Cs]$

5.1.4.2 Systems abatement efficiency

Abatement systems and management:

Abatement system/ Management	Into operation (Year)		Efficiency of abatement system		Comments
	Existing	Planned	Decontamination Factor	Other measure of efficiency	
Discharges:					
delay tank(s**)** **Liquid** : storage tanks prior to release in the river Molse Nete) 5 tanks (3 with volume of 400 m³ and 2 with volume 250 m³. **Ventilation Air and process gases** : Emissions consist of ventilation air, each installation is equipped	**Liquid** : < 1960 **Ventilated Air** : <1970 part of the original design since 1960. Also for recent installations		**Liquid** : see precipitation and ultra-filtration **Ventilated air and process gases**: release are mandatory filtered on PRE, HEPA filters See HEPA	Gamma spectroscopy and alpha/ beta counting	Ventilation air to keep installations in under pressure. Process gases mainly coming from the extraction of the incinerator and extraction of the tank ventilations.

[5] Tese are revised limits, in application since 2020; previously: concentration < 15 MBq/m3 and < 25 GBq/month or 150 GBq/y

[6] This is a reviewed formula, in application since 2020; previously
$2{,}5\ [\alpha\ \text{total}] + 0.4\ [^{90}Sr\text{-}^{90}Y] + 2.5\ 10^{-5}\ [^{3}H] + [^{60}Co] + 1.5\ [^{134}Cs] + 1.5\ [^{137}Cs] + 0.1\ [\beta] \leq 25$ GBq/month
(150 GBq/year maximum with a concentration limit of 15 MBq/m^3)

with $[\beta] = [\beta\ \text{total}] - ([^{90}Sr\text{-}^{90}Y] + [^{60}Co] + [^{134}Cs] + [^{137}Cs])$

with a discharge point with stack release after filtration.					
chemical precipitation	In operation in the late years 1960		Typical figures 95% Coagulation/flocculation for both radiological and chemical contaminants and sedimentation	Gross alpha, beta counting and gamma spectroscopy	4 reception tanks of 100 m³ each, 2 decanters of 100 m³ 'Cold' LW is treated in online system. LLW is treated batchwise
centrifuging	NO	NO			
hydrocyclone	NO	NO			
cross-flow filtration	NO	NO			
osmosis		NO			

Ultrafiltration: of the chemical components in the discharge liquid	Installation in operation since 2014		Removal of chemical parameters Hg, Ag, Co, U and Be to meet discharge norms	ICP analyses	2 separate treatment lines with a total capacity of 15 m³/h
Evaporation: Liquid with higher activity contents, medium -level aqueous waste water is concentrated by evaporation	Installation in operation since < 1970		Distillates are further treated by flocculation. Concentrates are stored awaiting cementation.	Gamma spectroscopy and alpha/ beta counting	Treatment of MLW
Emissions:					
electrostatic precipitation	NO	NO			
cyclone scrubbing: extracted ventilation air from process installations passes a wet scrubber cyclone filter	Part of the original design		Washing and neutralization of acid gases before they reach the HEPA filtration. 90%		Neutralization of acid
chemical adsorption	NO	NO			

HEPA filtration	part of the basic design of each installation		> 99 % (measured according to the technical specifications for classified filters)		Intervention area's with high alpha contamination are equipped with double HEPA filters
cryogenics	NO	NO			
Active carbon filter	NO	NO			

5.1.4.3 System(s) in place to reduce, prevent or eliminate atmospheric discharges of radioactive substances

Note that Belgoprocess air emissions are not within the scope of OSPAR, the data are mentioned for information only.

Origin: at Belgoprocess, gaseous wastes can be produced by burning solid and liquid wastes, by the gaseous and liquid waste treatments, by building ventilations,… The other nuclear installations also produce atmospheric wastes but will not be further discussed in this report.

Treatment: filtration by HEPA filters before releases in the chimneys.

Waste management: after filtration, releases are continuously monitored and sampled.

Section 6: Research reactors

- Name of research reactor
- Location of research reactor
- Year for commissioning/licensing/decommissioning
- Receiving waters and catchment area
- Other voluntary relevant information that does not tend to change.

6. Research reactors

6.1 Belgian reactor 1 (BR1)

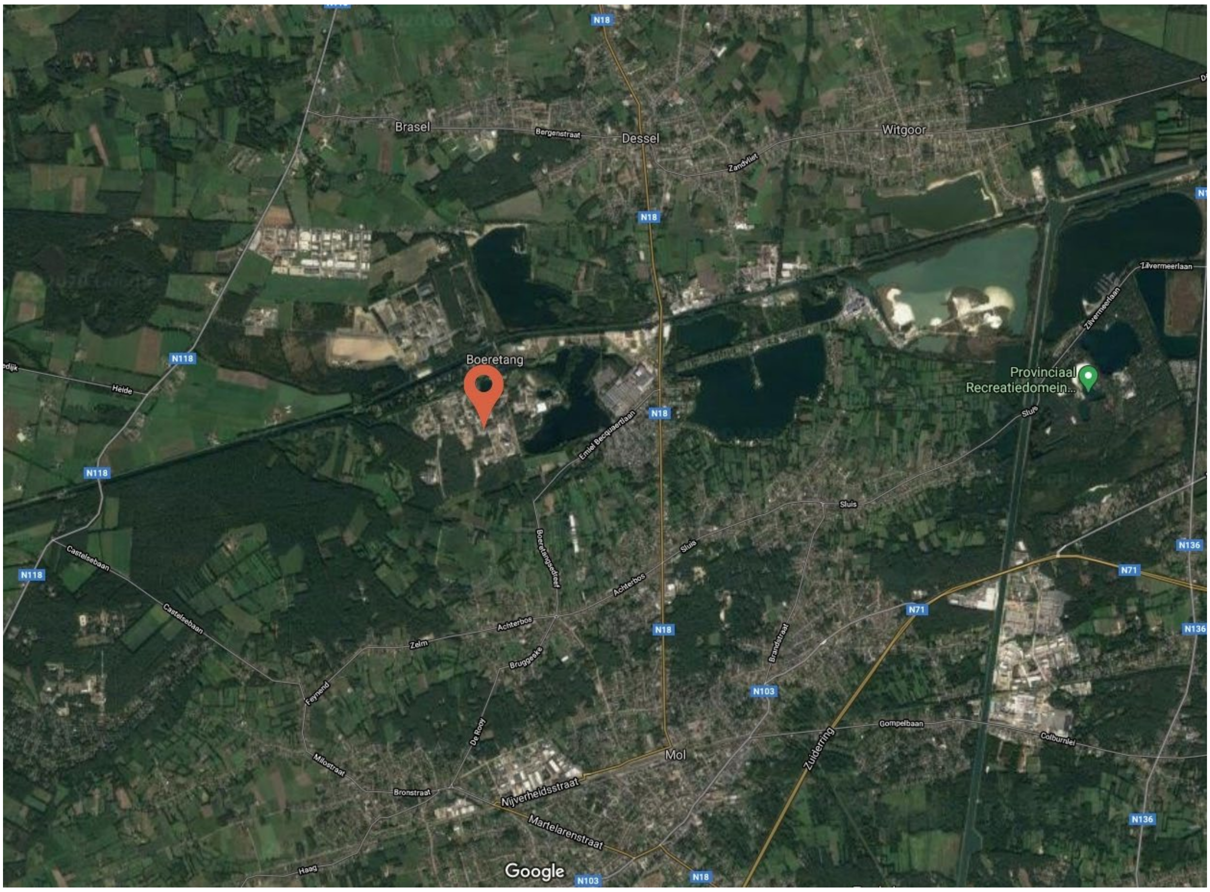
The BR1 is a natural uranium graphite reactor, comparable to the reactors ORNL X-10 (USA) and BEPO (Harwell, UK). The core is composed of a pile of graphite blocks thus forming a cube with ribs of 7 meter. The reactor is air cooled. The fuel is metallic natural uranium with an aluminium cladding. Its design thermal power is 4 MW.

However, since the start of BR2 this high power was no longer needed and since March 2018 BR1 is licenced to operate at a maximum thermal power of 1 MW using only the auxiliary ventilation system. Due to its very well thermalized neutron spectrum, the reactor is mainly used for neutron studies, such as neutron activation analysis and instrument calibration. Neutronography is also possible.

No significant modifications have been made to the reactor. The original fuel is still loaded. The burn up is still low and hence no replacement is foreseen at this moment. In 1963, after a long period of operation at higher power, the fuel was unloaded and the graphite matrix was heated in order to release the Wigner energy. In the current operating regime, using only the auxiliary ventilation, the graphite temperature is relatively high compared to the fast neutron dose, such that the Wigner energy is still decreasing.

6.1.1 Location

The BR1 is situated in the Mol-Dessel region on the SCK (Nuclear Research Center) site.



6.1.2 Year for commissioning/licensing/decommissioning

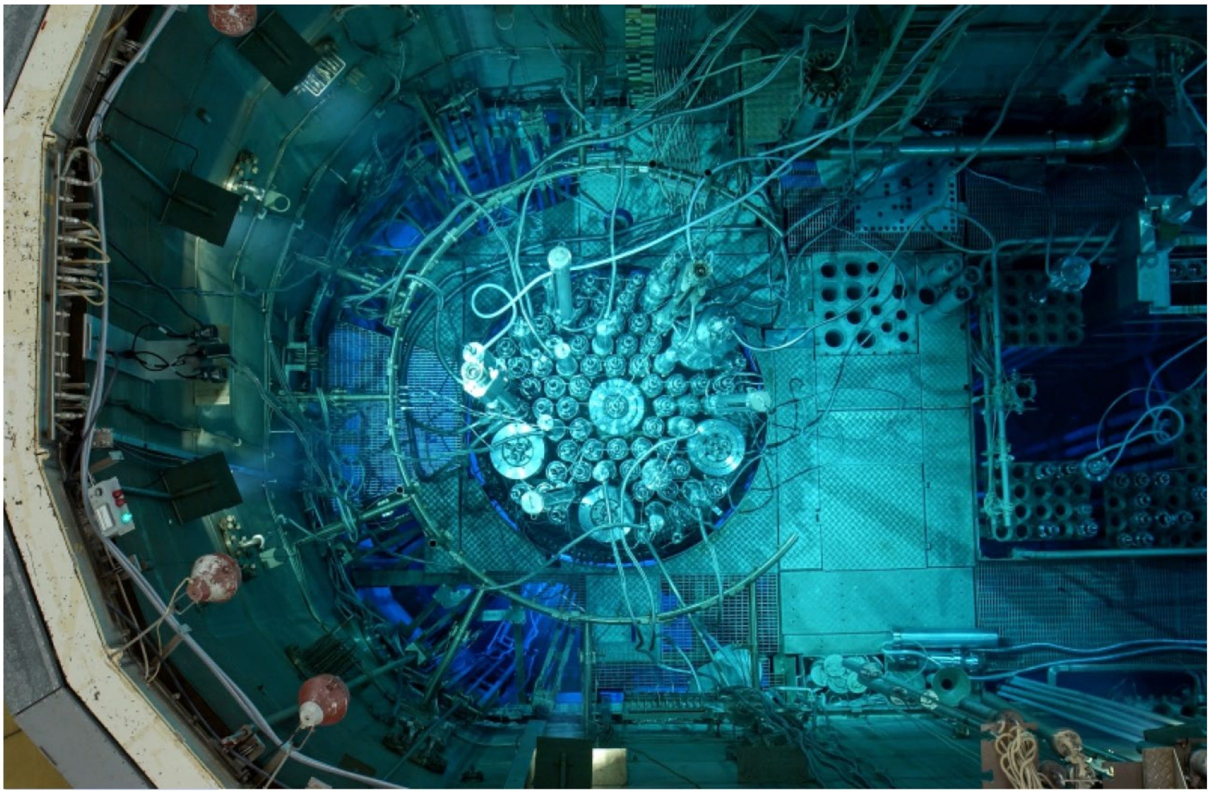
The reactor went critical for the first time in 1956.

6.1.3 Receiving waters and catchment area

No water is used to cool the core of the BR1 reactor.

Liquid waste is pumped underground to the nearby Belgoprocess waste treatment site. After treatment, the resulting releases are discharged in the Molse Nete river trough an underground pipe of 10 km long (see §5.1 for further details).

6.2 Belgian reactor 2 (BR2)



The BR2 is a heterogeneous thermal high flux test reactor, designed in 1957 for SCKCEN by NDA [Nuclear Development Corporation of America - White Plains (NY - USA)]. It is also built and located on the site of the SCKCEN in Mol.

The reactor is cooled and moderated by pressurised light water in a compact core of highly enriched uranium positioned in and reflected by a beryllium matrix. The maximum thermal flux approaches 10^{15} neutrons / (cm².s) and the ultimate cooling capacity, initially foreseen for 50 MW, has been increased in 1971 to 125 MW by replacement of the primary heat exchangers.

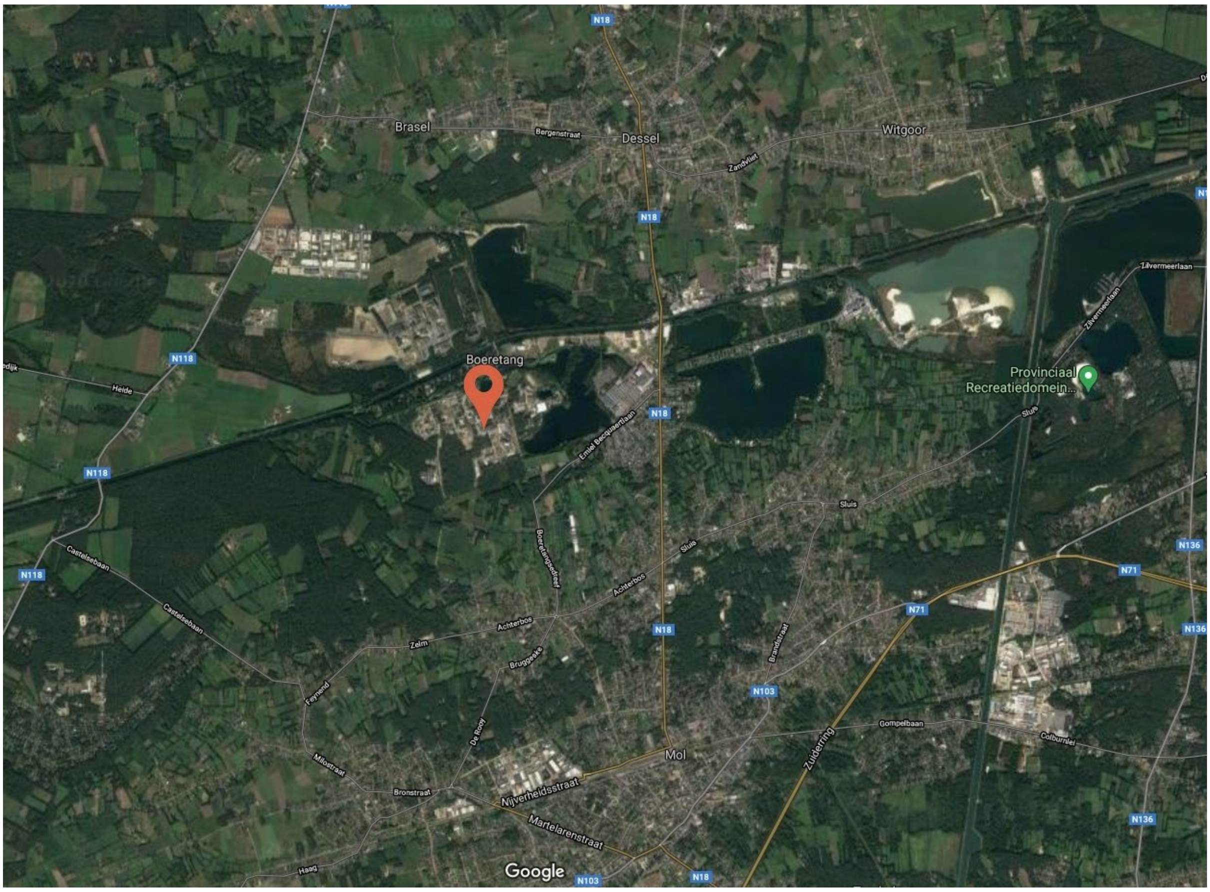
The reactor was originally designed for material and fuel testing and this still is an important activity. A number of irradiation devices are available. However, over the past years, isotope production (Mo-99, Ir-192 and others) has become an important activity. Besides that, two irradiation facilities for silicon doping are available.

The beryllium matrix swells under neutron irradiation due to the formation of gas (helium and tritium). This swelling causes cracking of the beryllium which is a brittle material. Furthermore, the build-up of the helium-3 isotope results in neutron poisoning. Due to these effects the lifetime of the beryllium matrix is limited. Three replacements were already performed. The first one took place in 1979 and the second one in 1996. The third replacement was done in 2015-2016 and the reactor was restarted by mid-2016.

During the lifetime of the reactor, continuous modernization projects have been executed. On the occasion of the third beryllium matrix replacement, a major refurbishment programme was realized including actions based on the conclusions of the stress test and Periodic Safety Review of 2016 such as a new emergency diesel generator system and a monitoring system that gives information of the state of the installation after a severe accident. The latter system is designed to work independent of all other systems for at least 72 hrs.

6.2.1 Location

The BR2 is situated in the Mol-Dessel region on the SCK•CEN (Nuclear Research Center) site.



6.2.2 Year for commissioning/licensing/decommissioning

The BR2 first criticality dates from 1961 and operation of the reactor started in January 1963.

6.2.3 Receiving waters and catchment area

The BR2 features a primary and secondary cooling system that removes the heat from the core via demineralized water. Ultimately the heat is rejected to the air via cooling towers. Normal losses of water of both cooling systems are supplemented by a water purification plant that takes in water from ground water wells. No surface waters are used to cool the BR2 reactor core.

Water from a nearby lagoon is used to cool certain components such as the oil of the primary pumps. Alternatively potable water can be used for this purpose.

Liquid waste is pumped underground to the nearby Belgoprocess waste treatment site. After treatment, the resulting releases are discharged in the Molse Nete river trough an underground pipe of 10 km long (see §5.1 for further details).

Section 7: Decommissioning activities

- This section is specifically related to all types of facilities at Sections 2 - 6
- Name of nuclear facility
- Location of nuclear/non-nuclear installation
- Year for commissioning/licensing/decommissioning
- Receiving waters and catchment area
- Other voluntary relevant information that does not tend to change.

CURRENTLY NOT APPLICABLE