

## Annual report 2021





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### Message from the Chair

Bel V is a private foundation established by the Federal Agency for Nuclear Control (FANC) as a subsidiary to which the FANC delegates oversight activities in the field of nuclear safety and radiation protection. On the basis of experience built up over more than 50 years, Bel V contributes to the protection of the general public, the workers and the environment against the danger of ionising radiation.

Bel V's mission of monitoring the safety of the Belgian nuclear facilities is part of the integrated inspection and monitoring strategy (GIC – 'geïntegreerde inspectie- en controlestrategie'). This six-year strategy was drawn up in response to the conclusions of the International Regulatory Review Service (IRRS) mission by the International Atomic Energy Agency (IAEA) of 2013 and the follow-up mission in 2018. In 2021, halfway through the implementation period, a review was carried out. That review, as well as a reflection on the adjustments needed to the inspection approach for nuclear power plants during the last year before definitive shutdown, led to an adjustment to the GIC which should not be underestimated from the perspective of the next IRRS mission in Belgium in 2023.

In 2021, the COVID-19 pandemic again required Bel V to take measures – in close consultation with the FANC – to continue to guarantee its business continuity and – together with the FANC – to fulfil its protection mission. Maximum protection of the employees and their families was again the main concern. Bel V succeeded, thanks

to the necessary flexibility, in fulfilling its principal tasks, namely (1) to verify compliance with the regulatory requirements and operating procedures in the field of radiation protection and nuclear safety, and (2) to analyse the safety studies submitted by the licensees.

To carry out its mission of monitoring and analysing the safety of the nuclear facilities, Bel V needs to draw on a multidisciplinary team of experts who have a high level of knowledge and skills. Maintaining and developing the necessary skills are also part of the core values that Bel V wishes to promote. This is why Bel V has a very high-quality knowledge management system, a multi-year research and development programme as well as an initial and continuous training programme. It also has tools to generate, collect, use, disseminate and stock useful knowledge. These tools are fundamental, as several experts with many years of experience will be reaching retirement age. Therefore, the transfer of knowledge deserves particular attention.

Given the announcement by ENGIE Electrabel at the end of 2020 that they will no longer invest in extending the life of Belgian nuclear power plants, the analysis of the future activities of Bel V continued. In accordance with Bel V's strategic plan, specific efforts were made in 2021 to develop international activities. The strategy adopted proved fruitful, since multi-year contracts have been concluded both with the Dutch nuclear safety authority ANVS and its Norwegian counterpart DSA. Our organisation thus reviewed and adjusted its longterm planning. This flexibility will remain crucial, given the impact on our organisation of the government's decision concerning the extension of the lifetime of the two most recent nuclear power plants. I am firmly convinced that the future will remain exciting.

In 2021, various results were obtained.

We have seen the capacity of Bel V to take on complex problems in our sector with new ways of thinking, new approaches and new coalitions.

I would like – in the name of the Board of Directors – to express my appreciation for and thank the management team and the entire workforce for the results they have achieved and for the professionalism with which they carry out their tasks in these challenging circumstances.

Didier MALHERBE Chair of the Board of Directors



#### Preface

Bel V, a private foundation established on 7 September 2007, with registered office currently at Walcourtstraat 148 rue Walcourt, 1070 Brussels, is a foundation whose purpose is to contribute at a technical and scientific level, on a non-profit basis, to the protection of the general public, the workers and the environment against the dangers of ionizing radiation.

It is governed by the Belgian Act of 23 March 2019 establishing the Belgian Companies and Associations Code, and by its own Articles of Association as filed at the registry of the Brussels Court of First Instance.

At year-end 2021, the Board of Directors was composed of:

D. Malherbe	President
J. Annane	Chairman of the Board of the FANC
F. Hardeman	General Manager of the FANC
J. Germis	member of the Board of the FANC
S. Vaneycken	member of the Board of the FANC
M. Jurisse, Ir	member

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## Michel Van haesendonck

Dear reader,

Seldom has there been a year that can be compared to 2021. Never before has our annual report looked back on such a challenging, unprecedented year in the history of our organisation.

As in 2020, our activities were to a significant extent impacted by the COVID-19 pandemic in 2021. The licensees of nuclear facilities implemented the specific 'coronavirus measures'. Our on-site inspections were again complemented by online meetings between the licensee and the FANC / Bel V in order to monitor the situation and the potential impact of the crisis on nuclear safety.

Given the announcement by ENGIE Electrabel at the end of 2020 that they would no longer invest in extending the life of nuclear power plants, Bel V took the necessary actions, together with its colleagues at the FANC and the licensee, to wind down the project in a structured manner. This meant ensuring that, in the light of the

government's decision, the project could be resumed if necessary at a later date.

The project to dismantle the Belgian nuclear power plants was given priority at that point, including at Bel V, and therefore in the second half of 2021, a new dynamic for this project became visible.

Given the Belgian nuclear context, Bel V devoted particular attention to the following activities in 2021:

- at the Doel and Tihange sites, the conditions and capacity for the storage of various waste streams and the monitoring of the construction of new storage facilities for spent fuel;
- at the Belgoprocess site: the licensing and monitoring of the construction of various new buildings that are meant to provide a solution for the concerns about the future storage capacity at the Belgoprocess site;
- at the National Institute of Radioelements (IRE) in Fleurus: the SMART project (Source of MedicAl RadioisoTopes);
- at the site of the Nuclear Research Centre (SCK CEN): the RECUMO project for the recycling of highly enriched uranium (HEU) from the IRE and the project on the examination and implementation of the MYRRHA/Minerva facilities.

The numerous initiatives taken in 2021 to prepare Bel V for the changing nuclear landscape and to further develop our international activities were very successful. Starting in 2022, Bel V as a member of international consortia, is offering technical support to foreign regulators.

In this context, I am delighted at the recertification of Bel V in 2021 based on the ISO 9001:2015 standard. The new certificate now also applies to its international activities.

I am very pleased with the positive attitude and resilience shown by the Bel V team in 2021 – a year that, as you will read, brought many challenges as well as opportunities. In these unprecedented times, we have had to revisit our way of working, with more flexibility, technological changes and a focus on creativity.

An enquiring mind, teamwork, curiosity, ambition, commitment and goal-oriented thinking constitute the foundations of Bel V. This introduction to our 2021 annual report illustrates how we continue to embrace these qualities and values, since they motivate and inspire us, especially in these times of great uncertainty.

I look forward to continuing to keep you informed of our progress in our future annual reports and hope that you will enjoy reading this year's report.

Michel VAN HAESENDONCK, Ir General Manager

#### Number of inspections carried out in 2021:





Facilities Nuclear power plant Tihange





Other class IIA nuclear facilities





# Regulatory activities in Belgium

ECTION 1 - REGULATORY ACTIVITIES IN BELGIUM





#### 1.1 General assessment of nuclear installations

#### Nuclear power plants

At the end of November 2020, ENGIE Electrabel decided to put an end to the PSR/LTO G2 project for the long-term operation (LTO) of the second generation (G2) reactors. As a result, at the beginning of 2021, Bel V took a number of actions. The most important of these involved documenting the 'state of affairs at the end of 2020', with a view to being able to quickly resume the project if at the end of 2021 (or later) it were decided to do so. Bel V continued to work on the independent identification of potential weaknesses in the design of Doel 4 and Tihange 3 in order to be able to form a judgement quickly about possible design improvements that ENGIE Electrabel may propose if the PSR/ LTO G2 project were ever to be resumed.

In light of the termination of the PSR/

LTO G2 project, a number of other projects were re-evaluated. Thus, the WENRA Reference Levels 2014 project was also thoroughly reviewed and a number of activities were halted or limited to the spent fuel pools (SPF).

The termination of the PSR/LTO G2 project freed up resources within the organisation of ENGIE Electrabel to take on the DECOM (previously D&D) in project preparation for the dismantling and, in particular, for the POP component (Post-Operational Phase). The reorganisation within ENGIE Electrabel took some time, but in the course of 2021, there was clearly a new dynamic in the DECOM project. On the one hand, a new process (NSRD - Nuclear Safety Reference Document) was launched to determine the nuclear island (the totality of safety-related or functional systems in the various phases of the POP). Great progress was made on this aspect. On the

other hand, considerable resources were devoted to developing an overall integrated vision and organisation of the dismantling project, including interaction with the other stakeholders (a.o. ONDRAF/NIRAS).

The construction of storage buildings for the dry storage of spent fuel was launched for the Doel power plant (after a licence had been obtained in July 2021) and was continued for the Tihange power plant.

At Tihange, a study was launched on making building DE (at Tihange 3) for the wet storage of spent fuel independent, with a view to the dismantling of Tihange 3, after which that building will need to remain operational. In 2021, Bel V also devoted particular attention to the storage conditions and capacity for the various waste streams at the Doel and Tihange sites. After an audit conducted by the Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF/NIRAS), the authorisations for the resins and, only at the Doel site, for concentrates, were still withdrawn. A new procedure for conditioning resins has been developed. At the moment, tests are still under way.

The specific measures taken regarding COVID-19 were implemented both by the licensee and Bel V. Thus, conference calls continued between the licensee and the FANC / Bel V in order to monitor the situation and the potential impact of the crisis on nuclear safety (in some cases with altered frequency during calmer periods). The combination of inspections in the field and remote activities continued to be the norm. The COVID-19 situation had no effect on the completion of the inspection programme in 2021 (with the exception of the postponement of a few thematic inspections until 2022 because of the illness of one of the inspection).

#### Other nuclear facilities

At Franco-Belge de Fabrication de Combustible (FBFC), the final release measurements of the site were carried out and the final dismantling report was drawn up.

The management of the National Institute for Radioelements (IRE) continues to face important challenges. The project to convert highly enriched uranium (HEU) to low enriched uranium (LEU) for irradiated targets is completed, but a few other projects are still under way: the installation of a new accelerator for the production of germanium-68, the LTO project for building B6, the SMART project (new accelerator for the production of molybdenum-99 without uranium) and the new interim storage for liquid waste. Several action plans

were implemented, including for the disposal of historic waste and for the periodic safety review (PSR) (which incurred some delay).

At Belgoprocess, Bel V devoted particular attention in 2021 to the licensing and monitoring of the construction of several new buildings. These projects have to address the concerns about future storage capacity at the Belgoprocess site. The PSR project, which was due to be completed in 2021, faced delays and will be continued into 2022. At SCK CEN, several important projects are under way: prelicensing of the MYRRHA project (which saw important developments (such as a new design for the primary circuit) and a number of technical workshops were held), MINERVA (for which a licence application was submitted at the end of 2021) and RECUMO (for the recycling of HEU and LEU originating from the IRE and for which a construction and operating licence was obtained at the end of 2021).

For the other facilities, regular conference calls were held between the licensee and the FANC / Bel V in order to monitor the situation and the potential impact of the COVID-19 pandemic on nuclear safety. The inspection practices were adjusted for the purpose (see Section 1.1.1).

#### Integrated inspection and oversight strategy (GIC – 'Geïntegreerde Inspectie- en Controlestrategie')

The new six-year integrated strategy for inspection (by the FANC) and oversight (by Bel V) was first implemented in 2018. This approach has been developed by the FANC and Bel V over the past few years in response to findings during the Integrated Regulatory Review Service (IRRS) audit in 2013.

In 2019. particular attention devoted to the further was development and implementation of the aforementioned oversight programme, consisting of inspection sheets (which document the legal framework and practical application of each inspection and which are handed over to the licensees) and inspection guidelines (which provide a guide for the inspectors and which represent the expertise of Bel V in the area of inspections).

In 2021, after half an implementation period, an evaluation of the GIC was carried out. This evaluation, along with the adjustments made following the reflection on additional inspections at nuclear power plants in the final year before definitive shutdown, gave rise to an adjustment to the GIC.

At the end of 2021, in accordance with article 38 of the general

regulations for the protection of the public, the workers and the environment against the dangers of ionizing radiation (RGPRI), this adjustment was forwarded to the licensees for implementation starting in 2022. The GIC working group was re-established, for the purpose of setting up an inspection programme for phases DSD 2 and DSD 3 (definitive shutdown) at units that are definitively shut down and now only hold fuel in the nuclear fuel docks. The working group is also tasked with drawing up a GIC for dismantling and a GIC for storage facilities (e.g. cAt).



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#### 1.2 Overview of inspections at nuclear power plants

#### 1.2.1 Doel 1/2

Both Doel 1 and Doel 2 were operating at full power during this period, except for the annual refuelling outage. For Doel 1, this was during the period from 21 May to 20 June and for Doel 2 from 27 March to 30 April.

On 28 June, Doel 1 shut down automatically after a power failure in a non-safety related panel, as a result of which some equipment in the secondary circuit was turned off. After having determined the cause and resolved the issue, Doel 1 was restarted on 29 June.

On 15 July, Doel 2 had to be stopped manually after a rapidly degrading hydrogen leak was identified in the alternator. After repair, the unit was restarted. 1.2.2 Doel 3

Doel 3 operated at nominal power, except:

- on 28 March, when electric power was reduced by 250 MW upon the request of the GENCOs (power generation companies) for around 5 hours;
- during a planned shutdown from 9 to 10 April for tests on a control rod;
- from 10 to 13 April, when electric power was limited, at Elia's request, to 300 MW because of work on the high voltage power grid;
- during the planned outage for refuelling and maintenance from 27 August to 25 September;
- on 20 October, when electric power was reduced by 250 MW for around 4 hours upon the request of the GENCOs;
- on 2 December, when electric power was limited, at Elia's request, to 800 MW because of work on the high voltage power grid;

1.2.3 Doel 4

Doel 4 operated at nominal power, except during the planned refuelling and maintenance outage from 22 October to 4 December.

One event was rated at Level 1 of the International Nuclear Event Scale (INES): upon restart after the planned stop, the reactor building operated for two days at higher pressure than permitted by the operational limits of the technical specifications.

#### 1.2.4 Doel common (WAB)

In the context of the upgrade of the water and waste treatment facilities (WAB – 'water- en afvalbehandelingsinstallaties') and the preparation for the DSD phase of the reactor units, attention was devoted to completing the following projects:

- There was intensive work done on replacing the existing concentrate tanks and expanding the storage capacity for concentrates.
- The upgrade of the remotecontrolled carriages is in progress.
- As part of the upgrade of the decontamination equipment, the obsolete equipment was removed and the space was prepared for the installation of the new equipment.

Non-compliant packaging was identified in a number of drums with historic waste, albeit without radiological impact in the storage zone. The licensee is taking the necessary corrective measures to repackage the waste and store it correctly.

#### 1.2.5 Doel site

The Bel V oversight programme at the site was further implemented as follows:

- Inspection meetings were held with the heads of various departments (Operations, Maintenance, Care and Engineering) and services, in order to evaluate their organisation and the management of different processes related to nuclear safety or radiation protection.
- Particular attention was paid to emergency preparedness and response, radiation protection, experience management, etc. with a focus on the importance of the sustainability of the improvement actions.
- Specific inspections were carried out in order to discuss topics that apply to various units (human performance, radiological discharges, security, etc.).

Bel V provided support to the FANC within the framework of its inspections, especially the management inspection and the inspections relating to subcontracting, mid-loop operation, staffing and skills management.

In 2021, the specific measures taken by the licensee in 2020 in response to the COVID-19 pandemic remained in force. The evolution of the situation and the possible impact of the COVID-19 crisis on nuclear safety were monitored via regular conference calls.

#### 1.2.6 Tihange 1

The unit operated at nominal power without interruption.

#### 1.2.7 Tihange 2

The unit operated at nominal power, except for the following periods:

- from 1 to 27 January, as part of the end of the programmed unit shutdown for maintenance and refuelling started at the end of 2020;
- on 21 April, after a reactor trip linked to the inadequate operation of a valve during a periodic test;
- from 22 to 24 April, after a turbine trip related to a leak at the level of a secondary circuit pipe (nonsafety related);
- on 24 April, after a reactor trip during the restart phase, due to human factors (non-compliance with procedures, etc.);
- from 14 to 28 May, to carry out repairs to the secondary circuit (non-safety related);
- from 28 August to 6 September, operating at 86% of nominal power, for the replacement of a secondary circuit pump (nonsafety related);
- on 12 October, operating at about 28% of nominal power, for repairs to the secondary circuit pumps (non-safety related).

The following two events were rated as level 1 on the INES scale:

- On 19 January, during restart operations, an automatic reactor shutdown occurred at 3% nominal power. This event resulted from several human factors (incorrect application of a procedure, etc.).
- During tests conducted during the shutdown in May 2021, operating times that exceed the criterion were noted for steam isolation valves.



#### 1.2.9 Tihange site

The Bel V monitoring programme at the site was further implemented as follows:

- meetings with management and the heads of various departments (Maintenance, Operations, Care and Engineering) and services in order to evaluate their organisation and the management of various processes relating to nuclear safety or radiation protection;
- systematic and specific inspections to address topics that apply to several units (monitoring of the construction of a new building to store spent fuel, experience feedback, etc.);
- attention to human and organisational aspects.

Bel V lent its technical support to the FANC's inspections, including those relating to radiological impact, subcontracting, management, etc. Particular attention was, of course, paid to the management of the COVID-19 pandemic by the licensee.

Bel V also continued to follow closely the management of radioactive waste.

Specifically, it should be noted that:

- The power plant was in prealert for flooding of the Meuse river from 15 to 17 July. Preventive measures were taken during this time, in line with the procedures.
- Sporadic protests (strikers' pickets at the entrance to the site or demonstration in Brussels) were carried out in November by employees of the power plant in order to raise public awareness of the expected government decision regarding confirmation of the phase-out of nuclear energy.

#### 1.2.8 Tihange 3

The unit operated at nominal power without interruption, with the exception of three power reductions for purposes of power modulation: 29 July (75% of nominal power), 8 August (75% of nominal power), and 2 October (75% of nominal power).





## 1.3 Overview of inspections at other nuclear facilities



#### 1.3.1 Nuclear Research Centre (SCK CEN)

The operating regime of the BR2 reactor in 2021 consisted of 7 cycles and 2 short cycles of 2 days in order to carry out a transient on a test assembly.

The transient was not carried out during the 06/2021B cycle, however, because the experimental conditions could not be achieved after the reactor was restarted.

On 27 March, there was a scram of the BR2 reactor due to the loss of 10 kV supply from the substation. The normal network was out of service for 1 hour and the emergency network was supplied by the emergency generators. During the outage of the normal power grid, there was no access via the speedgates or the emergency door from the administrative building to the machine hall. Outside the BR2 site, the various speedgates for vehicles were out of service, as a result of which access both inside and outside the BR2 was difficult. The reactor was contaminated (Xenon contamination) after the scram and was restarted after around 40 hours.

When loading the PRF3 irradiation device during the 01/2021 cycle, the reactor operators placed the reactor control system settings in a state that was not compliant with the requirements of the technical specifications. A reactive inspection by the FANC / Bel V took place and a number of corrective actions were imposed.

During the 01/2021 cycle, a reverse took place in the BR2 reactor due to an action relating to the flow rate in the sampling circuit. This action was due to a faulty electronic Sineax module. After the reactor was shut down, a replacement device was installed and the reactor was restarted.

During the 04/2021 cycle, a leak was measured in the primary circuit of the BR2 reactor, which had risen above 150 l/h. The reactor was temporarily shut down to repair the leak. Upon visual inspection, the leaks were located along the axis of two check valves in the primary pumps.

On 15 September 2021, it was noted in the BIDASSE system ('BR2 Integrated Data Acquisition System for Survey and Experiments') that the signals from several primary water measurement loops in the BR2 reactor were falling, because a tap had not been turned off correctly. The unavailability of the primary water measurement loops constituted a deviation from the technical specifications.

During the evacuation test of the reactor building on 24 September, the outside door of the emergency air lock did not open. This was caused by adjustments to the operation of the emergency air lock carried out as part of the physical protection without the necessary communication about the adjusted procedure for using the emergency air lock and electric problems when carrying out these adjustments.

The VENUS reactor did not see much use in 2021. The reactor was used only for experiments for the purposes of a Master's thesis and for minor verifications relating to experiments that had already been carried out.

On 18 March, there was a scram at the VENUS reactor. An error occurred in the safety rods, with a report that a control rod had fallen off, but the precise cause could not be determined. On 16 December, there was a second scram at the VENUS reactor due to a power outage.

In the BR1 building, the dismantling of the Pu-lab is nearly finished.

On 14 July, a lack of water in the fire hydrant network for the BR1 building was identified during a check of the fire hydrants. For the BR1 reactor and the VENUS reactor, the fire hydrant network is not required under the technical specifications, but should be usable as part of the ultimate fire extinguishing procedure.

No significant events occurred in the other SCK CEN facilities in 2021. The dismantling of BR3 is proceeding according to plan.

The new calibration building (LNK) entered into service and the old calibration building (KAL) will be declassified in 2022.

#### 1.3.2 Belgoprocess

Periodic reports on the activities relating to the problem of the gel drums from the Doel nuclear power plant were submitted to Bel V. In this regard, inspections were carried out for the concentrate packages and the resin packages in buildings 150X and 151X. The sorting of all the packages of the Doel nuclear power plant in storage building 150X has been completed.

The construction of the new building 167X (the 'gel drum building') for the storage of noncompliant packages has begun, and will be monitored by Bel V with hold and witness points. The construction project will include an expansion of the building for the storage of the gel drums with inactive concrete stoppage.

The construction of the facility for the production of monoliths (IPM) and of building 170X (for the dismantling of the vessels in buildings 105 and 122) is ongoing and on schedule, and Bel V is monitoring the hold and witness points. For IPM, the site acceptance tests of the various types of equipment are being carried out.

Belgoprocess offered one lot of lead blocks to an external smelter with a much higher actual activity than estimated and declared by Belgoprocess. However, no operating limitations at the smelter facility were exceeded. Belgoprocess is taking the necessary corrective measures to improve the characterisation of those materials and the related controls.

When a container with historic waste containing radium was opened in building 280X, there was a brief flame, followed by a release of gases. This incident had no effect on the staff involved or the facility. In building 127X, the control of the bridges was upgraded and the transfer car was replaced.

#### 1.3.3 National Institute for Radioelements (IRE)

The National Institute for Radioelements has completely converted its purification process of medical radioisotopes from highly enriched uranium (HEU) to lowenriched uranium (LEU).

The residues from the HEU process (and, in the longer term, the LEU process) are transferred to SCK CEN, where it is planned to reduce the enrichment level (see Section 2.8 on the RECUMO project).

In order to improve its operational safety, its diversification and its future, the IRE has launched ambitious projects:

- installation of a new accelerator provided by IBA for the production of germanium-68;
- long-term operation of B6B, B6C and B6D;
- IUS ('installation d'ultime secours');
- new interim storage for radioactive liquid effluents;
- study of a new accelerator for the production of molybdenum-99 without uranium (see Section 2.9 on the SMART project);
- refurbishment of shielded cells and renovation of buildings and rooms transferred from ONSF and NTPE.

By the end of 2021, the leakage rate of cell C27 (according to ISO 10648) had deteriorated and was no longer as low as when this cell was first put into operation. This cell is still used for production from HEU. However, the health physics department has temporarily stopped HEU production in order to identify and adopt compensatory measures for the production in cell C27.

#### 1.3.4 JRC-Geel

In accordance with the action plan drawn up by JRC-Geel, a consolidated version of the Safety Analysis Report (SAR) approved by the Health Physics Department was finalised.

The upgrade of the Radiation Safety System (RSS) of the MONNET accelerator as well as the new version of the RSS of the GELINA facility were accepted. The addition of a new beamline for the GELINA facility is in the process of acceptance by the Health Physics Department.

On 9 January, a loss of negative pressure occurred in the laboratories and the hallway of MS2. This event was the consequence of the breakage of a belt of the GE02 extractor, for which preventive maintenance was not performed correctly in 2020. Replacing the GE02 extractor meant replacing three extractors. This change has yet to be made. On 5 June, a loss of negative pressure occurred once again in three laboratories of MS2. This event was the consequence of the breakage of a belt of the GE01 extractor. Negative pressure could be restored a few hours later by replacing the broken belt and restarting the GE01 extractor.

On 16 July, a loss of negative pressure was observed in the laboratories of the Main Building (building 010). This event was caused by water seepage in a corroded underground ventilation duct. The necessary repairs were made.

During systematic inspections, Bel V noted a failure to comply with the operational limit as regards the minimum air extraction rate for some hoods in the Main Building (building 010) and the Mass Spectrometry Building (building 040). This non-compliance led the Health Physics Department to temporarily adjust the height of the opening of the hoods in question, to allow JRC-Geel to conduct the necessary investigations and repairs.

#### 1.3.5 Franco-Belgian Fuel Fabrication (FBFC)

All dismantling activities were completed in 2021 and all the radioactive waste was transferred to ONDRAF/NIRAS.

The final dismantling report was submitted to Bel V.



#### 1.3.6 Other (class IIA) facilities

The year 2021 was marked by continued regulatory monitoring adapted to the specific situation of the licensees as a result of COVID-19.

Bel V observed that the Health Physics Department continued its missions and that the critical safety functions were maintained at the various class IIA facilities.

The following specific points should be noted for the class IIA facilities:

 A dismantling application was submitted for the cyclotrons at Telix. These cyclotrons were decommissioned at the Telix site and moved to SCK CEN for treatment in the BR3 workshop.

- A research programme was requested for the delivery of the experimental proton therapy bunker at the university hospital UZ Leuven. This element is necessary in order to approve the justification of this installation.
- Tests for the IRE's SMART project were conducted by IRE-Elit.
- The IRE submitted a class IIA application for authorisation of the operation of a C30 cyclotron. This application is currently under review.
- A letter by the FANC / Bel V with hold points during dismantling was sent to the licensee. The decommissioning of building B7 and of the premises in the B6E-B6F wing were finalised at the ONDRAF/NIRAS site in Fleurus. The construction of the annex for dismantling building B14 is under way. The transfer of the licence for the NTPE facilities to the ONSF took effect on 30 June.

- The FANC decree on Sterigenics was terminated after the requested action plan had been completed.
  The 'gamma cell' was evacuated from Sterigenics via Transrad.
- The dismantling plan for the VUB's cyclotron was approved by ONDRAF/NIRAS. The application for a dismantling licence will be submitted to the FANC in January 2022.
- An application for a licence to use an accelerator in the context of FLASH therapy was submitted by GasthuisZusters Antwerpen (the new licensee) and is currently under review.
- An application for a licence for proton therapy in Charleroi was submitted by ProtonW (the new licensee) and is currently under review.



## 1.4 Emergency preparedness and response

#### 1.4.1 Introduction

The onset of the COVID-19 pandemic in early 2020 and its continued impact throughout 2021 had a major effect on the resources available to the competent authorities as regards the response to an emergency situation. Priority was given (rightly so) to supporting the government in the development and monitoring of the actions taken to address the many challenges posed by this pandemic. However, despite these constraints, activities could be carried out to maximally maintain the response and intervention capabilities to be implemented in the event of activation of the Nuclear and Radiological Emergency Plan for the Belgian territory, in particular through the response exercises organised in Belgium and the (albeit limited) activities carried out within national and international groups.

#### 1.4.2 Emergency response exercises

In 2021, the following emergency preparedness and response exercises were held under the supervision of the National Crisis Centre (NCCN) of the Federal Public Service Interior:

- in September for Belgoprocess in Dessel: partial exercise limited to the interaction between the emergency crisis cell of the licensee (on-site) and the evaluation cell CELEVAL (off-site);
- in November for SCK CEN in Mol: partial exercise limited to the interaction between the emergency crisis cell of the licensee (on-site) and the evaluation cell CELEVAL (off-site);
- a methodologically supported exercise with the participation of local authorities and emergency services, in addition to federal cells and committees (coordination committee, evaluation / information / measurement cells) combining the exercise postponed from 2020 for the Tihange nuclear power plant and that of 2021, in the form of a two-stage exercise (in March and June 2021), the second of which was devoted to specific aspects of the transition phase;

 a methodologically supported exercise with the participation of local authorities and emergency services in addition to federal cells and committees (coordination committee, evaluation / information / measurement cells) for the Doel nuclear power plant in October 2021.

Despite the COVID-19 context and measures, these exercises were prepared, conducted and evaluated according to the current Belgian methodology for the preparation, execution and evaluation of emergency preparedness and response exercises.

As in previous years, these exercises, which allow the relevant persons at Bel V to regularly put into practice the provisions of the operational plans and procedures, also allowed for a number of findings to be made that will, after analysis, be subject to specific actions. In particular, the solutions reached during these exercises to address the constraints imposed by the public health situation, such as the use of hybrid working (on site and remote) by certain cells, could be made permanent in the way those cells operate, while taking into account the lessons learned from the exercises, such as the discipline needed for a partially virtual way of working.

In addition to the above-mentioned exercises, Bel V participated, to a limited extent, in an international exercise organised by the International Atomic Energy Agency (IAEA) at the Barakah (United Arab Emirates) nuclear power plant in October 2021.

#### 1.4.3 Other related activities

After the publication in the Belgian Official Journal of the Royal Decree of 1 March 2018 establishing the Nuclear and Radiological Emergency Plan for the Belgian territory, established under the aegis of the National Crisis Centre and with the participation of Bel V, Bel V continued to participate actively in the projects initiated in previous years (such as the development of improvements concerning the protection of responders in radiological emergencies and related training sessions).



#### 1.4.4 Improvement of Bel V's role

In order to improve the Belgian emergency preparedness and response in case of a nuclear emergency and especially the role of Bel V therein:

- Bel V staff participated in the Belgian emergency response and intervention capacity exercises, which, besides the response activities, required a lot of preparation, observation and evaluation of the response by the Bel V crisis team, by the licensee and by the other parties involved (evaluation cell of the National Crisis Centre).
- Limited communication and availability exercises and tests were organised throughout the year. A total of 38 such tests took place in 2021.
- Bel V together with the FANC continued actions intended to implement and use the tools developed by the Incident and Emergency Centre (IEC) of the IAEA as part of its 'Assessment and Prognosis' process, and in particular the 'Reactor Assessment Tool', to support the technical analysis carried out within CELEVAL.

- Two Bel V experts participated in a pilot training programme organised by the IAEA that is dedicated to the preparation, management, realisation and evaluation of largescale nuclear or radiological exercises.
- A Bel V expert spoke at the round table on tackling the unpredictable through crisis exercises that was part of a colloquium held in Paris on 24 November by the Institute for Radiological Protection and Nuclear Safety (IRSN, France) entitled 'Après l'accident nucléaire de Fukushima Daiichi : s'adapter à l'imprévu' (after the Fukushima Daiichi nuclear accident: dealing with the unpredictable).

#### 1.4.5 International collaboration

Bel V took part, partly in support of the Belgian competent authorities, in the following activity and working group:

 Working Group Emergencies of HERCA (Heads of European Radiological Protection Competent Authorities) (online meeting, 12 and 13 April and 20 and 21 September).





## Safety assessments and national projects



SECTION 2 - SAFETY ASSESSMENTS AND NATIONAL PROJECTS -----



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#### 2.1 **Probabilistic Safety Assessment (PSA)**

In 2021, ENGIE Electrabel and ENGIE Tractebel Engineering continued the development of Probabilistic Safety Assessments for spent fuel pools (including internal events and hazards as well as external hazards, i.e. seismic and external flooding events) in order to comply with the Royal Decree of 28 February 2020 (completing the Royal Decree of 30 November 2011 on the safety requirements for nuclear installations to incorporate the WENRA Safety Reference Levels for Existing Reactors of September 2014). Bel V closely monitors these PSA projects from a technical point of view. As a result of the first finalised PSA studies (i.e. Spent Fuel Pool PSA for internal events and hazards), ENGIE Electrabel proposed an action plan for the implementation of improvements on site. This action plan is also being monitored by Bel V.

As a reminder, at the end of 2020, due to ENGIE Electrabel's decision

to no longer target long-term operation for the post-2025 period, the Seismic PSA project was discontinued. Quick wins identified during walk downs performed within the context of the Seismic PSA project (and followed up by Bel V in 2020) were nevertheless retained as potential improvements. Some of these were implemented in 2021.

The upgrade of the Internal Events PSA also continued in 2021. The upgrade of the Level 2 PSA was finalised by ENGIE Electrabel and ENGIE Tractebel Engineering for Doel 1/2 and Tihange 1. In particular, Bel V discussed the 'graded approach' proposed by ENGIE Electrabel within the context of the Level 2 Fire PSA (for Doel 3, Tihange 1 and Tihange 3). After these discussions, the decision was made to develop a complete Level 2 Fire PSA for Tihange 3 (based on the last Internal Events PSA model) and to reassess the necessity to develop such a detailed Level 2 Fire

PSA for the other units (after assessing the Tihange 3 results). For Doel 1/2, the 'graded approach' for the Level 2 Fire PSA will be finalised by ENGIE Electrabel (as it was already ongoing at the time of the discussions).

The PSA applications and procedures developed on site by the licensee were also monitored by Bel V.

In particular, Bel V discussed the use of PSA within the context of the Safety Referential for the Post-Operational Phase. Bel V's international and R&D activities on PSA methodology and **PSA** applications are presented in Section 4.4.





#### 2.2 Periodic Safety Reviews (PSR)

#### National Institute for Radioelements (IRE)

In 2018, the National Institute for Radioelements submitted to the safety authorities the assessment reports on 15 safety factors prescribed by the IAEA methodology, as well as the overall assessment report. This allowed for a plan with 126 actions (and a timetable) to be drawn up and submitted to the Scientific Council of the FANC at the end of 2018. At the end of each action a request for completion is sent to Bel V, which verifies its accomplishment. Implementation of the action plan began in early 2019 and is scheduled for completion by the end of 2022. At the end of 2021, there were 29 actions left to finish before 31 December 2022.

#### Belgoprocess

Within the framework of the periodic safety review at Belgoprocess Site 1, the deadline for implementing the action plan expired in theory on 30 June 2021, but Belgoprocess has informed the FANC in writing that a number of actions have run into delays. Belgoprocess has continued working on implementing the outstanding actions.

With regard to the periodic safety review at Belgoprocess Site 2, the deadline for implementation of the action plan was 30 June 2021. Belgoprocess has carried out all the actions, with the exception of one involving the upgrade of the internal message broadcasting system, which is shared by both sites. This action will therefore be handled in future via the action plan for Site 1. In addition, the Q&A for a number of actions at Site 2 is continuing.

#### **JRC-Geel**

In 2021, JRC-Geel submitted the methodology document for the decennial review of JRC-Geel. Bel V analysed the document in question, clarified several aspects and formalised its analysis in a Safety Evaluation Report (SER), which was forwarded to the FANC. The evaluation phase is in progress. In the status report, Bel V noted a delay in the evaluation of different safety factors by JRC-Geel in comparison to the initial timetable. JRC-Geel explained the delay by the prioritisation of the various tasks to be completed (scientific projects, maintenance, operations, etc.).

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#### 2.3 PSR/Long-Term Operation (LTO) – G2

At the end of November 2020, ENGIE Electrabel decided to put an end to the PSR/LTO G2 project for the long-term operation (LTO) of the second generation (G2) reactors. Bel V took a number of actions in this regard in 2021. The most important of these involved documenting the 'state of affairs at the closing' of PSR/LTO G2, with a view to being able to quickly resume the project if it were decided to do so. Bel V also took the first step in 2021 to identify the needs and opportunities to improve the safety of the two newest reactors in the event of longterm operation, independently of ENGIE Electrabel. Because the project was terminated, this exercise was not carried out as initially planned, but was wrapped up and documented in such a way that it could be resumed quickly in the event of a decision to extend it.

The periodic safety review for the adjoining buildings of the Doel nuclear power plant (the building for waste treatment, the spent fuel container building and the building where the removed steam generators are stored) were still part of the PSR/LTO G2 project in 2021. Also in 2021, Bel V evaluated the scope and methodology for the periodic review proposed by ENGIE Electrabel, together with the FANC. A number of exchanges were held with the licensee regarding the questions and requirements by the FANC / Bel V in that regard.



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## 2.4 DECOM

The objective of the DECOM project (formerly 'D&D' – 'Decommissioning & Dismantling') is to prepare for the definitive shutdown and dismantling of the Doel and Tihange nuclear reactors. The current focus of the project is to prepare for the definitive shutdown of Doel 3 in October 2022 and of Tihange 2 in February 2023.

At this time, the project is at the stage of configuring the nuclear island, which will remain important for safety during the post-operational phase (POP), that is, from the definitive shutdown of the unit until the beginning of its dismantling. The nuclear island allows for safety functions to be performed (confinement, evacuation of residual heat, fire protection, etc.) for the facilities that will contain nuclear risks in POP and that will therefore have to remain operational. These facilities are mainly the spent fuel pools, but also include some facilities for treating effluent and waste at Tihange 2, as well as all the support systems at the other units.

In 2021, ENGIE Electrabel noted prohibitive difficulties with the approach previously discussed with Bel V in 2019 and 2020, and therefore decided to relaunch completely this phase of identifying functional systems or those that are important for safety that are to be retained, based on a structured methodology incorporating deterministic, probabilistic and risk assessment approaches. Validating this approach and applying it to the three main safety functions for the two units were the main activity of Bel V in 2021 as regards the DECOM project. At the end of the year, an agreement on the main lines of the configuration of the nuclear island was reached for Doel 3, and important progress was made for Tihange 2. In 2022, the following step will consist of validating, on the basis of the validated status of each system, the proposed status for each component, be it mechanical, electric or structural, in order to launch the ageing and qualification analyses, with a view to preparing the files for the change, decommissioning,

replacement or extension of the qualification. The objective was to obtain a validated, operational nuclear island in the months following the unit's definitive shutdown.

In this context, Bel V engaged in active dialogue with ENGIE Electrabel regarding the principles to be followed for the development of the safety report and of the technical specifications in the POP, as well as on the development of the management programmes for maintenance, ageing, qualification, etc. for the various statuses of the components. At the end of 2021, agreements in principle were given by Bel V regarding the various programmes.

All the information mentioned above must be included in the notice of termination of activities that ENGIE Electrabel has to provide six months before the definitive shutdown, that is, on 1 April 2022 for Doel 3 and 1 August 2022 for Tihange 2. The preparation of the notice of termination was the subject of numerous exchanges between ENGIE Electrabel and Bel V in 2021.

At the same time, ENGIE Electrabel has made good progress on preparations for the activities to be carried out in the post-operational phase, which are mainly the emptying of the pools of spent non-fissile materials and fuel (PAPOP – Pool Activities in Post-Operational Phase) and chemical decontamination of primary systems (CSD – Chemical System Decontamination). ►

The chemical decontamination of the primary system is the first activity carried out after the definitive shutdown and evacuation of the fuel outside the reactor building, and is intended to reduce the radiological risks in the final stages of the reactor's life. In 2021, Bel V focused mainly on analysing the status requests for the modifications planned at Doel and Tihange, and accepted the status of Non-Important Modification (NIM). Next, Bel V began the analysis of the first technical documents relating to the completion of the chemical decontamination, modifications to be made to the existing systems for purposes of decontamination and to the treatment of the radioactive waste generated.

After the definitive shutdown of the reactor, the spent fuel pool will become a place of important activities and ancillary activities. Preparations for these activities, in order to ensure that they are carried out safely and that the radiological impact on workers is reduced, are the objective of the PAPOP. In 2021, Bel V mainly analysed the first documents on the modifications to be made to these pools, on the validation of the containers and on the monitoring of ENGIE Electrabel's programme.

Lastly, as regards the post-operational phase, a great step forward is the development by ENGIE Electrabel of its overall vision and integrated planning for all the activities enabling the identification of the interfaces, risks and critical path of the dismantling. Beyond this intensive stage of technical analysis, strategic discussions continued in 2021 in order to prepare optimally for the transition from the operating licence to the dismantling licence. Nevertheless, in 2021 Bel V noted a lack of progress on a significant number of



strategic decisions related to the dismantling and the ending of discussions about the future waste treatment facilities for the dismantling.

The year 2021 was marked by the significant transfer by ENGIE Electrabel of responsibilities relating to the DECOM of the Corporate to the two sites. Bel V stresses the need for good relations and collaboration among these three units in 2021. In conjunction with the reorganisation of ENGIE Electrabel, Bel V set up a more or less mirror organisation to facilitate exchange and efficiency.



#### 2.5 Radioactive waste management

Since the licence application by ONDRAF/NIRAS on 31 January 2013, Bel V, in collaboration with the FANC, has been closely involved in the licensing process for the future facility for the disposal of low- and medium-level short-lived radioactive waste (category A waste) in Dessel. On 3 October 2019, the FANC's Scientific Council issued, at one of its sessions, a positive provisional prior opinion based partly on a safety inspection conducted by the FANC and Bel V. In this provisional prior opinion, the Scientific Council identified a number of elements which ONDRAF/NIRAS was asked to develop before the second session of the Scientific Council. ONDRAF/NIRAS started working on them in 2020 and continued to do so in 2021. In 2021, the FANC and Bel V therefore conducted an independent analysis of the documents submitted by ONDRAF/ NIRAS to develop those elements.

As part of the research into the 'bergbaarheid' (disposability) of the waste intended for near-surface disposal, in 2021 the 'action plan' version of the first conformity files were approved after analysis by Bel V. These conformity files, drawn up by ONDRAF/NIRAS, are intended to show that radioactive waste from a specific (sub-)family or

(sub-)variety is in conformity with the criteria for near-surface disposal. As regards 'bergbaarheid', Bel V analysed a number of technical notes from ONDRAF/NIRAS, including one about radiological uncertainties and one about an estimate of the frequency/volume of destructive/non-destructive tests (DT/NDT) that are to be carried out under the additional physical checks that ONDRAF/NIRAS will conduct of the waste. Lastly, in 2021 Bel V carried out an analysis of the accountability note by ONDRAF/ NIRAS for the 63 nuclides that licensees are required to provide when transferring cat. A and cat. B waste to ONDRAF/NIRAS.

In 2014, the FANC and Bel V initiated a collaboration involving the activities of the FANC and of ONDRAF/NIRAS around the longterm management of high-level and/ or long-lived waste (category B and C waste). As in previous years, so in 2021 the Belgian government has not yet made a decision about the long-term management of this type of waste. In this regard, Bel V offered its support to the FANC for the review of the national policy measures that are being prepared for this type of waste. Bel V also drew up a Safety Evaluation Report (SER), as part of the preparations for an initial methodological Safety & Feasibility Case (SFC1), after having analysed the 'contextual framework for ONDRAF/NIRAS SFC1' proposed by ONDRAF/NIRAS; this SER was submitted to ONDRAF/NIRAS via the FANC. These exchanges are important in preparation for this SFC1, the publication of which is planned for 2024 or 2025.

In 2021, Bel V also participated in drawing up a convergence note for ONDRAF/NIRAS / FANC / Bel V on 'monitoring a geological disposal facility'. Work on this note will continue in 2022.

Lastly, Bel V took an active part in the European Joint Programme on Radioactive Waste Management (EURAD) and in conducting research as part of the Strategic Research Needs (SRN), which identifies and structures the research and development needs of the regulatory body in the area of high level and/or long-lived waste disposal.



#### 2.6 MYRRHA / MINERVA

#### **MYRRHA**

MYRRHA is a project for a multipurpose irradiation facility coupling a 600 MeV proton accelerator with a fast spectrum reactor using leadbismuth eutectic coolant. The prelicensing phase of the MYRRHA project, initiated in 2011 in order to analyse the eligibility of the facility for licensing, continued in 2021.

After the federal government had announced in September 2018 that it would continue to support the MYRRHA project, and the year of transformation that followed in 2019, the year 2020 served to consolidate the project and set the foundations for the further development of MYRRHA into the decisive stages of the project.

At the end of 2020, in consultation with the federal government through the MYRRHA group, SCK CEN made several important decisions. In order to make more efficient use of resources taking into account all other important projects being carried out at SCK CEN, the license application date was set at December 2028 and the current pre-licensing period was extended to the end of 2024. At that date, the safety authority is expected to render an opinion on the status of MYRRHA. SCK CEN has committed to developing the full plant at concept design level by that time, and not only focusing on the primary circuit as was the case until now. In order to achieve that goal, SCK CEN will complement its technical and scientific capabilities by commissioning external engineering services providers, so that the full range of competencies required will be available for the project.

The year 2021 was marked by significant progress on the project. The licensee presented the new version of the design of the reactor's primary circuit, after several years of development. The design has been substantially simplified, leading to a reduction in the size, power and temperature of the reactor in order to prevent problems linked to the lead-bismuth chemistry (corrosion, etc.) and the pressure of the primary circuit. Bel V is mainly waiting for the licensee's document detailing this new design before moving forward on this topic.

At the same time the licensee introduced new versions of the summary documents of the safety guidelines to be implemented and of its management system. These key documents required for pre-licensing are currently being analysed by Bel V.

Technical workshops were conducted between the safety

authority and SCK CEN in order to flesh out some of these safety guidelines, such as the classification of the components and the combination of events.

An agreement was concluded with SCK CEN to facilitate access to data obtained in their experimental facilities, allowing Bel V staff to work on modelling those facilities and to get direct experience in the thermohydraulic issues happening in a reactor as complex as MYRRHA. This work will facilitate the license application process by providing Bel V staff with the solid technical knowledge required to assess the positions taken by the applicant in the safety case.

Based on the experience feedback acquired through working with foreign regulators and through the participation in international forums such as the Working Group on the Safety of Advanced Reactors of the Organisation for Economic Co-operation and Development (OCDE), activities were launched in collaboration with the FANC to assess the suitability of the current regulatory framework for the licensing of MYRRHA. Based on the results of this review, areas where additional requirements or technical guidance may be needed will be identified.

#### MINERVA

MINERVA (Myrrha Isotopes productioN coupling the linEar acceleRator to the Versatile proton target fAcility) is a linear accelerator (LINAC) characterised by a maximum proton beam energy of 100 MeV and a beam intensity of 4 mA.

This accelerator should be coupled with different sub-systems allowing the innovative production of medical radio-isotopes, the verification of the beam stability over time, etc.

SCK CEN, which initially followed the methodology for obtaining a class I licence, opted in the course of 2021 for a class IIa licence.

The licence request was submitted to the FANC in November 2021. In December 2021, Bel V received the Preliminary Safety Analysis Report (PSAR) and a series of supporting documents, which are currently being analysed.





#### 2.7 SF<sup>2</sup> – spent fuel storage facilities

The current interim spent nuclear fuel storage facilities at Doel and Tihange will be saturated by 2023. A new temporary storage facility for spent fuel (SF<sup>2</sup>) is therefore being built at both sites. For both facilities, the dry storage concept with dual purpose containers (transport and storage) was selected.

On 26 January 2020, the licence was obtained for the SF<sup>2</sup> facility on the Tihange site. In the second half of 2021, technical meetings were launched between the FANC /Bel V and the licensee ENGIE Electrabel in order to discuss the technical details of various licensing conditions.

The construction of the principal buildings was launched in April 2020 and the structure will be completed in March 2022. Bel V monitored the construction through periodic inspections and through hold points and witness points defined

by the safety authority. In parallel, Bel V monitored the construction and installation of the travelling crane and continues to monitor the mechanical aspects, EI&C (Electric Instrumentation & Control), etc. with a view to the confirmation of the operating licence in 2023.

After a positive opinion issued at the second session of the FANC's Scientific Council held on 28 May, in July 2021 the licence was granted to the SF<sup>2</sup> facility on the Doel site. Following this Scientific Council session, Bel V carried out a safety evaluation of the details on a number of topics that ENGIE Electrabel had worked out, which required further investigation on the basis of the safety evaluation prepared for the first session of the Scientific Council.

The construction of the principal building was launched in September 2021, and the foundations will be completed by the beginning of 2022. The base mat and part of the walls will be completed in the course of 2022. Bel V is monitoring the construction through periodic inspections and through hold points and witness points defined by Bel V.

The safety reports (TSAR – Topical Safety Analysis Report) for the five types of containers (by two manufacturers) that will be used for the storage of spent fuel in buildings SF<sup>2</sup> in Doel and Tihange are currently being analysed by Bel V. It should be noted that in 2021, the TSARs for the first two types of containers were validated by Bel V. The analyses of the TSARs for the three remaining types of containers will begin / continue in 2022.

#### \_\_\_\_\_ 2.8 RECUMO

The REcovery and Conversion of Uranium from MOlybdenum production (RECUMO) project consists in purifying HEU and LEU residue coming from the medical radio-isotope production process at the National Institute for Radioelements (IRE).

On 10 December, it was presented for the second time to the FANC's Scientific Council. A second positive opinion was issued.

As a result, SCK CEN obtained a construction and operating license.

In the future, in addition to the transport of HEU and LEU between the IRE and SCK CEN, Bel V will have to follow up the construction of the building and the implementation of the process, in order to monitor compliance with the license conditions.





## 2.9 Smart 4F

The Source of MedicAl RadioisoTopes (SMART) project of the National Institute of Radioelements (IRE) aims to develop an alternative method for the production of molybdenum-99.

The molybdenum-99 / technecium-99m generator still accounts for the majority of examinations performed in nuclear medicine. Before it can request a new authorisation, the IRE needs to carry out a research and development programme. Within this framework, throughout 2021, the IRE conducted a series of experiments in Fleurus and at European research sites in order to validate the theoretical concepts implemented in the SMART project. Bel V and the FANC were able to evaluate the first experimental results obtained during meetings with the IRE.



(2014 Safety Reference Levels)

In 2016, ENGIE Electrabel launched the WENRA RL2014 project, intended to ensure the full implementation of the WENRA Safety Reference Levels (SRL) of September 2014<sup>1</sup> in the Belgian nuclear power plants of Doel and Tihange. The WENRA SRL 2014 was included, via the Royal Decree of 19 February 2020, in the safety regulations of the Royal Decree of 30 November 2011 containing safety regulations for nuclear power plants.

ENGIE Electrabel divided up the WENRA RL2014 project into a number of studies, namely, 'Design Extension Conditions (DEC)' for both the reactors and the Spent Fuel Pools (SFP), 'Natural Hazards', 'External Flooding', 'Postulated Initiating Events for Spent Fuel Pools (SFP PIE)', 'Spent Fuel Pool PSA (SFP PSA)', 'Seismic PSA' and a number of 'Specific Activities'. For the completion of the safety improvements (design, procedures, etc.) resulting from these studies, a number of realisation projects were started. All studies were included in the WENRA Action Plan, while the realisation projects were included in the WENRA Implementation Plan.

From the start of the project until the end of 2021, more than 500 documents – for all the various studies – were submitted to Bel V, what amounts to around 86% of the planned studies. For all the studies, Bel V continued its analysis of the documents received in 2021 and discussed them at the technical meetings with ENGIE Electrabel.

In addition, ENGIE Electrabel launched a number of realisation projects, in particular for DEC A and DEC B (procedure updates, installation of alternative systems for DEC B) and for extreme meteorological phenomena (heat wave procedures). Moreover, various safety improvements that were identified during the development of the Seismic PSA and the Spent Fuel Pool PSA were partially implemented in 2021 (see Section 2.1). These realisation projects and safety improvements, which are part of the WENRA Implementation Plan, were carefully monitored by Bel V.

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<sup>&</sup>lt;sup>1</sup> Report 'WENRA Safety Reference Levels for Existing Reactors', 24 September 2014

 $https://www.wenra.eu/sites/default/files/publications/wenra\_safety\_reference\_level\_for\_existing\_reactors\_september\_2014.pdf$


#### 2.11 Construction projects Belgoprocess

The construction of building 167X and of the facility for the production of monoliths (IPM) is in progress. The construction programmes were monitored by Bel V via hold points and witness points. • For building 167X. the construction activities are in progress. Bel V takes the view that the Health Physics Department adequately carries out the various construction checks. Bel V had no particular observations during the inspections and associated site visits.

 For IPM, functional tests and site acceptance tests (SAT) were carried out on the worksite. Bel V had no particular observations during the inspections it carried out.

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# 2.12 Making the DE building independent

The project to make the DE building at Tihange (MIB.DE) independent, presented by ENGIE Electrabel to the safety authority in June 2021, is intended to make the DE building independent of Tihange 3 from both a technical and a legal point of view (operating licence). The aim is to be able to operate the pools of spent fuel from the DE building independent from the start of the dismantling of Tihange 3 and the shutdown of the last support systems, currently planned for 2030, until at least 2057. The longterm storage of spent fuel at the nuclear power plant will thus be ensured by the SF<sup>2</sup> (dry storage via containers, see section 2.7) and

by the independent DE building (storage in pools).

Technical independence will require internal changes to the DE building as well as the construction of annexes containing new systems that enable the DE building to operate independently of Tihange 3.

In particular, the Nuclear Safety Reference Document (NSRD) for the project, which defines the frame of reference of the project as well as the nuclear safety requirements that apply to an Independent Spent Fuel Storage Installation (ISFSI) was evaluated by Bel V in October. Bel V did not identify any objections as regards the decision to save the DE building and make it independent, and neither has it identified at this stage any hurdles in the way of the next set of (pre-)feasibility studies. Nevertheless, Bel V will be attentive to the safety demonstration of the independent DE building and to the essential principles applied in said demonstration.

In October, ENGIE Electrabel also submitted to the safety authority a concept note describing the safety guidelines for the proposed technical configurations of the independent DE building. The note is under analysis by Bel V.



# **Boostivities and projects**

SECTION 3 - INTERNATIONAL ACTIVITIES AND PROJECTS -----



# 3.1 Cooperation with international organisations

#### **OECD and IAEA activities**

Bel V continued participating in the activities of the various committees, working groups and meetings organised by the Organisation for Economic Co-operation and Development (OECD):

- the Committee on Nuclear Regulatory Activities (CNRA);
- the Committee on the Safety of Nuclear Installations (CSNI);
- the Nuclear Science Committee (NSC);
- the CNRA Working Group on Inspection Practices (WGIP);
- the CNRA Working Group on Operating Experience (WGOE);
- the CNRA Working Group on Safety Culture (WGSC);
- the CNRA Working Group on the Safety of Advanced Reactors (WGSAR);
- the CSNI Working Group on Fuel Cycle Safety (WGFCS);

- the CSNI Working Group on Risk Assessment (WGRISK);
- the CSNI Working Group on Analysis and Management of Accidents (WGAMA);
- the CSNI Working Group on the Integrity and Ageing of Components and Structures (IAGE), and its subgroups on the integrity of metal components and structures and on the ageing of concrete structures;
- the CSNI Working Group on Human and Organisational Factors (WGHOF);
- the CSNI Working Group on Fuel Safety (WGFS);
- the CSNI Working Group on Electrical Power Systems (WGELEC);
- the CSNI Working Group on External Events (WGEV);
- the RWMC Integration Group for the Safety Case (IGSC);
- the CDLM Committee on Decommissioning of Nuclear Installations and Legacy Management (CDLM);
- the Incident Reporting System Coordinators' activities (IRS, IRSRR, FINAS).

For more information on the participation of Bel V in specific OECD projects, please refer to Section 4.4 on research and development.

Bel V's activities in relation to the International Atomic Energy Agency (IAEA) cover a number of standing committees as well as specific events. Concerning the standing committees:

- The former General Manager of Bel V (who retired in 2018) is a member of the International Nuclear Safety Group (INSAG) of the IAEA, and attended the virtual meetings organised in 2021.
- The current General Manager of Bel V, elected in 2020 as chair of the Technical and Scientific Support Organization Forum (TSOF) of the IAEA, participated in the activities of the Steering Committee of the TSOF.
- A Bel V representative is a member of the Steering Committee on Regulatory Capacity Building and Knowledge Management (coordinated by the IAEA) and he continued his activities in this committee.
- Bel V participated in the meetings of the Steering Committee of the Regulatory Cooperation Forum and support meetings with the European Commission.

Concerning the specific events, Bel V experts participated in several IAEA conferences, workshops and technical committee meetings, mainly on the following subjects:

- evaluation of physical protection systems at nuclear facilities;
- application of graded approach in regulating nuclear installations;
- ageing and obsolescence of nuclear I&C systems and components;
- experience in the development and application of level 2 PSA for nuclear power plants;
- · leadership and its development in nuclear organisations;
- · accelerators for research and sustainable development;
- · decommissioning of small facilities;

- neutronic and thermal-hydraulic calculational methodologies for research reactors;
- derivation of specific clearance levels for materials suitable for recycling, reuse or disposal in landfills;
- · seismic safety evaluation;
- · safety culture continuous improvement;
- safety of near surface disposal;
- demonstration of the operational and long-term safety of geological disposal facilities for radioactive waste;
- methodology, practices and approaches for determining critical knowledge in nuclear organisations;
- use of periodic safety reviews for long term operation of nuclear power plants;
- I&C and computer security for small modular reactors and microreactors.



#### 3.2 Cooperation with safety authorities

#### 3.2.1 WENRA Western European Nuclear Regulators Association

Bel V representatives participated, in support of the FANC representatives, in the WENRA meetings. In addition to the work progress of the subgroups (see below), the implementation of WENRA's future strategy was discussed. In 2021, special attention was paid to the Topical Peer Review (TPR) process, the need for revision of the safety objectives and their applicability for small modular reactors (SMR), some specific current technical challenges and relations with other international organisations (such as the IAEA and HERCA).

#### Reactor Harmonization Working Group (RHWG)

Bel V participated, in support of the FANC, in three RHWG meetings held in 2021.

The RHWG proceeded with benchmark study on the а implementation of the 2014 Safety Reference Levels (SRL) and practicable reasonably safety improvements for design extension conditions at the nuclear power plants. Bel V provided the requested information for the Belgian nuclear power plants.

With a view to the next update of the WENRA Safety Reference Levels for Existing Reactors, which is scheduled for 2024, a gap analysis has been performed for most issues in order to identify differences between the current SRL (published in 2020) and other valid references defining higher safety standards than those in the current SRL. Bel V experts contributed to this gap analysis for several issues. The gap analysis results will be further examined by the RHWG, in order to identify the desirable SRL updates.

For the 2023 Topical Peer Review (TPR) on 'Fire Protection', Bel V participates in the RHWG's preparation of the technical specifications for this Topical Peer Review.

Bel V also participated in meetings between the RHWG and ENISS (European Nuclear Installation Safety Standards), in particular to discuss ENISS documents on highquality industrial grade items.



#### Working Group on Waste and Decommissioning (WGWD)

The 45th WGWD meeting was held online from 22 to 26 March. Bel V participated in support of the FANC.

The WGWD discussed the current status of benchmarking progress and the way forward. In addition, a topical issue was presented by Slovakia on the import / export of foreign radioactive waste.

The WGWD contribution to the IAEA International Conference on Radioactive Waste Management: Solutions for a Sustainable Future (1 to 5 November) was discussed.

Bel V did not participate in the 46th WGWD meeting, which was held online from 27 September to 1 October.

#### 3.2.2 French-Belgian Working Group on the safety of nuclear installations

This working group is composed of the regulatory authorities of France and Belgium (ASN, IRSN, the FANC and Bel V). One or two meetings are held each year, alternately in Paris and in Brussels (the latter chaired by Bel V). The working group meetings cover a large range of topics on nuclear safety.

A virtual meeting took place on 17 March, in which the following topics were discussed:

- · Regulatory aspects and projects
  - France
    - Recent safety developments
    - Continued operation of the French 900 MWe nuclear
      power plants
  - Belgium
    - Regulatory developments and projects (LTO, SF2, stress test)
    - General news on facilities and notable events
- Overview of events in nuclear facilities
- · Post-accident management of nuclear accidents
  - Recent developments in post-accident management of nuclear accidents cross-observations to 2020 exercises
  - Bel V / FANC situation / review of the 2019 / 2020 crisis exercise and outlook for 2021
- Joint review of the 'Terms of Reference' of the French-Belgian working group on 'Installations Nucléaires de Base' (WG-INB)

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#### 3.2.3 Belgian-Swiss Working Group

This working group is composed of the regulatory authorities of Switzerland and Belgium (respectively ENSI, and the FANC and Bel V). One meeting is held each year, alternately in Bruges and in Brussels.

In 2021, due to the COVID-19 pandemic, this working group was held online again, on 24 September. The following topics were discussed:

- Exchange of information
- Changes in the regulatory framework
- Overview of recent events and projects
- Update on decommissioning projects
  - Status of the decommissioning of Mühleberg
  - Definition of the 'Nuclear Island', including maintenance

and ageing strategy and the inspection programme in the event of permanent shutdown of nuclear power plants in Belgium and Switzerland

- · Update on backfitting projects
  - Backfitting projects of the Leibstadt and Gösgen
    nuclear power plants
  - Backfitting of the main steam relief stations in Belgium
- Status of the disposal project in Belgium and Switzerland since the last time this was discussed
- Experience feedback on the preparation of IRRS (Integrated Regulatory Review Service)

#### 3.2.4 ANVS Autoriteit Nucleaire Veiligheid en Stralingsbescherming (Netherlands)

The agenda of the LTO consultations included the following items:

- 1. Brief explanation of the situation of the second LTO Borssele (ANVS)
- 2. Brief explanation of the LTO situation in Belgium (Bel V)
- 3. Adoption of PSR (LTO) measures: role and approach of Bel V in this (Bel V)
  - a. Independent research into potential measures (Bel V)
  - b. What is the role of the comparison with modern designs and which designs are involved as a reference (requirement of the Euratom Directive)?
  - c.How is the coordination with the operator carried out?
  - d. How will the final package be determined?
- 4. Overview of main PSR/LTO measures to be implemented in 2021-2025 (Bel V)

The management meeting had the following agenda:

- 1. Brief recap of the IAEA General Conference
- 2. Recent developments in both countries
  - a. Developments at regulatory level
  - b. Safety situation of the nuclear power plants and nuclear facilities
  - c. Topical themes: ANVS (PALLAS, SHINE, SMRs); FANC / Bel V (SF2, DECOM/POP)
  - d. Joint inspections and emergency plan exercises
  - e. Crisis preparations
- 3. Peer reviews
  - a. TPR-II and missions (IRRS ARTEMIS, OSART, INSARR)
- 4. Current affairs and agreements
  - a. Communication and information exchange
  - b. Cross-border information in permit procedures
  - c. Joint inspections exchange of interests and further agreements
  - d. Joint emergency plan exercises
  - e. Other actions and agreements

#### 3.2.5 Deutsch-Belgische Nuklearkommission (DBNK)

The 2021 meeting, which was held on 26 May, was the fifth meeting of the German-Belgian Nuclear Commission (Deutsch-Belgische Nuklearkommission – DBNK) as provided for in the bilateral agreement concluded between Belgian minister for Security and the Interior Jambon and German Environment Minister Dr Hendricks on 19 December 2016. Due to the COVID-19 pandemic, the meeting that was originally planned to be held in Bonn was replaced by a virtual meeting (and the agenda was shortened to 1 day instead of 2 days).

The following topics were discussed:

- General exchange of information regarding recent regulatory topics
  - Belgium
    - Overview of changes in the regulatory framework
    - Status of the preparations for decommissioning
  - Germany
    - Overview of changes in the regulatory framework (especially the 17th and 18th amendments to the German Atomic Energy Act)
    - Status of decommissioning
    - Update on the disposal site selection procedure
- Exchange of information on specific issues (status, operational experience, current safety topics, projects, COVID-19 impact and measures) and licensing, including research reactors
  - Belgium
    - Doel site (events, SF<sup>2</sup>, etc.)
    - Tihange site (events, SF<sup>2</sup>, etc.)
    - SCK CEN (BR2, prelicensing Myrrha, etc.)
  - Germany
    - General operational experience and German Information Notices (WLN)
    - FRM II (INES 1 event regarding discharges)





#### 3.3 Collaboration with technical safety organisations

#### 3.3.1 EUROSAFE

EUROSAFE is a global and initiative aimed European at promoting the convergence of technical nuclear safety practices in Europe. It is formed and managed by the EUROSAFE partners Bel V (Belgium), CSN (Spain), CV REZ (Czech Republic), MTA EK (Hungary), GRS (Germany), ANVS (The Netherlands), ENEA (Italy), IRSN (France), NRA (Japan), JSI (Slovenia), LEI (Lithuania), PSI (Switzerland), RATEN ICN (Romania), SSM (Sweden), SEC NRS (Russia), SSTC NRS (Ukraine), VTT (Finland), VUJE (Slovakia), Wood (United Kingdom), a group of technical safety organisations and European regulatory bodies with nuclear safety expertise and competent in nuclear safety assessments. Besides the authorities CSN, ANVS and SSM, all organisations are also members

of the European Technical Safety Organisations Network (ETSON).

Due to the COVID-19 pandemic, the 2020 EUROSAFE edition initially planned in Paris had to be postponed and was eventually held on 22 and 23 November 2021. The EUROSAFE Forum, which is a co-organisation with the Institut de Radioprotection et de Sûreté Nucléaire (IRSN, France), Bel V and the other EUROSAFE partners, brings together representatives of organisations specialised in nuclear and radiological safety techniques, research institutes, power companies, industry, public authorities and non-governmental organisations. Bel V participated actively in this Forum by being involved in the EUROSAFE Programme Committee, by cochairing technical seminars and by presenting several papers.

#### 3.3.2 ETSON European Technical Safety Organisations Network

The European Technical Safety Organisations Network contributes substantially activities to all within the framework of the EUROSAFE approach (i.e. the Forum, the newsletter and the public website), as well as to the work of strengthening the scientific and technical partnership. This work area applies to general or specific issues directly linked to the convergence of scientific and technical safety practices in Europe.

From 2015 until October 2018, the then General Manager of Bel V was President of ETSON. Since October 2019, the present General Manager of Bel V is Vice-President of ETSON.



From 2012 until Spring 2018, a Bel V representative chaired the ETSON Technical Board for Reactor Safety (TBRS) to oversee the technical activities of ETSON, such as the functioning of the ETSON Expert Groups and the publication of Technical Safety Assessment Guides (available at http://www.etson.eu/reports-andpublications). Since 2018, the chair has been held by a representative of IRSN. Bel V representatives took an active part in the ETSON Expert Groups, aimed at sharing views and experiences with colleagues of other technical safety organisations. The Chair of the ETSON Technical Board for Reactor Safety took initiatives in 2020 to propose collaboration with the WENRA Reactor Harmonization Working Group. These initiatives resulted in the TBRS being involved in two tasks led by the Working Group on Waste and Decommissioning (see Section 3.2).

Bel V is also active in the ETSON Research and Development Group (ERG) and has chaired the ERG since 2018. For more information, please refer to Section 4.4.2.

Due to the COVID-19 pandemic, the ETSON Junior Staff Programme (JSP) Summer Workshop could not be held in 2021.

#### 3.3.3 Collaboration with technical safety organisations on waste management

Bel V collaborates closely with other technical safety organisations, among others within the SITEX Network association (mainly aimed at strengthening TSO expertise in the field of radioactive waste managemen) and through its strong involvement in the European Joint Programme on Radioactive Waste Management (EURAD) (established in 2019 with a focus on R&D, strategic studies and knowledge management-related activities).



#### International 3.4 assistance projects

Within the framework of its international activities, Bel V collaborates with several technical safety organisations - such as IRSN (France) and Jacobs (United Kingdom) - within consortia created with the aim of supporting foreign safety authorities.

#### 3.4.1 Fusion for Energy (F4E)

The consortium led by APAVE including Bel V has tendered for three projects to support Fusion Energy (F4E):

- · provision of support services in the field of nuclear safety and engineering for the EC launchers for the International Thermonuclear Experimental Reactor (ITER);
- provision of support services in nuclear safety;
- · follow-up assessment of the level of nuclear safety culture currently existing in F4E staff.

In response to these calls for tender, for these three projects, the consortium was ranked 2nd, 3rd and 1st respectively.

#### 342 **Office for Nuclear Regulation (ONR)**

Bel V is part of a consortium (composed of Jacobs as tier 1 and Bel V and Tecnatom as tier 2) that has been selected for supporting the United Kingdom's safety authority ONR (Office for Nuclear Regulation) in a Technical Services Framework. The scope includes service provision across a wide range of technical disciplines.



#### 3.4.3 Direktoratet for strålevern og atomtryggleik (DSA)

Bel V, as leading entity and member of a consortium composed of Bel V, IRSN, ARPANSA and the Norwegian University of Life Sciences (NMBU), has been selected for a contract to support the Norwegian Radiation and Nuclear Safety Authority (Direktoratet for strålevern og atomtryggleik – DSA) with regard to the regulatory control of nuclear facilities and activities in Norway. The contract covers the following regulatory functions:

- Task 1.1 Development of regulations and guides
- Task 1.2 Notification and authorization
- Task 1.3 Review and assessment of facilities and activities
- Task 1.4 Inspection of facilities and activities
- Task 1.5 Enforcement
- Task 1.6 Emergency preparedness
- Task 1.7 Communication and consultation with interested parties

The duration of the contract is three years.

#### 3.4.4 Autoriteit Nucleaire Veiligheid en Stralingsbescherming (ANVS)

Bel V, as leading entity and member of a consortium composed of IRSN (for lots 1 and 3) and a consortium with IRSN and Bureau Veritas (for lot 2), has been selected for supporting the Dutch safety authority ANVS in three areas:

- Lot 1 Safety assessment
- Lot 2 Inspections
- Lot 3 Information gathering and advice for developments

The duration of the contract is six years.

#### 3.4.5 Autorité de sûreté nucléaire (ASN)

Bel V has been selected to support the French safety authority ASN for the project 'Prestations d'appui dans le cadre de l'instruction des analyses de sûreté soumises par le CEA à l'Autorité de sûreté nucléaire (ASN) relatives à l'installation nucléaire de base n° 24 (CABRI) localisée à Cadarache'.

The duration of the contract is four months. The contract is scheduled to start mid-January 2022.

#### 3.4.6

#### Institut de Radioprotection et de Sûreté Nucléaire (IRSN)

A contract was signed by Bel V to provide expertise to the French technical support organisation IRSN for the validation of the SCANAIR software. The objective of this software is to simulate the thermomechanical behaviour of a fuel rod during a reactivity insertion accident in a pressurised water reactor.

#### 3.4.7 Assistance projects of the European Commission

The main objective of the Instrument for Nuclear Safety Cooperation (INSC) projects financed by the European Commission is to promote a high level of nuclear safety, radiation protection and the application of efficient and effective safeguards of nuclear materials in third countries. For Bel V, it is a clear opportunity to share and apply its experience and practices at the international level.

The first phase of this programme was completed. The second phase of INSC projects covers the period 2014-2020. The beneficiaries of these projects are the regulatory safety authorities of the countries eligible for cooperation with the European Union. Bel V participated in the projects discussed below.

#### Ukraine

Bel V participates in the INSC project to strengthen the capabilities of the State Nuclear Regulatory Inspectorate of Ukraine (SNRIU) for the regulation of nuclear activities and for licensing and severe accident management of nuclear installations. This project will end in 2022.

Bel V is involved in two tasks:

- Task 1: Development of a strategy on completing regulatory capacity building and resource planning
- Task 4 (as Lead): Support in licensing of diversified nuclear fuel supplies for Ukrainian nuclear power plants

The partners for these two tasks are GRS, IRSN and DSA.

#### Morocco

Bel V participates in the second INSC project (which started in February 2018): 'Support to the regulatory body of Morocco for capacity-building and for enhancing the regulatory framework for nuclear and radiation safety'. This project is aimed at supporting the Moroccan regulatory body AMSSNuR in carrying out the duties and responsibilities assigned to a regulatory body, as well as organising its internal structure.

The consortium for this project is composed of IRSN, GRS, CSN, TECNATOM, SNRIU and Bel V.

The duration of the project initially planned for four years has been extended by six months to compensate for the delays caused by the COVID-19 pandemic.

#### Serbia

The consortium led by ENCO and also comprising SCK CEN, the IRE, HAEA and Bel V has been selected for a project to support the Serbian regulatory body SRBATOM and the Vinča site.

The beneficiaries are the Serbian Radiation and Nuclear Safety and Security Directorate (SRBATOM) and two organisations at the Vinča site (Public Company Nuclear Facilities of Serbia (PCNFS) and Vinča Institute of Nuclear Sciences (VINS)).

The project aims to:

- achieve further transposition of EU acquis in the field of radiation protection and nuclear safety into the national legislation of Serbia;
- contribute to the further development of the nuclear regulatory body SRBATOM through the provision of assistance in regulating radiation protection, nuclear safety and radioactive waste management;
- provide assistance in decommissioning selected facilities at the Vinča site.

The duration of the contract is 36 months. The contract started on 17 May.

#### **Belarus**

The consortium led by ENCO and also comprising SCK CEN, HAEA, UJV, SUJB, TUV-Nord, SNSA, UJD-SR and Bel V has been selected for a project to provide regulatory assistance to Belarus in the field of nuclear safety and radiation protection including radiological emergency.

The overall objective of the project is to further strengthen the managerial and technical capabilities of the Belarusian regulatory authority (Ministry of Emergency Situations (MES) – Gosatomnadzor (GAN)) and its technical support organisations.

The duration of the contract is 30 months. The project is scheduled to start in June 2022.





# Expertise management

SECTION 4 - EXPERTISE MANAGEMENT ----





# 4.1 Domestic experience feedback



Each year, Bel V performs a systematic screening of events at all Belgian nuclear facilities, as well as an indepth analysis of a number of events with emphasis on root causes, corrective actions and lessons learned. In 2021, more than 60 events were registered into the domestic experience feedback database.

For a number of events, a more detailed event analysis was performed with a view to identifying lessons learned which are potentially applicable to a wider range of nuclear facilities. In 2021, these analyses resulted in the drafting of one IRS report regarding degradations and non-conformities of concrete structures of bunkered buildings (at Doel 3, Doel 4, Tihange 2 and Tihange 3).

2021 was marked by several events in particular, which were analysed in depth by Bel V and for which appropriate analysis, regulatory inspection and followup of corrective actions were carried out. From these events, some lessons learned were identified, among others for the following topics:

- Correct procedure management
- Application of the STAR (Stop, Think, Act, Review) or PDCA (Plan, Do, Check, Act) approach
- · Handling of 'urgent' modifications
- Clear and appropriate communication
- · Need for quality control of subcontractors
- · Compatibility of parts
- Knowledge of consignment methodology
- · Selectivity of electrical protections

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# 4.2 Foreign operating experience feedback

In addition to screening domestic events, Bel V also performs a screening of events at foreign nuclear facilities as well as potential generic issues that are safetysignificant, require technical resolution by licensees or require generic communication to the licensees.

In this context, the analysis by Bel V of selected events may result in formal Operating Experience Examination Request Letters (OEERL) or Operating Experience Information Letters (OEIL) or requests to provide clarification on the extent to which the operating experience was taken into consideration by licensees, or in the conduct of specific inspections.

The Belgian nuclear power plant licensee was invited to provide answers to specific questions after analysis of the following reports:

- IRS 8935 'Phase-to-phase short circuit on the motor's electrical penetration insulating disc following a trip of a reactor coolant pump at nominal power and therefore an automatic reactor trip in QINSHAN 2-3';
- NRC IN 2007-21 S1 'Pipe wear due to interaction of flow-induced vibration and reflective metal insulation';
- IRS 8984 'Electronic transmitter component heat rise and the impact on qualified life';

- IRS 8996 'Damage to wheels of the containment polar cranes at nuclear power plants';
- NRC IN 2021-01 'Design basis capability of poweroperated valves at nuclear power plants'.

Further follow-up was performed for:

- NRC RIS 2013-09 and IRS 8381 'Guidelines for effective prevention and management of system gas accumulation';
- NRC IN 2016-05 'OPEX regarding complications from a loss of air instrument';
- IRS 8567/NRC IN 2017-05 'Potential loss of safety function for multiple systems from uncorrected Masterpact 480 Volt circuit breaker causing intermittent failure to close';
- IRS 8720 'Power supply failure results in operation in a condition prohibited by technical specifications';
- IRS 8725 'Inadequate Emergency operating procedure guidance for asymmetric natural circulation cooldown';
- IRS 8858 'Indications found during the Eddy-Current Testing of Steam Generator Tubes in Emsland (KKE) and Neckarwestheim-2 (GKN-2)';
- IRS 8859 'Failure of a contactors cells component in the 6.6 KV switchboards disabling some emergency systems';
- IRS 8890 'EDGs robustness in seismic conditions (generic issue at EDF nuclear power plants)';
- NRC IN 2018-10 'Thermal sleeve flange wear leads to stuck control rod at foreign plant' –;
- Westinghouse 10 CFR Part 21 notification 'CRDM thermal shield defect'.



#### 4.3 Knowledge management

For several reasons (one of them being that in the next years several experienced Bel V staff members will retire), Bel V is attaching great importance to knowledge management. Various tools are used in order to generate, capture, transfer, use and store knowledge.

The Technical Responsibility Centres (TRC) continue to play a key role in knowledge management within Bel V. There are about 20 Technical Responsibility Centres, acting as 'centres of competence' for all important fields of expertise of Bel V. Whenever needed to keep up with developments in nuclear issues, new Technical Responsibility Centres are set up (the latest examples concern decommissioning or security). Moreover, TRC management and operation are fully embedded in Bel V's Quality System.

In 2021, several new engineers were recruited. This requires considerable efforts on the part of the more experienced engineers to ensure an adequate transfer of knowledge. A coach is assigned to every newly recruited person, to facilitate their integration. This knowledge transfer approach is combined with, among other things, on-the-job training and cross-functional activities. The recruitment of a high number of new people also requires customised training (see Section 4.5).

Mention should also be made of the Bel V focus on knowledge transfer from retiring experts to younger staff. A Knowledge Transfer Form is used for this purpose. In addition, we also use a Knowledge Critical Grid that aims to identify and reduce the risk of knowledge loss. Other knowledge transfer tools (such as the Knowledge Books) are currently in the implementation phase.

Knowledge management is also closely linked to the R&D programme aimed at generating new skills, better ideas or more efficient processes (see Section 4.4).

The continuous implementation of the Bel V adapted Electronic Documentation Management software (KOLIBRI, based on Hummingbird DM) is an important tool for efficient retrieval of information, good knowledge sharing and easier integration of new members of staff. To this end, a specific committee known as the DOCumentation USers group (DOCUS) focuses on user needs analysis and on improvements. In 2020, Bel V also reinforced its capacity to retrieve documents by acquiring and implementing a more powerful searching tool.

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#### 4.4 Research and development

#### 4.4.1 Introduction

Research and development (R&D) activities are fundamental for the development of independent and informed safety positions. Continuous efforts must be made to build up, enhance and consolidate the expertise of Bel V's technical team in various relevant technical domains of nuclear safety. In addition, R&D activities performed or supported by Bel V are becoming increasingly important with a view to supporting the business development strategy. Regular interactions were therefore held between R&D and the Business Development Team in order to ensure consistency, support and synergies between these complementary activities.

The total effort in R&D activities in 2021 amounted to 8,198 hours, which represents 7,5% of the total working time of Bel V's technical staff.

The R&D activities in 2021 were in line with the milestones of the strategy 2020-2024, with several interactions with international organisations and other European organisations being organised within the framework of the OECD Nuclear Energy Agency (NEA) and the calls for EURATOM and Horizon Europe Work Programme 2021-2022. In particular:

- Bel V joined the OECD/NEA ETHARINUS and ATLAS3 projects.
- Bel V joined the end user/ support group of three European Commission projects (ACES, CORI and SFC).

- Bel V participated actively in the EC/H2020 projects MUSA and R2CA, as well as in the management and various activities of the European Joint Programme on Radioactive Waste Management (EURAD) co-funded by the European Commission.
- Bel V participated actively in the development of four project proposals submitted to the European Commission within the framework of the calls for EURATOM and Horizon Europe Work Programme 2021-2022 (HARMONISE, HARPERS, ASSAS and RESYST).

It should be also emphasised that collaboration with universities and research institutes was pursued and remained an essential part of Bel V's R&D strategy. The R&D activities carried out by Bel V in 2021 are described in the following sections.

#### 4.4.2 R&D on nuclear installation safety

# Thermal hydraulic phenomena

Most of the thermal-hydraulic R&D activities scheduled in 2021 were carried out successfully despite the COVID-19 pandemic. This included the following activities:

- The OECD/NEA experimental thermal-hydraulic projects with a view to gathering valuable information for a better evaluation of the different accidental scenarios under design extension conditions (DEC-A). This concerns the following projects:
- The ETHARINUS project, for which Bel V proposed to carry out an experimental test related to the impact of a delayed main coolant pump trip during a small break loss of coolant accident (SBLOCA) on the peak cladding temperature (PCT). The objective is to assess the cooling pump trip timing that leads to excessive cladding temperature.
- The ATLAS3 project, for which the Bel V representative was chosen to chair the Program Review Group (PRG). In this project, a Bel V proposal to carry out an experiment in the ATLAS facility was endorsed by the consortium and scheduled for 2023. This experiment addresses issues related to asymmetric cooldown procedure under natural circulation flow under extended accident conditions.
- The RBHT Workshop, for which Bel V provided technical support for the interpretation of the simulated test matrix assessing PCT quenching during the

reflood phase of a large break loss of coolant accident (LBLOCA).

- Within the framework of the French DENOPI project, a CATHARE model for simulating the MIDI test facility was developed and used to perform pre-test calculations of scheduled test matrix the containing nine experiments. The simulation results have been documented in a dedicated report. The bilateral cooperation with IRSN allowed Bel V to get the advanced CATHARE 3 code, while provision of the NEPTUNE CFD code is also foreseen. The latter will be used exclusively within the DENOPI project.
- Within the framework of the EC/ H2020 R2CA project, a CATHARE model for a 3-loop nuclear power plant was developed and used to simulate the steam generator tube rupture (SGTR) accident under design basis (DBA) and DEC-A scenarios.

The CATHARE radioelement model was considered in order to assess the amount of radioactivity released to the environment. This participation allowed to gather information about approaches and models used by the participants for DBA and DEC-A scenarios.

- Within the framework of the MYRRHA project, the RELAP5-3D computer code was used to support pre-licensing safety assessment activities. This included:
- simulation of a transient resulting

in primary side overpressurisation following heat exchanger tube rupture and secondary coolant ingress in a generic nuclear reactor with Pb-Bi primary coolant and ordinary water as secondary system fluid;

- preliminary simulation of the operation and performance of tests on the SCK°CEN experimental facility E-SCAPE using a RELAP5-3D model of the facility;
- preparation of lectures and auxiliary material for an internal training course 'Use of RELAP5-3D for Simulation of PWR and Pool-type Reactors with Heavy Liquid Metal Coolants (HLMC)'.

Several papers and technical deliverables from the outcomes of these activities were produced during 2021.

#### **Mechanical safety**

In 2021, Bel V continued to collaborate with IRSN and the French Alternative Energies and Atomic Energy Commission CEA on the mechanical testing of flaked material. Meetings were held to be kept informed of the progress. First testing results was obtained on a sound material. CEA then prepared flaked test coupons, and their testing is scheduled for early 2022.

As regards the expertise developed with the ABAQUS code, the geometry, the load distribution and the meshing of the bolting on trunnion for type C packages for radioactive spent fuel elements have been implemented in a finite element model. As part of the package safety design, the aim of such work is to analyse the functional capability of trunnion systems. In particular, possible localised plasticisation of the constituent material will be identified and linearised stresses (membrane + stress) will be evaluated. The finite element model includes the trunnion, the bolts and an appropriate part of the container wall with necessary contact conditions on all interfaces between these components. A mesh refining analysis was carried out to overcome a memory overload.

Bel V also participated in two international R&D projects. The first one concerned the EC/H2020 JHOP2040 project. During this workshop, the Jules Horowitz Reactor was presented, and the main management aspects of the project were described. The expectations of the support group in which Bel V participates were briefly addressed. The second project concerns the EC/H2020 ORIENT-NM project, whose aim is to produce a strategic research agenda for materials for all nuclear fission reactor generations, projected until 2040.

Finally, Bel V became a member of the End User Group of the SFC project on spent fuel characterization and evolution until disposal. This R&D project is part of the EC/H2020 Joint Programme on Radioactive Waste Management (EURAD).

#### Participation in the Halden Reactor Project

Bel V continued its participation in the project that started in 2018. Valuable information on postirradiation examinations (PIE) of already irradiated material has been obtained.

#### **Fire protection**

In 2021, Bel V took part in the benchmark exercise organised within the framework of the OECD/ NEA PRISME3 project, in collaboration with the OECD/NEA FIRE database. The objective of this project is to compare fire modelling codes and practices between PRISME3 members and associated organisations, as well as to assess the predictive capabilities of these codes by ultimately simulating a real fire event from the FIRE database. Simulation results of the PRISME3 experiment have been submitted, and show a satisfactory agreement with results from several other organisations as well as with the experimental data. Bel V also continued contributing to the OECD/NEA FIRE database, by adding selected fire events from the past. The preparation work for version 2020:01 of the database is ongoing and the database is expected to be published in 2022. Bel V also continued its participation in the OECD/NEA High Energy Arcing Fault Events (HEAF-2) project.



#### Probabilistic Safety Assessment (PSA)

In 2021, Bel V participated in several virtual events related to PSA (PSAEA Technical Meeting, RiskSpectrum User Group Meeting, and the OECD/NEA Working Group on Risk Assessment). Bel V was also involved in the End User Group of the EC/H2020 METIS (NUGENIA) project on Methods and Tools' Innovation for Seismic Safety Assessment. Finally, Bel V performed some specific investigations related to the modelling in RiskSpectrum for Spent Fuel Pool PSA submitted by the licensee within the framework of the WENRA RL 2014 project.

#### Severe accidents

The efforts in developing and improving Severe Accident (SA) simulation capabilities with the MELCOR code at Bel V continued in 2021, aimed at strengthening Bel V's capabilities for independent severe accident safety assessment of the Belgian nuclear power plants, but also at increasing its international visibility and experience. The progress regarding the SA simulations in 2021 was focused mainly LOCA on scenario investigations in support of Bel V's activities within the EC/H2020 MUSA project. Those investigations are achieved using a MELCOR 2.2 model of a 3-loop pressurized water reactor. Also within the framework of the MUSA project, the further development of capabilities in modelling uncertainties in SA was achieved. In addition, animation models have been developed to facilitate the validation of MELCOR models for different transients.

The Cooperative Severe Accident Program (CSARP) Research agreement between the US Nuclear Regulatory Commission and Bel V continued supporting the development of Bel V expertise. Bel V contributed to the CSARP meeting. In addition, Bel V participated in the MELCOR Code Assessment Program (MCAP) meeting and the 12th European MELCOR User Group (EMUG) meeting, which provided valuable support to Bel V's Severe Accident modelling activities, including information on capabilities of MELCOR and SNAP codes.

Bel V also participated in a number of non-recurrent workshops and conferences, such as the Workshop on 'Reactor core and containment cooling systems – long-term management and reliability' organised by the OECD/NEA and the EUROSAFE Conference.

Finally, Bel V joined a consortium led by IRSN in submitting the proposal for the ASSAS project for tender, following the recent call for Euratom Work Programme 2021-2022.

Several papers and deliverables on the R&D activities carried out were produced during 2021.

#### Concrete ageing

Bel V participated in the annual technical meeting of the ODOBA project, which was held with all partners to discuss the status of the project, the ongoing results and the next steps of the project. ODOBA is an experimental study of concrete and degradation ageing mechanisms conducted by IRSN in Cadarache (France). Bel presented the analyses and findings linked to the ageing and degradation mechanisms observed in the Test Walls at the Belgian surface disposal site.

Bel V joined the End User Group of the EC/H2020 ACES project (improved assessment of NPP concrete structures toward ageing).

# ETSON Collaboration and Expert Groups

As in previous years, and despite of the challenges posed by the COVID-19 pandemic, V Bel continued contributing to the activities of the Technical Board on Reactor Safety (TBRS) and related ETSON Expert Groups, aimed at sharing views and experiences with colleagues from other technical safety organisations. The following activities and achievements can be highlighted:

- finalisation, publication and sharing with other stakeholders (ENSREG, IAEA etc.) of the ETSON TBRS work plan for 2020-2025;
- preparation of two workshops to be organised in 2022: one related to safety issues during the last years of power reactor operation before final shutdown and another related to data science and

artificial intelligence for nuclear safety enhancements;

- continued contribution to the initiatives and tasks of the ETSON Communication Group (ETSON News, etc.);
- active participation in the preparation and organisation of the ETSON Award contest organised by the ETSON Junior Staff Programme (during the EUROSAFE Forum held in November 2021).

#### **SNETP network**

In 2021, Bel V participated in the different sessions of the SNETP Forum as well as in the General Assembly. Bel V was also actively involved in the discussions held within Technical Area 2 on severe accidents regarding project proposals in preparation in response to the call for Euratom Work Programme 2021-2022.

#### **MYRRHA**

A first topical report was written within the framework of the MYRRHA pre-licensing project.

It deals with the implications for licensing of using lead-bismuth eutectic (LBE) as a coolant and spallation target.

Several international papers, deliverables and internal reports were produced documenting the activities carried out in 2021.

### 4.4.3 R&D on waste and decommissioning

#### Near-surface disposal of category A waste

'Bergbaarheid' activities

- Bel V oversaw a physics engineering project of an ULB student on the 'Development of a tool to estimate the probability of exceeding radiological waste acceptance criteria for the safe disposal of radioactive waste'.
- Bel V participated in the review of deliverable D3.2 of the EC/H2020 CHANCE project on R&D needs for conditioned waste characterisation.

# Impact of cellulose on sorption in cementitious materials

Bel V became a member of the End User Group of the EC/H2020 CORI project (EURAD) and participated in the annual meeting of the project. Answer were provided to the following key questions on the impact of cellulose on sorption in cementitious materials, based on a review of the State-of-the-Art document developed in the CORI project:

- What are the possible degradation mechanisms of cellulose under ambient conditions of category A waste disposal (aerobic and anaerobic conditions)?
- What are the possible degradation products of cellulose and their quantities?
- What is the state of knowledge regarding the substitution in cementitious materials of anionic forms of critical radionuclides by anionic organic molecules resulting from cellulose degradation?

# Geological disposal of category B&C waste

2021 was a productive year for Bel V's R&D activities in the field of geological disposal. Initially, the programme for 2021 mainly included making progress on and finalising several actions of the Deployment Plan of the B&C Strategic Research Needs (SRN DP) and performing our contractual and co-funded EURAD activities (Lead of and contribution to the UMAN project, as well as contribution to the ACED and ROUTES projects). Contributions to the strategic development EURAD and SITEX\_Network were also foreseen. Several key milestones were achieved in the UMAN project:

- organisation of a second seminar on uncertainty management, gathering several participants providing a well-balanced representation of the views of waste management organisations, technical support organisations, research entities, regulators and civil society organisations;
- finalisation of several milestone documents and draft deliverables;
- organisation of a specific session of the first EURAD annual event, focussing on the management of uncertainties associated with residual heat emission of waste and its possible impact on clay barriers of disposal facilities;

 preparation of a UMAN course (scheduled to be organised at Bel V at the end of 2022) about uncertainty management.

Bel V also participated in the UMAN project as Lead of the expert group responsible for the identification of possible options for the management of uncertainties associated with the waste inventory. These activities are complementary and constitute a valuable input to the work on waste disposability (i.e. 'bergbaarheid') within the framework of the Belgian surface disposal project.

Moreover, in 2021, Bel V played a key role in the strategic development of EURAD as Bel V coordinated (as Chair of the EURAD Bureau) the development of the update process for the EURAD Strategic Research Agenda. The proposed process was accepted by the EURAD General Assembly.

As a consequence of the strong involvement of Bel V in EURAD activities, Bel V's contribution in the SRN DP actions was significantly reduced and mainly focussed on actions dealing with:

 the development of modelling tools and their use for the screening of radionuclides considered as critical for the longterm safety of a disposal facility. Bel V continued its collaboration with the von Karman Institute for Fluid Dynamics (VKI) on the use of the OpenFOAM code for the modelling of radionuclide migration in potential host rocks for the geological disposal of category B & C waste. Within that framework, a new simulation tool (OpenFOAM solver) was developed with the support of the VKI. This tool greatly facilitates and speeds up (by a factor of 500 to 10,000) the modelling of decay chains in radionuclide migration simulations, allowing for long-term safety assessments and in particular uncertainty / sensitivity analyses to be carried out more efficiently.

 the organisation of PEP (Pathway Evaluation Process) sessions in collaboration with the University of Liège. The PEP is a serious game developed by SITEX\_Network to structure constructive exchanges about the safety of radioactive waste management between different actors (including civil society).

Finally, due to the COVID-19 pandemic, SITEX\_Network activities in 2021 were limited to a few meetings. For instance, Bel V participated in a benchmark of review approaches implemented by several technical safety organisations when reviewing a safety case for a disposal facility.

Several papers and technical reports on these R&D activities were produced during 2021.

# Decommissioning and clearance

The SuDoQu project progressed well in 2021, with Bel V implementing further refinements in the SuDoQu model in order to bring it in accordance with the latest radiation protection data and to speed up and automate the calculation procedure. This resulted in the derivation of a set of surface-specific clearance levels and a methodology for publication in the Journal of Radiological Protection.

Within the framework of developing skills related to performing independent compliance measurements, the AEGIS software analysis routine was fine-tuned with the gamma intercomparison results performed by Bel V for all Class I installations. Other sample measurements were performed at the Bel V laboratory to gain confidence in the analysis method. Subsequently, field measurements were performed at the cyclotron department of UZ Brussel, where preparations for the dismantling of the cyclotron are ongoing and different components as well as the casemate were available for gamma spectrometric measurements.

Within the framework of the End User Group of the new H2020/LD-SAFE project (Laser Dismantling Environmental and Safety Assessment), Bel V responded to a project questionnaire and attended the LD-SAFE workshop held during the World Nuclear Exhibition conference to follow the progress of the project.

#### 4.4.4 R&D on cross-cutting issues

#### **Radiation protection**

The activities carried out in 2021 consisted in dose rate and shielding calculations, which allowed to benchmark the Dosimex and MCNP codes. This work showed that Dosimex can be used to verify the results obtained with other codes when geometries are simple.

#### Safety culture assessment

Bel V has a continuous focus on a better integration of the safety culture within the oversight practices, staff behaviour and its management system. With regard to R&D activities, a technology / regulatory monitoring has been set up to maintain and improve processes in place. Bel V also tried to share its developments through different publications in scientific journals.

In addition, from a regulatory body perspective, Bel V conducted a second Safety Culture Self-Assessment (SCSA) project. This SCSA was composed of a qualitative part and, as a new practice, а quantitative part (survey). For the latter. а questionnaire dedicated to safety culture issues was developed and sent to Bel V staff.

#### Cybersecurity

The activities in 2021 focused on the development of research programmes dedicated to the cybersecurity of industrial control systems for the forthcoming years. The partnership with ULB allowed Bel V to support a request for a new European master's degree, to join the CYPRESS project and to participate in the consortium that developed the REsilient and cybersecure electric **SYSTems** (RESYST) project proposal on cybersecurity and electricitv transportation in response to the call for Horizon Europe Work Programme 2021-2022. Since the purpose of these activities was to bootstrap R&D activities in cybersecurity, it is considered that these positive advances could lead to strong foundations for further R&D developments in cybersecurity.

# Emergency preparedness and response

In view of enhancing Bel V's expertise and competence in emergency preparedness and response, as well as strengthening the technical assessment capabilities of the evaluation cell CELEVAL, initiatives were taken at both national and international levels.

In 2021, these initiatives were mainly focused on gaining more insight into methodologies and tools developed by the IAEA Incident and Emergency Centre (IEC), in particular the Reactor Assessment Tool in view of its integration in the evaluation process (within the CELEVAL Technical Assessment Group). Practical tests were successfully performed during Belgian national exercises (i.e. organised and coordinated by the National Crisis Centre).

#### Advanced reactors

An MSc student project on the comparison of existing small modular reactor (SMR) technologies and related safety issues was initiated at ULB. The various SMR designs currently available on the market were identified and classified according to the type of technology (LWR, REP, etc.).

The most predominant technologies were identified. The next step is to perform a deeper analysis of these predominant technologies. This analysis will address the safety aspects.

# Fusion safety and licensing

Bel V participated in drafting the HARMONISE project proposal in response to the call for EURATOM Work Programme 2021-2022. This project aims to contribute towards the development of distinct performance-based licensing methodologies for innovative fission as well as fusion designs.

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# Accelerator-driven systems

In 2021, Bel V mainly updated available information, i.e. data, publications, patents and references, on the decommissioning of accelerators. These references were analysed and discussed during IAEA workshops on the decommissioning of small medical, industrial and research facilities (MIRDEC), during the EUROSAFE 2021 conference and with one of the main suppliers (IBA) of cyclotrons used for the production of radioisotopes for medical use.



#### 4.4.5 R&D collaboration

Several R&D collaborations were initiated in 2021 and in previous years with Belgian universities and research institutes as well as with other organisations, mainly within the framework of OECD/NEA and European Commission initiatives. Some of these collaborations ended in 2021.

# R&D collaboration with Belgian universities

#### **Ghent University**

The previous post-doctoral research work with Ghent University was reoriented towards improving the modelling of transient effects of fires in confined and mechanicallyventilated enclosures, as a direct continuation of the previous PhD work. The research funded by Bel V at Ghent University is reaching the end of the funding period. However, Ghent University will pursue the research work for the next year using the remaining budget and own funding.

#### von Karman Institute for Fluid Dynamics (VKI)

Bel V continued its collaboration with the VKI on the use of the OpenFOAM code for the modelling of radionuclide migration in potential host rocks for the geological disposal of category B & C waste. Within that framework, a new simulation tool (OpenFOAM solver) was developed with the support of the VKI. This tool greatly facilitates and speeds up (by a factor of 500 to 10,000) the modelling of decay chains in radionuclide migration simulations, allowing for long-term safety assessments and in particular uncertainty / sensitivity analyses to be carried out more efficiently.

# Université catholique de Louvain (UCL)

Two PhDs were sponsored by Bel V at UCL:

- A PhD is continuing on the complexation and colloid formation of U(VI) with boom clay dissolved organic matter.
- The PhD on 'Evaporation-driven turbulent thermal convection in water pools' within the framework of the DENOPI project was published in 2021. A meeting was also held to discuss future collaborations in the field of spent fuel pool safety.

#### **University of Antwerp**

The PhD that started in 2018 continued in 2021. The aim is to detect signals of radicalisation and psychological, family or financial problems, and to respond adequately. This work is performed in cooperation with the FANC, ENGIE Electrabel, Elia, G4S and Brussels Airport.

The third year of the PhD was mainly dedicated to the analysis of the survey conducted in 2020-2021 on insider threat awareness in several organisations and to the development of an insider threat mitigation model and its further development through the Delphi Study. Good practices in terms of insider threat mitigation were identified. A presentation was also given at the Membership Meeting Food Security Conference. Consequences for Bel V activities include the identification of practical measures to mitigate the insider threat with the support of the insider threat mitigation model.

#### Université libre de Bruxelles (ULB)

The following MSc student project with a direct link to Bel V's R&D needs related to radioactive waste disposal was supervised and completed in 2021: 'Development of a tool to estimate the probability of exceeding radiological waste acceptance criteria for the safe disposal of radioactive waste'.

Another MSc student project on the comparison of existing SMR technologies and related safety issues was initiated in 2021.

In 2021, the partnership with the ULB allowed Bel V to support the request for a new European master's degree, to join the CYPRESS project and to participate in the consortium that submitted the RESYST project proposal on cybersecurity and electricity transportation in response to the call for Horizon Europe Work Programme 2021-2022.

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#### University of Liège (ULiège)

In 2021, together with the FANC, Bel V set up a collaboration with the University of Liège (ULiège) on interactions with civil society within the framework of radioactive waste management programmes. This collaboration led to the organisation of PEP (Pathway Evaluation Process) sessions involving ULiège students. The PEP is a serious game developed by SITEX Network to structure constructive exchanges about the safety of radioactive waste management between different actors (including civil society).

#### R&D collaboration with other technical safety organisations, research entities and regulatory bodies

# Institut de Radioprotection et de Sûreté Nucléaire (IRSN)

Bel V collaborates with IRSN within the framework of the following activities:

- Bel V participates in the ODOBA project, an experimental study of concrete ageing and degradation mechanisms conducted by IRSN in Cadarache (France), aimed at developing a predictive tool to estimate the durability of reactor containment buildings of nuclear power plants or waste repository facilities.
- Bel V participates in the DENOPI project managed by IRSN. This project is aimed at acquiring experimental data on the physical phenomena associated with a spent fuel pool loss-of-cooling and

loss-of-coolant accidents. The project consists of a number of experiments, whose results will serve as a basis for model development and validation of numerical simulation tools.

• IRSN, the French alternative energies and atomic energy commission CEA and Bel V launched biaxial tensile and bending experiments on test samples containing hydrogen flakes. The purpose of these tests to further challenge the robustness of the safety demonstration performed bv ENGIE Electrabel and ENGIE Tractebel, which led to the nuclear power reactors of Doel 3 and Tihange 2 being restarted in 2015. In 2021, the first testing results were obtained on a sound material. CEA then prepared flaked test coupons, and their testing is scheduled for early 2022.

#### Rijksinstituut voor Volksgezondheid en Milieu (RIVM)

Bel V collaborates with the Dutch national institute for public health and the environment RIVM within the framework of the surface dose quantification (SuDoQu) model development.

#### Sustainable Nuclear Energy Technology Platform (SNETP)

Bel V collaborates with other R&D actors of the European nuclear community through its membership of the Sustainable Nuclear Energy Technology Platform (SNETP) and NUGENIA (which is now embedded in SNETP). The purpose of NUGENIA is to advance the safe, reliable and efficient operation of the nuclear power plants by facilitating collaboration among its members for applied R&D of the nuclear community. In 2021, Bel V participated in the different sessions of the SNETP Forum as well as in the General Assembly.

Bel V was also actively involved in the discussions held within Technical Area 2 on severe accidents regarding project proposals in preparation in response to the call for Euratom Work Programme 2021-2022.

#### ETSON Collaboration and Expert Groups

As in previous years, and despite of the challenges posed by the COVID-19 pandemic, Bel V continued contributing to the activities of the Technical Board on Reactor Safety (TBRS) and related ETSON Expert Groups, aimed at sharing views and experiences with colleagues from other technical safety organisations. The following activities and achievements can be highlighted:

- finalisation, publication and sharing with other stakeholders (ENSREG, IAEA etc.) of the ETSON TBRS work plan for 2020-2025;
- preparation of two workshops to be organised in 2022: one related to safety issues during the last years of power reactor operation before final shutdown and another related to data science and artificial intelligence for nuclear safety enhancements;
- initiation of the first reflections on the drafting of a report on

'Challenges and opportunities for licensing process and safety assessment of small modular reactors (SMR)', scheduled for publication in 2022;

- continued contribution to the initiatives and tasks of the ETSON Communication Group (ETSON News, etc.);
- active participation in the preparation and organisation of the ETSON Award contest organised by the ETSON Junior Staff Programme (during the EUROSAFE Forum held in November 2021).

#### SITEX\_Network

Bel V is actively involved in the activities and management of SITEX Network (Sustainable network for Independent Technical EXpertise of radioactive waste disposal). The purpose of SITEX Network is to enhance and foster cooperation at the international level in order to achieve a highquality expertise function in the field of safety of radioactive waste management, independent from organisations responsible for the implementation of waste management programmes and waste producers. aimed at supporting the nuclear regulatory bodies as well as civil society. SITEX Network is open to any institution or individual party having interest in independent regulatory assessment of radioactive waste management activities (technical safety organisations, regulatory and bodies civil society organisations).

#### European Joint Programme on Radioactive Waste Management (EURAD)

Bel V is actively involved in the activities and management of EURAD. This includes participation in the Bureau and General Assembly of the programme, as well as in several projects. The aim of EURAD is to implement a joint strategic programme of research and knowledge management activities at the European level. This programme brings together and complements EU Member State programmes in order to ensure cutting-edge knowledge creation and preservation in view of delivering safe, sustainable and publicly acceptable solutions for the management of radioactive waste across Europe now and in the future. EURAD gathers mandated waste management organisations, technical safety organisations and research entities from EU Member States and associated countries.

#### **OECD/NEA** joint projects

In 2021, Bel V participated in the following OECD/NEA projects:

- ETHARINUS;
- ATLAS3;
- Rod Bundle Heat Transfer (RBHT);
- Fire Propagation in Elementary, Multi-room Scenarios (PRISME-3);
- Fire Incidents Records Exchange (FIRE);
- High Energy Arcing Fault Events (HEAF-2);
- Experiments and Analysis for the Reduction of Severe Accident Uncertainties (ROSAU);

 THAI Experiments on Mitigation measures, and source term issues to support analysis and further Improvement of Severe accident management measures (THEMIS).

# European Commission H2020 projects

In 2021, Bel V participated in the following EC/H2020 projects:

- Reduction of Radiological Consequences of design basis and design extension Accidents (R2CA);
- Management and Uncertainties of Severe Accidents (MUSA);
- EURAD projects:
  - Uncertainty Management Multi-Actor Network (UMAN) (Bel V acts as Lead of this project);
  - Assessment of Chemical Evolution of Intermediate Level Waste (ILW) and High Level Waste (HLW) Disposal Cells (ACED);
  - Waste management routes in Europe from cradle to grave (ROUTES).

Bel V joined or continued its participation in the Advisory Board, the End User Group or the Support Group of the following H2020 projects co-funded by the European Commission:

- Characterisation of Conditioned Nuclear Waste for its Safe Disposal in Europe (CHANCE);
- Methods and Tools' Innovation for Seismic safety assessment (METIS);
- Laser Dismantling Environmental and Safety Assessment (LD-SAFE);
- Organisation of the European Research Community on Nuclear

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ш s Materials (ORIENT-NM);

- Jules Horowitz Operation Plan 2040 (JHOP2040);
- Spent Fuel characterisation and evolution until disposal (SFC (EURAD));
- Cement-Organic-Radionuclide interactions (CORI (EURAD));
- Improved assessment of NPP concrete structures toward ageing (ACES).

Bel V contributed to the development of the following project proposals which were submitted to the European Commission within the framework of the calls for EURATOM and Horizon Europe Work Programme 2021-2022:

- Towards Harmonisation in Licensing of Future Nuclear Power Technologies in Europe (HARMONISE);
- Harmonized Practices, Regulations and Standards (in waste management and decommissioning) (HARPERS);
- Artificial intelligence for the Simulation of Severe AccidentS (ASSAS);
- REsilient and cybersecure electric SYSTems (RESYST).







#### 4.5 Training

A structured training approach has been adopted on the basis of the Systematic Approach to Training (SAT) of the International Atomic Energy Agency (IAEA). Training programmes are developed for all staff members, and in particular for new hires, on the basis of the job descriptions and the relevant competencies needed. In this respect, Bel V has implemented the IAEA SARCON model in order to properly assess the competence level of new members of staff and therefore to fine-tune our competence needs analysis. In this regard, Bel V plays a leading role in the field of competence management, regularly providing support to other regulatory bodies through IAEA channels.

The training programmes are implemented using different methods, depending on the availability of training materials and the adequacy of external courses: self-study, internal training sessions, external courses or on-the-job training.

A key element of the initial training of new members of staff is the programme of internal training sessions conducted by the Technical Training Manager with the help of experienced experts (mainly from Bel V) as lecturers. This programme comprises 35 training modules: 7 sessions took place in 2018, 8 in 2019, 6 in 2020 and 7 in 2021 (mainly virtual sessions in 2020 and 2021):

- Q2-NS-11 Risk analysis (HAZOP, Bow tie...);
- Q1-REG-4 Quality management system;
- Q2-SPE-2 Ageing and mechanical analysis (obsolescence and qualification);
- Q3-RB-6 Physical protection and interfaces with safety;
- Q2-NS-9 INES;
- Q2-RP-1 Radiation protection basics (see Art. 25);
- Q3-RB-9 Waste management.

In addition, Bel V organises so-called 'Internal Technical Sessions' aimed at disseminating the R&D results to the Technical Responsibility Centres. In 2021, 3 Internal Technical Sessions were held.

Non-technical training was also offered on an as-needed basis (languages, IT, soft skills, leadership, etc.).

Also worth mentioning is the participation of Bel V staff members in numerous specialised or refresher training activities, and in several working groups, seminars and conferences at the international level.

In total, more than 27 training activities took place in 2021. Overall, the time dedicated to training represents approximatively 66 hours per individual per year.


# Financial report

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# Balance sheet as at 31 December 2021

(amounts in € 1,000)

	20	21	20	20
ASSETS		15925		15322

FIXED ASSETS		4339		4388
II. Intangible fixed assets		0		13
III. Tangible fixed assets		4336		4373
A. Land and buildings	3819		3981	
B. Plant, machinery and equipment	396		261	
C. Furniture and vehicles	121		131	
IV. Financial fixed assets		2		2

CURRENT ASSETS		11586		10935
VII. Amounts receivable within one year		3293		3176
A. Trade receivables	3174		3062	
B. Other amounts receivable	119		114	
IX. Cash at bank and in hand		8073		7597
X. Deferred charges and accrued income		220		161

	20	21	20	20
LIABILITIES		15925		15322

EQUITY		13254		12679
I. Capital	4732		4732	
IV. Reserves	2868		2868	
V. Result carried forward	5654		5079	

DEBTS		2671		2643
VII. Amounts payable after more than one year				
IX. Amounts payable within one year		2667		2643
A. Current portion of amounts payable within one year				
B. Trade debts	441		381	
D. Advances received on contracts in progress	200			
E. Taxes	2026		1348	
F. Other amounts payable				
X. Deferred charges and accrued income		4		0

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# **Profit and loss account as at 31 December 2021**

(amounts in € 1,000)

	2021	2020
Turnover	12941	14022
Other operating income	290	252
Total operating income	13231	14274
Services and other goods	1491	1862
Wages and social security costs	10735	10463
Depreciation	306	294
Write-downs on trade receivables		
Other operating charges	102	111
Total operating charges	12634	12730

Operating result	597	1544
Financial charges and income	-22	-4
Profit on ordinary activities	575	1540
Profit for the financial year	575	1540

## Profit and loss account: notes

### **Operating income**

Income in 2021 was 7% lower than in 2020. The decrease is largely the result of the reduced activities after the decision taken by ENGIE Electrabel at the end of 2020 to end all projects to extend the lifetime of two nuclear power plants. The costs remained stable compared to the previous financial year.

### Turnover

The largest part of the turnover of Bel V (95%) was related to the regulatory inspections and safety assessments at Class I facilities, which are invoiced to the licensees on the basis of a fixed rate set by law. This year was marked by the customary inspections within the framework of the operations, the preparation for the possible decommissioning of the seven nuclear power plants, the activities relating to the temporary on-site storage of spent fuel (SF<sup>2</sup> project), the inspections and analyses carried out within the framework of the licence application for the near-surface disposal facility, the activities under the WENRA RL2014 action plan, and the work done for the MINERVA/MYRRHA project.

A small portion of the turnover derived from contracts with the European Commission for support to nuclear safety authorities in emerging countries, as well as from regulatory inspections carried out at specific Class II facilities.

### Other operating income

Other operating income is not actual revenue, but consists of contributions by staff for the private use of company cars and for the provision of meal vouchers. In addition, part of the payroll tax was recovered in the context of R&D activities.

### **Operating charges**

### Services and other goods

Services and various goods represented 11% of the total operating charges. The transport costs stayed at the same level as in 2020, the first year of the COVID-19 pandemic.

The decrease in these costs is due to various factors. First, there were fewer expenditures for fees and for insurance. In addition, research and development expenditures were lower than in 2020 (in 2021, they still represented 1.9% of operating charges).

### Wages and social security costs

Staff expenses represented 83% of our costs, including training expenses. This is a slight increase in relation to 2020, but the absolute value of staff costs in 2021 had risen only slightly compared to the previous financial year.

### **Operating result**

Operating result for the financial year has been allocated to the result carried forward.

# List of abbreviations

ANVS	. Autoriteit Nucleaire Veiligheid en Stralingsbescherming (Netherlands)
APAVE	. Association des propriétaires d'appareils à vapeur et électriques (France)
ARPANSA	. Australian Radiation Protection and Nuclear Safety Agency
ASN	. Autorité de Sûreté Nucléaire (France)
CEA	. Commissariat à l'énergie atomique et aux énergies alternatives (France)
CNRA	. Committee on Nuclear Regulatory Activities (OECD)
CSNI	. Committee on the Safety of Nuclear Installations (OECD)
DECOM	. Decommissioning
ENSREG	. European Nuclear Safety Regulators Group
ETSON	. European Technical Safety Organisations Network
EURAD	. European Joint Programme on Radioactive Waste Management
FANC	. Federal Agency for Nuclear Control
FBFC	. Franco-Belgian Fuel Fabrication
FINAS	. Fuel Incident Notification and Analysis System
GIC	. 'Geïntegreerde inspectie- en controlestrategie' - integrated inspection and control strategy
GRS	. Gesellschaft für Anlagen- und Reaktorsicherheit (Germany)
HERCA	. Heads of European Radiological Protection Competent Authorities
IAEA	. International Atomic Energy Agency
INES	. International Nuclear and Radiological Event Scale
INSC	. Instrument for Nuclear Safety Cooperation (European Commission)
IRE	. National Institute for Radioelements
IRS	. Incident Reporting System
IRSN	. Institut de Radioprotection et de Sûreté Nucléaire (France)
IRSRR	. Incident Reporting System for Research Reactors
LTO	. Long-Term Operation
NCCN	. National Crisis Centre of the Federal Public Service Interior
NEA	. Nuclear Energy Agency (OECD)
NRC	. Nuclear Regulatory Commission (US)
OECD	. Organization for Economic Cooperation and Development
ONDRAF/NIRAS	. Agency for Radioactive Waste and Enriched Fissile Materials
POP	. Post-operational phase
PSA	. Probabilistic Safety Assessment
PSAR	. Preliminary Safety Analysis Report
PSR	. Periodic Safety Review
R&D	. Research & Development
RECUMO	. Recovery and Conversion of Uranium from Molybdenum Production
RIVM	. Rijksinstituut voor Volksgezondheid en Milieu (Netherlands)
SAR	. Safety Analysis Report
SCK CEN	. Studie Centrum voor Kernenergie – Centre d'études d'Energie Nucléaire
SER	. Safety Evaluation Report
SMART	. Source of MedicAl RadioisoTopes
SRL	. Safety Reference Levels
TBRS	. Technical Board for Reactor Safety (ETSON)
TRC	. Technical Responsibility Centre (Bel V)
TSAR	. Topical Safety Assessment Report
TSOF	. Technical and Scientific Support Organization Forum (IAEA)
TSO	. Technical Safety Organisation
VKI	. von Karman Institute for Fluid Dynamics
WENRA	. Western European Nuclear Regulators Association

