Authority for Nuclear Safety and
Radiation Protection

State of Nuclear Safety and Radiation Protection

Dutch nuclear facilities in 2019

Preface

This first report on the *State of Nuclear Safety and Radiation Protection* explains how the national and international system in the field of nuclear safety is structured. We go on to show how this system operated at Dutch nuclear facilities in 2019, also taking into account the aspect of radiation protection. Above all else, the goal is to protect workers, local residents, and the environment.

Day in, day out, we work to maintain and improve safety, for everyone today and for future generations. The licensees bear primary responsibility in this regard. Our authority monitors them by granting licences, regulating the industry, and taking enforcement action where necessary.

Much of this work takes place behind the scenes, both in the sector itself and within our own authority. We feel that it is important to share details of this work with you, and to gauge the levels of safety for others. It is not without reason that our key principles are openness, transparency, and continuous improvement. We take pride in the fact that this *State of Nuclear Safety and Radiation Protection* report enables us to lend further substance to this endeavour.

The Authority for Nuclear Safety and Radiation Protection,

Annemiek van Bolhuis, Chair of the Board

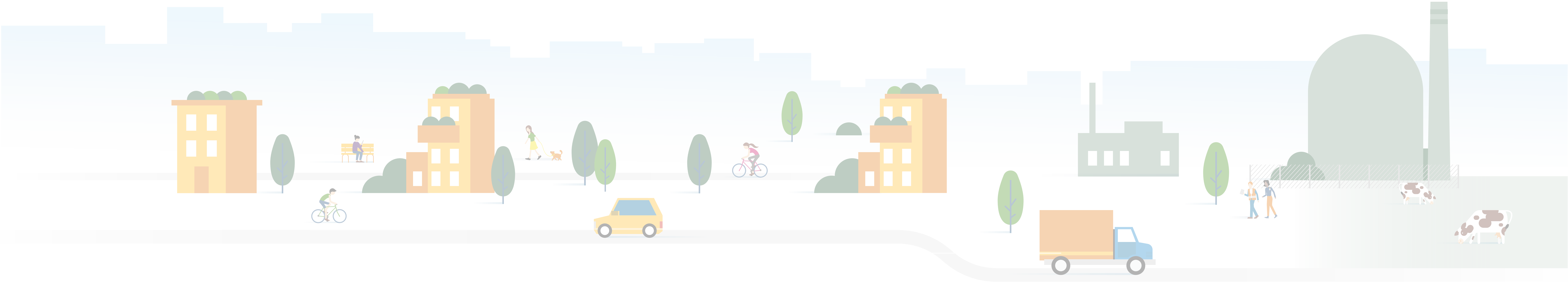
Marco Brugmans, Deputy Chair of the Board

01 Introduction

This is the first *State of Nuclear Safety and Radiation Protection* report. This State of Nuclear Safety and Radiation Protection report presents the international system that is designed to guarantee nuclear safety and to protect people and the environment against ionizing radiation. It also gives details of the safety situation at the Netherlands' nuclear facilities in 2019.

Despite its relatively small scale, the Dutch nuclear landscape is characterized by a diverse range of nuclear facilities. Each of these facilities work (or have worked) with fissile materials, to a greater or lesser extent. The nuclear technology used has various applications, ranging from energy generation to medical diagnosis and treatment, and from scientific research to industrial use. With each of these applications, it is vital for the nuclear facilities concerned to guarantee nuclear safety.

Ever since the first controlled use of nuclear technology, the need for a safe operating environment has been a priority. In the interests of operating nuclear facilities safely, the Dutch nuclear sector has traditionally placed great importance in engaging with international partners and sharing details of its experiences in this area. The International Atomic Energy Agency (IAEA), an autonomous organization within the United Nations, has been the intergovernmental forum for scientific and technical cooperation in nuclear technology since 1957.



01 Introduction

Throughout the world, guaranteeing nuclear safety and protecting people and the environment against ionizing radiation have been enshrined in various international instruments, which are often implemented in national legislation and regulations. In this context, the IAEA has produced an extensive collection of documents setting out the safety requirements to be met by different types of nuclear facilities, and how to comply with them[1]. Officially, the implementation of these documents is not mandatory. In addition, the European Atomic Energy Community (Euratom) has produced a Euratom directive[2] setting out the nuclear safety rules with which the Member States and the licensees of nuclear facilities are required to comply. The EU Member States are obliged to implement this directive in their national legislation and regulations. This has led to the creation of an international system that is as uniform as possible, and that incorporates various guarantees to ensure the safe use of nuclear technology.

One element of the nuclear safety system is the establishment of an independent regulator. Accordingly, in the Netherlands, the *Nuclear Energy Act* stipulates that there must be an independent administrative body (IAA), the Authority for Nuclear Safety and Radiation Protection (ANVS). The ANVS continuously monitors and augments nuclear safety, radiation protection, and security for this and future generations.

This first report gives details of the nuclear safety situation at the Netherlands' nuclear facilities in 2019. The ANVS uses *the State of Nuclear Safety and Radiation Protection* to supplement its *Unusual events*[3] report, which the Minister of Infrastructure and Water Management has annually disclosed to the House of Representatives in recent years[4]. Future reports on the *State of Nuclear Safety and Radiation Protection* will also cover the safety situation with regard to other uses of radiation.

The *State of Nuclear Safety and Radiation Protection* does not address the situation at nuclear facilities in the neighbouring countries of Belgium and Germany. As Member States, they are affiliated with the IAEA and Euratom and, like the Netherlands, have undertaken to independently comply with the agreed international standards on nuclear safety and radiation protection. The Netherlands maintains partnerships with its neighbouring countries, with whom it regularly exchanges information. The Netherlands also has a national warning monitoring network (the National Radioactivity Monitoring Network). This network, which operates independently of other countries, continuously measures outside air radiation levels throughout the country.

Chapter 2 gives details of the national and international system that is designed to guarantee nuclear safety. It also explores the various instruments used for this purpose, at greater depth. Chapter 3 provides a more detailed explanation of how this system's safety requirements are implemented at nuclear facilities, by means of a safety concept (or Defence-in-Depth concept). This includes outline descriptions of the safety situation at each facility in the Netherlands in 2019. These descriptions cover developments at these facilities, together with any improvement measures that have been taken (if applicable).

The ANVS continuously monitors and augments nuclear safety, radiation protection, and security for this and future generations.

In the Netherlands, there are six sites that house nuclear facilities, which involve a range of applications

1 High Flux Reactor and other facilities
Petten

Research reactor
Commissioned: 1961
Licensee: Nuclear Research and Consultancy Group

2 Urenco
Almelo

Uranium enrichment facility
Commissioned: 1973
Licensee: Urenco

3 Higher Education Reactor
Delft

Research reactor
Commissioned: 1963
Licensee: Reactor Institute Delft (RID)

4 Nuclear Power Plant
Dodewaard

Nuclear power plant
Commissioned: 1969 **Shutdown:**1997
Licensee: Joint Nuclear Power Plant Nederland

5 COVRA
Nieuwdorp

Central Organisation for Radioactive Waste
Commissioned: 1982
Licensee: COVRA

6 Nuclear Power Plant
Borssele

Nuclear power plant
Commissioned: 1973
Licensee: EPZ

02

The system that guarantees nuclear safety

This chapter introduces the national (and international) system that has been established to guarantee nuclear safety. The goal of nuclear safety is to take all necessary measures to prevent accidents or – if accidents do occur – to avoid or limit any associated impacts. The emphasis is on accident prevention. For this reason, the licensees of nuclear facilities must take timely (reasonably achievable) measures to improve nuclear safety.

In the Netherlands, the Euratom definition of nuclear safety is set out in the *Safety of Nuclear Facilities Regulations*[5]:

'Nuclear safety' means the achievement of proper operating conditions, prevention of accidents and mitigation of accident consequences, resulting in protection of workers and the general public from dangers arising from ionizing radiations from nuclear installations.

The national and international system consists of rules and organizations with the shared responsibility of guaranteeing nuclear safety. The licensee of a nuclear facility is primarily responsible for the nuclear safety of their facility. This is enshrined in the Euratom *Nuclear Safety for Nuclear Installations Directive*, which has been implemented in the Netherlands via ministerial regulations. The Euratom Directive also prescribes that each Member State must establish a competent authority to grant licences and to monitor the licensees' compliance with legislation and regulations (with a segregation of duties). The ANVS was established as a competent authority. Within the framework of its statutory duties, it takes substantive decisions independently of the Minister of Infrastructure and Water Management or the Dutch government. Policy responsibility for nuclear safety and radiation protection lies with the Ministry of Infrastructure and Water Management. The Ministry of Economic Affairs and Climate Policy is responsible for energy policy.

One form of Member State cooperation prescribed by the Euratom directive is peer review. The international system attaches great importance to this. That process often takes the form of an international mission to review the performance of a given Member State or facility (possibly with regard to a specific theme) and to suggest improvement measures (if applicable). Many of the system's safety measures are preventive in nature.

Accordingly, the results of inspections and peer reviews mainly contain recommendations for further safety improvements. That does not mean that the existing situation was unsafe, but simply that there is room for the introduction of extra safety measures.

These recommendations are in line with the nuclear sector's guiding principle of 'continuous improvement'. The licensee's legal obligations[6] and social responsibility require them to regularly assess the nuclear safety of their nuclear facility in terms of state-of-the-art developments, science, and operational experiences at other facilities. Once such knowledge becomes available, licensees are required to determine its implications for the nuclear safety their own facilities, and whether any resultant safety improvements are reasonably achievable.

2.1 International system

The international system that is designed to guarantee nuclear safety features a set of treaties, conventions, directives, and supporting documents (often of a technical nature). Known as the Euratom Nuclear Safety for Nuclear Installations directive, this system is the binding framework to which the Netherlands has committed itself as a Member State of the European Union. The requirements pursuant to the Euratom Convention[7] and the directives in the area of nuclear safety that derive from it are implemented in Dutch legislation.

One major convention to which the Netherlands is a signatory is the IAEA's *Convention on Nuclear Safety*[8] (CNS). Every three years, the Netherlands reports to other parties to the Convention regarding compliance with the requirements that this convention entails. The Convention provides important input for the Euratom directive. With regard to the renewal of the Euratom directive, great value is a ttached to more technical documents, such as the IAEA's Safety Fundamentals, Nuclear Safety Standards, and facility-specific Safety Guides. For some facilities in the Netherlands, various IAEA Standards have been made binding by attaching them to the licence in the form of a requirement.

The Western European Nuclear Regulators Association (WENRA) also provides key input for the Euratom directive. The Association is made up of independent competent authorities from various European Member States. Their common goal is to develop a harmonized approach to nuclear safety within the Member States. One of the first key results in this area was the publication (in 2006) of a series of Safety Reference Levels (SRLs) for the operation of nuclear power plants. These SRLs reflect the requirements and practices that WENRA countries will be implementing in their national systems and nuclear facilities. As with all IAEA Standards, SRLs can be made binding and can be attached to the licence as a requirement[9].

The *European Nuclear Safety Regulators Group* (ENSREG) is a key organization within the international system. ENSREG is an independent advisory body to the European Commission. It is made up of individuals from the Member States who are all experts in the fields of nuclear safety, radiation protection, and radioactive waste. One of ENSREG's objectives is to improve cooperation and openness between Member States and, where necessary, to advise the European Commission on additional European rules.

The nuclear accidents at Three Mile Island (1979), Chernobyl (1986), and Fukushima (2011) have had a significant impact on the development of the international system. It was the accident at Three Mile Island that triggered the development of general IAEA standards. After Chernobyl, the ten-year periodic safety reviews (PSR) were introduced, IAEA standards were tightened-up still further and the 1994 *Convention on Nuclear Safety* (CNS) was drawn up. This convention formed the basis of the 2009 Euratom Nuclear Safety for Nuclear Installations directive. Prompted by the accident at Fukushima, the European Commission ruled that stress tests should be conducted at EU nuclear facilities (see subsection entitled 'Peer review'). The European approach to stress tests gave a powerful impetus to closer cooperation between European national regulators.

2.2 National legislation and regulations

The Euratom Nuclear Safety for Nuclear Installations directive is, as previously mentioned, binding for the Netherlands. The EU Member States are obliged to incorporate the contents of this directive into their national legislation and regulations.

In the Netherlands, all activities with ionizing radiation are covered by the Nuclear Energy Act system. They are also subject to the general administrative orders (general orders in council), ministerial regulations, and ANVS regulations that derive from that Act. This includes the following (the list is not exhaustive):

- Nuclear Facilities, Fissionable Materials and Ores Decree;
- Decree on Basic Safety Standards for Radiation Protection;
- Fissionable Materials, Ores and Radioactive Substances (Transport) Decree;
- Regulation on the Safety of Nuclear Facilities;
- Regulation on Basic Safety Standards for Radiation Protection;
- Decree on Occupational Radiation Protection;
- ANVS Regulation on Basic Safety Standards for Radiation Protection.

Schematic overview of national legislation for activities with ionizing radiation.

2.3 Continuous improvement: PSR and peer review

The introduction to this chapter states that licensees are obliged to continuously improve the nuclear safety of their facilities[10]. Two key tools aimed at achieving continuous improvement are the ten-year periodic safety review (PSR) and the use of peer review.

2.3.1 Ten-year periodic safety review (PSR)

The licensees of nuclear facilities must carry out a periodic safety review (PSR) at least once every ten years (or sooner, if the ANVS deems it necessary)[11].
The PSR is used to systematically assess whether, at the very least, the facility's design requirements are being met, and whether any new safety improvements can be identified. The practical implementation of these reviews involves the use of internationally agreed standards and procedures. The PSR is certainly not intended to be used as a compliance check. There are standard regulatory procedures for that purpose.

2.3.2 International missions and peer review

Another practical application of the 'continuous improvement' principle is the participation by nuclear facilities or national regulators in international missions or peer reviews. These activities are quite unlike the inspections carried out by national regulators.
They often involve specially appointed teams of international nuclear safety experts, who examine a facility or organization and then publish a set of recommendations and suggestions. The ANVS publishes these reports on its website. In the course of any follow-up missions (such as IRRS missions, see below) checks are carried out to confirm that the recommendations have been followed up. The ANVS monitors these developments.

Reviews at nuclear facilities

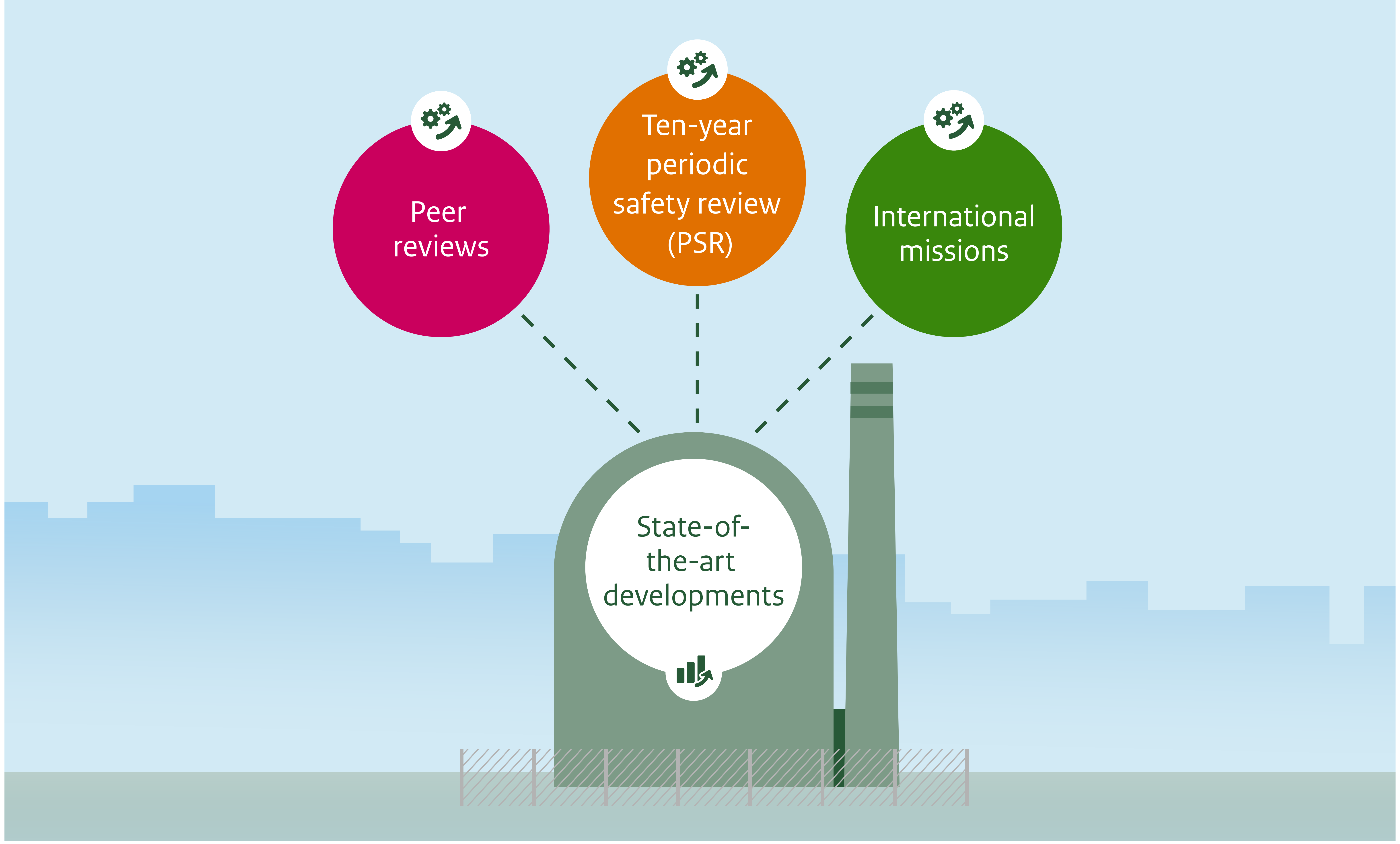
INSARR and ISCA are two examples of international IAEA missions that review nuclear facilities. INSARR (*Integrated Safety Assessment of Research Reactors*) is a comprehensive peer review designed to assess the safety of research reactors in terms of IAEA safety standards. Based on the results, it generates a list of recommendations for safety improvements. ISCA (*Independent Safety Culture Assessment*) was developed to provide the applicant organization with insight into the features of safety culture, shared values, and key principles. ISCAs enable organizations to develop and strengthen their own culture. The ANVS actively monitors the implementation of the recommendations arising from such missions. Depending on the level of risk involved, it may also include these in its regulatory programme.

One form of peer review is the Topical Peer Review. ENSREG was instrumental in the development of a system of six-yearly *Topical Peer Reviews*, which was incorporated into the Euratom directive in 2014. The first Topical Peer Review featured the theme of *Ageing management*. This review took place in the Netherlands in 2018, at the Borssele Nuclear Power Plant, the High Flux Reactor in Petten, and the Higher Education Reactor in Delft. Countries are expected to draw up national action plans, setting out the actions to be taken by both the licensee and the regulator. In this specific case, the ANVS monitors progress. In the context of its regulatory programme, it also checks that the licensee is performing these actions correctly.

One form of peer review that is not repetitive in nature is the performance of stress tests at nuclear facilities. After the 2011 accident at the Fukushima nuclear power plants, ENSREG began using stress tests at nuclear facilities in the EU. Stress tests supplement existing national safety studies. They are intended to shed light on a nuclear power plant's ability to cope with extreme events (involving natural disasters, human actions, and combinations thereof). Originally, these stress tests were only intended for nuclear power plants. Following the Fukushima accident, every facility in the Netherlands (except for the Dodewaard Nuclear Power Plant – which has been shut down) underwent a stress test. In 2012, experts from various European countries reviewed and debated each other's stress test reports. The ensuing improvement measures have been followed up by the licensees.

Reviews within national frameworks
International missions or peer reviews are not limited to nuclear facilities alone. The Euratom directive obliges Member States to undergo a 10-year self-evaluation, to examine their own performance within the chain. The key mission is the IAEA's *Integrated Regulatory Review Service* (IRRS). Such missions are invited in by individual Member States. Based on the applicable IAEA standards in the area of nuclear safety and radiation protection, these missions review legislation and regulations, the organization concerned, and the government's performance of its tasks. The Netherlands underwent its first IRRS mission in 2014, which included a Follow-Up Mission in 2018[12]. The next IRRS mission is scheduled for 2023.

One form of peer review in which the Netherlands participates takes place within the framework of the IAEA's *Convention on Nuclear Safety* (CNS), to which the Netherlands is a signatory. In a three-yearly national report, the Netherlands reflects on the implementation of its obligations under that Convention. It also discusses this issue in a presentation/Q&A session during a Review Meeting at the IAEA in Vienna. In the course of that meeting, the challenges faced by individual countries are discussed, and suggestions are made regarding ways to improve compliance with the Convention. Any progress made in following-up these challenges and suggestions is discussed during the following Review Meeting.



Summary of tools aimed at achieving the continuous improvement of nuclear safety.

2.4 Licensing system

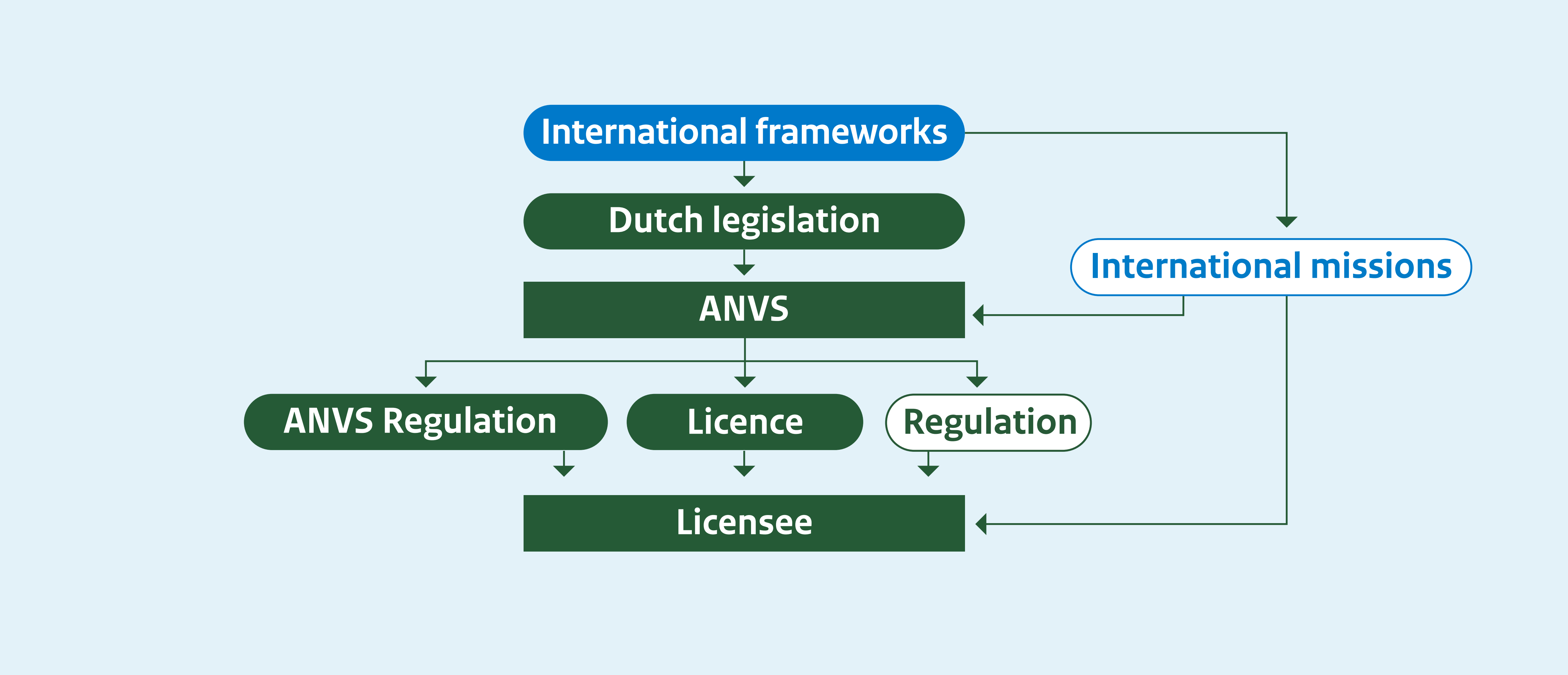
The licensing system is one of the *Nuclear Energy Act*'s key tools in the area of nuclear safety. The "establishment, starting up and operating, modifying, shutting down, and decommissioning of nuclear facilities are prohibited without a Nuclear Energy Act licence" [13]. The ANVS is the competent authority that grants such licences.

The *Nuclear Energy Act* distinguishes between a number of aspects on which an application for a nuclear facility must be assessed. One concern is the protection of people, animals, plants, and goods. Key issues such as the safety of the State and the security of nuclear facilities are also assessed. Operators must also hold an insurance policy pursuant to the *Nuclear Accidents (Liability)* Act and must comply with international requirements. Some licensing decisions entail both an inspection procedure and an Environmental Impact Assessment (EIA)[14].

Applications are also assessed to determine whether the nuclear facility in question complies with state-of-the-art developments. If it transpires that the facility's technology is outdated, the licence application can be refused. Any party applying for a licence to operate a nuclear facility is required to submit a safety report. This must include a risk analysis of any damage incurred outside the facility by accidents during normal operations.

Based on the information contained in the application, the ANVS also checks whether the applicant is compliant with the principles of radiation protection, i.e. justification, optimization, and dose limits. The review of compliance with these conditions takes place in the following order.

- **Justification** means that an activity which entails exposure to ionizing radiation is only permitted if the economic, social and other advantages of the activity in question outweigh the health detriment that it might cause.



Schematic overview of the relationship between international frameworks and Dutch legislation.

Nuclear facilities monitor the exposure of people and the environment. RIVM measures radiation levels in the outside air via the National Radioactivity Monitoring Network (NMR).

- **Optimization** means that all cases of exposure of individuals, in conjunction with the number of individuals exposed, resulting from activities with ionizing radiation must be kept as low as reasonably achievable, with social and economic factors being taken into account. The extent and probability of exposure are also included here. Optimization is a continuous process that takes place both in the preparatory and planning phase, and in the phase following the approval and implementation of the activities in question. This principle is known internationally as the ALARA principle (As Low As Reasonably Achievable). In the nuclear sector, optimization is often quantified in terms of dose constraints. These dose constraints (which are self-imposed by the licensees) must not be exceeded.
- **Dose limits** fulfil a safety-net function for workers and the population, i.e. if the application of justification and optimization (ALARA principle) is insufficient to achieve a given level of protection. The Decree on Basic Safety Standards for Radiation Protection[15] stipulates that an activity is only permitted if the organization ensures that any cases of exposure involving people and the environment that result from activities with ionizing radiation are kept within the dose limits. These dose limits for exposure and discharges are laid down in law. Working with fissile and radioactive materials invariably means that people and the environment will receive a dose of radiation (albeit a low one), despite all of the protective measures that have been taken. Nuclear facilities are obliged to continuously check and monitor any exposures and discharges. The results of these measurements are reported to the ANVS in periodic notifications. In addition, the National Institute for Public Health and the Environment (RIVM) carries out independent annual inspections of nuclear facilities, on behalf of the ANVS.

2.4.1 Licence amendments/assessments

If a licensee wishes to perform any activities that are not covered by their current licence, they must first apply for an amendment to that licence. This may concern changes in the areas of technology, processes, procedures, and organization. Alternatively, the licensee may wish to make safety-related changes in one of these

areas, within the framework of their licence.
Before they can proceed, they must obtain permission from the ANVS. After assessing the requested change, the ANVS may decide to include further requirements in the licence.

2.4.2 ANVS guidances
On its own initiative, the ANVS prepares guidances that are designed to help applicants draw up a license application. While they are not binding, these guidances do provide insight into the ANVS's procedures. Two examples of such guidances are the *Guidelines on the Continuous Improvement of Nuclear Safety*, and the *Notification Criteria Guidelines for Nuclear Facilities.*

2.5 Regulation and intervention
Legislation and regulations create a framework for regulation and intervention by the national regulator. This takes the form of a licence, based on the Nuclear Energy Act (and a number of generally applicable rules). The aim of regulation and intervention is to ensure compliance with statutory provisions, to encourage the adoption of an adequate safety and compliance culture, to guarantee adequate security, and to augment – in a general sense – the protection of people and the environment.

The ANVS has laid down the system of regulation and intervention at nuclear facilities in the form of a Regulation and Intervention Strategy (RIS)[16]. This sets out the principles and considerations on which the ANVS bases its choices, and explains how regulation and intervention are implemented in practice. The requisite, periodic stock-taking exercise reviews the extent to which internal inspection agendas are carried out (proactively) and when these are influenced by events at the facilities, in particular by incidents and notifications (reactively). The ANVS uses a risk-oriented approach to regulation. Regulators cannot monitor all risks equally, accordingly they make well-substantiated choices about which areas to address and how. This involves in an information-driven approach based on analyses that identify areas in which potential risks might be found. In preparing risk assessments, the ANVS takes account of national and international trends and developments in the sector, in the area of safety.

2.5.1 Proactive
The ANVS regularly specifies the subjects it is targeting (and the capacity involved) with its proactive inspections of nuclear facilities. These tactical choices are laid down, per facility, in a regulation plan (often spanning several years), and in more specific, thematic annual programmes. This programming is based on sources such as the ANVS Course Document[17], input from the licensing process, the impact of policy changes, and the evaluation of regulation and intervention over a transitory period. One specific type input used is Operational Experience Feedback (OEF), another is Regulatory Experience Feedback (REF). Here, details of experiences at the operational (at nuclear facilities) and regulatory (ANVS) levels are evaluated and used to plan future activities efficiently.

2.5.2 Reactive
The ANVS also carries out reactive inspections. These derive from a licensee's obligation to submit details of certain changes to the ANVS, for example. The ANVS assesses any amendment plans and carries out follow-up inspections where necessary. Reactive inspections can also be triggered by unusual events (see box) at a facility. Nuclear facilities are required to keep a record of any unusual events that take place at their facility. In addition, notification criteria have been established to identify any anomalies involved in those unusual events that are subject to a notification requirement. The ANVS has drawn up a guidance to assist with this[18].

The ANVS also performs inspections to assess the licensees' supervision of any internally recorded events. The purpose of such inspections is to verify that these recorded events are correctly resolved, that the licensee learns the necessary lessons, and to ensure that the ANVS is, indeed, notified about every event that is subject to a notification requirement. Only a small proportion of the unusual events that are notified to the ANVS can be rated as INES events (see box). The vast majority are rated as 'INES 0' (an unofficial category), because they are of very limited significance in terms of nuclear safety.

Unusual events

The International Nuclear and Radiological Event Scale (INES) – a system that is widely supported at international level – is used to classify unusual events. The aim is to apply the scale in the same way throughout the world. The International Nuclear and Radiological Event Scale (INES) is used to classify any events involving sources of ionizing radiation that impact (or could potentially impact) the safety of people and the living environment. This covers a wide range of events, such as the theft or loss of a radioactive source, a radiation incident at a hospital, or an accident at a nuclear power plant.

The ANVS assesses the severity of the event and determines the corresponding INES level. The initial INES-scale rating is not allocated until the immediate impact of an event has been identified and there is no further progression in terms of its severity. Thus, it is not always possible to allocate an INES rating immediately upon receiving the initial notification of an event. An INES rating only becomes definitive once the investigation into the malfunction has been completed and every item of information has come to light.

The INES scale has seven levels (from 1 to 7). In practice, an additional level is added at the lower end of the scale: INES 0. Events that are categorized as INES 0 have no impact on people and the living environment. These are of very limited significance in terms of nuclear safety and radiation protection within the facility.

All INES 0 notifications are monitored and recorded. The idea is to learn from them, in order to prevent potential larger-scale incidents.

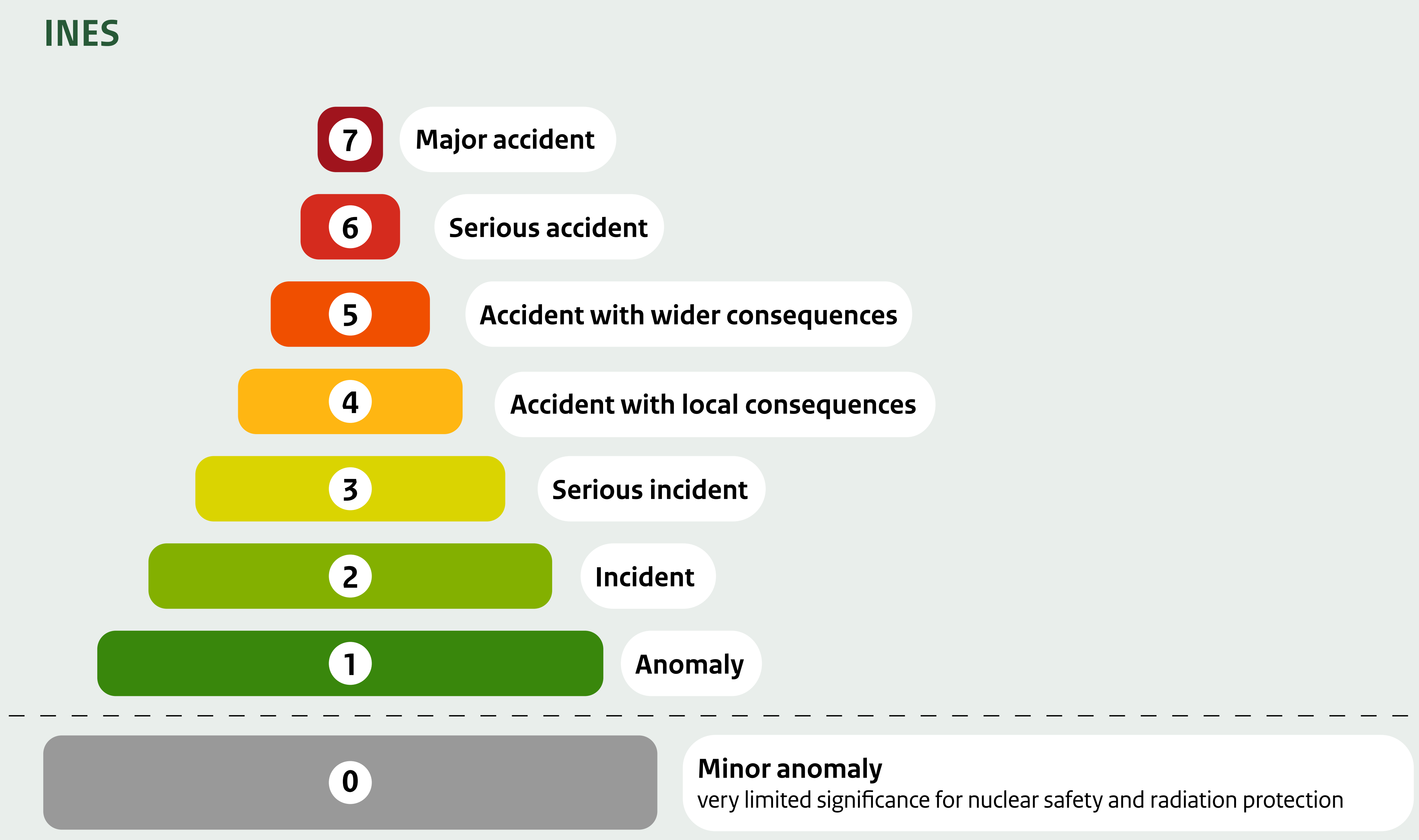


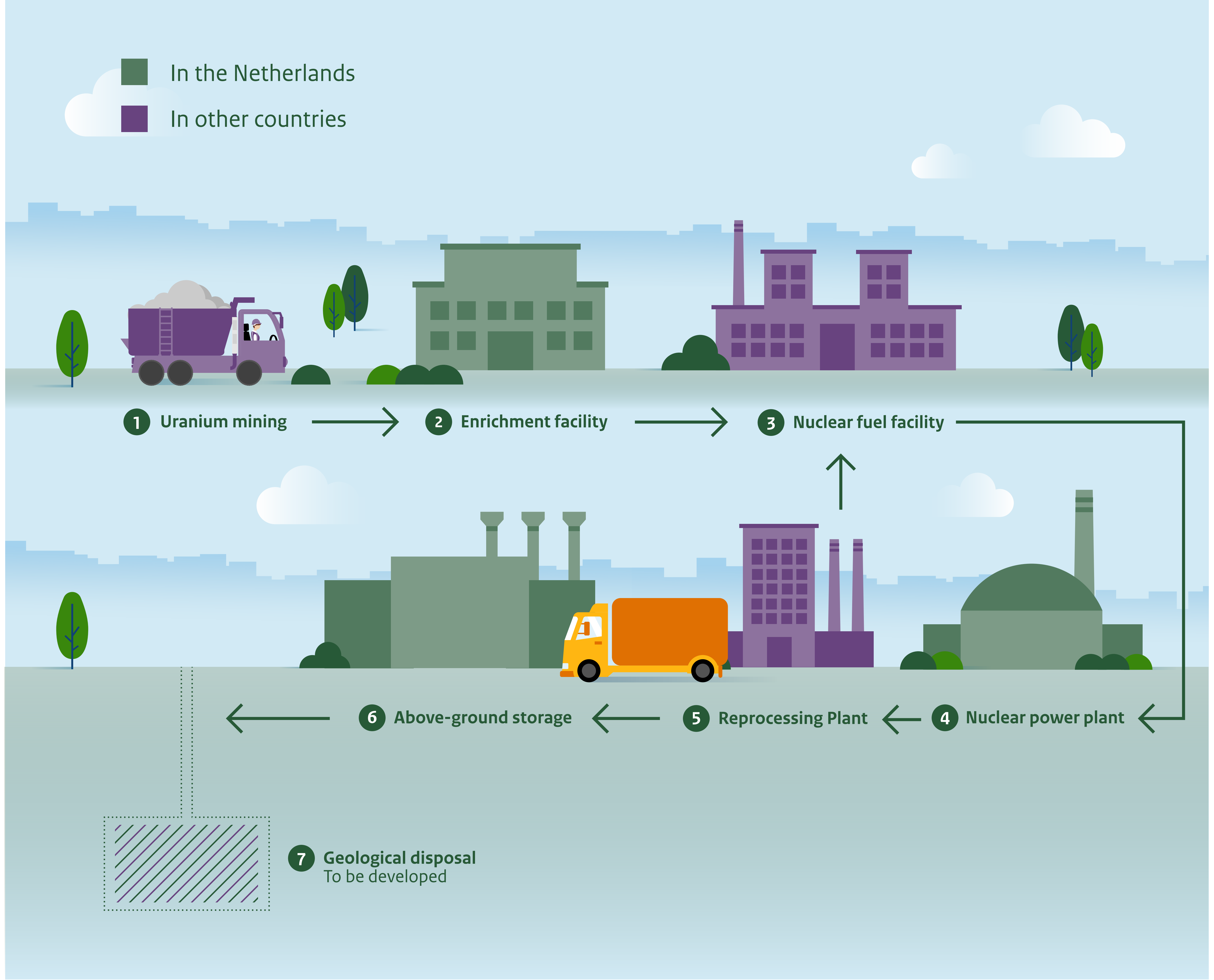
Diagram showing the various levels of the International Nuclear and Radiological Event Scale (INES).

03
Nuclear safety in the Netherlands in 2019

The Dutch nuclear landscape consists of various types of nuclear facilities. Each of these facilities work (or have worked) with fissile materials, to a greater or lesser extent. Nuclear safety is guaranteed by three safety functions that must always be ensured. These are controlling reactivity (the chain reaction of nuclear fission), cooling the fissile materials, and containing the radioactive substances or fissile materials (to prevent the release of these substances).

These three safety functions must be guaranteed at all nuclear facilities, but they are not equally important everywhere. For example, cooling is not a major factor at URENCO, as no heat is generated during the enrichment process. The only relevant factor at the Dodewaard Nuclear Power Plant is containment, as no fission process is taking place on site.

As previously stated, it is the licensees who bear primary responsibility for nuclear safety. This is enshrined in law. Legislation and regulations impose general requirements on the way in which the facilities are organized.



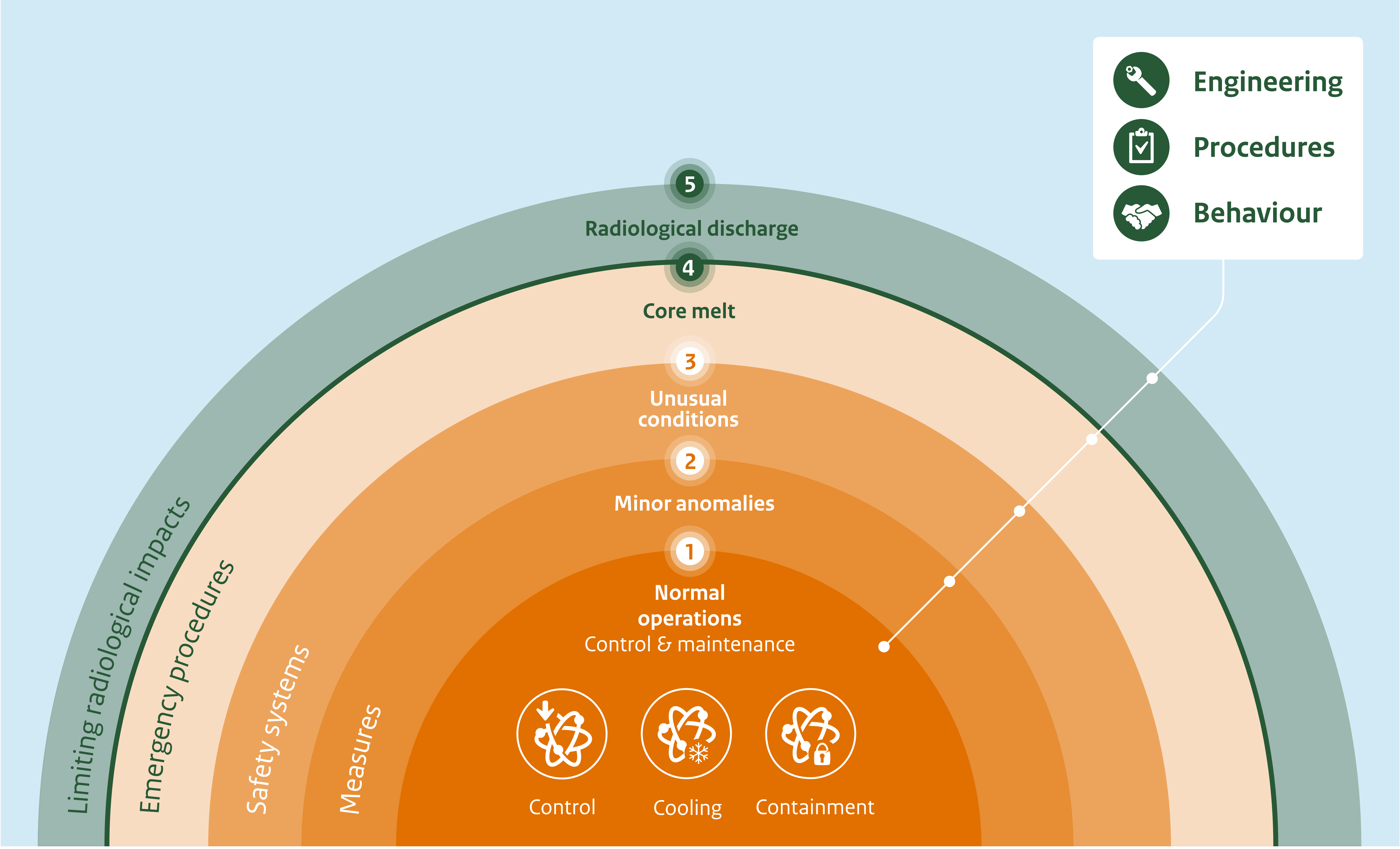
The nuclear fuel cycle features the steps required to convert uranium into nuclear fuel for the production of electricity.

For instance, they must be equipped with a management system. The conditions of the licences also require the licensees to conduct annual drills with the alarm organizations. The facilities are also subject to specific requirements. For example, reactor safety committees are required for the Borssele Nuclear Power Plant and the Nuclear Research and Consultancy Group's High Flux Reactor.

3.1 Gelaagd veiligheidsconcept

The nuclear safety of every nuclear facility in the Netherlands (and elsewhere) is based on the *Defence-in-Depth* concept. This strategy for defence in depth is twofold: first, to prevent accidents and, second, if prevention fails, to limit their potential consequences and prevent any evolution to more serious conditions. This is specified in various international directives and standards, as described in Chapter 2.

This safety concept involves an interplay of technical, organizational and human measures. One defining feature of this principle is that if measures at one level prove to be insufficient there are always additional overlying levels of measures to call upon. In the event of a defect, the independent nature of these measures prevents the entire safety system from failing all at once. There is always another independent layer.



The Defence-in-Depth concept involves an interplay of technical, organizational and human measures and barriers.

Each safety level has its own set of independent measures. These operate independently of one another, wherever possible.

1. Guaranteeing a normal process state. Preventing anomalies by designing features that make the installation reliable, stable, and simple to operate. That involves high-quality technology, with wide safety margins for the strength and capacity of safety-related components. It is also important for workers to be well-trained and to undergo regular retraining.

2. Managing anomalies. A nuclear power plant must have control equipment that can detect any anomalies in good time, and adjust the process to the normal process parameters.

3. Managing accidents, without core melt. If, however, the above-mentioned equipment should fail, due to abnormal circumstances, then the inbuilt safety systems will automatically bring the reactor to a safe condition and prevent any radioactivity from escaping. These systems have been designed with a predetermined number of abnormal events and potential accidents in mind. Furthermore, these systems are always installed in groups (so if one of them fails or is undergoing maintenance, there is at least one other functional system available to perform the tasks properly) and feature a degree of diversity (to ensure that one type of fault will not cause every system to fail).

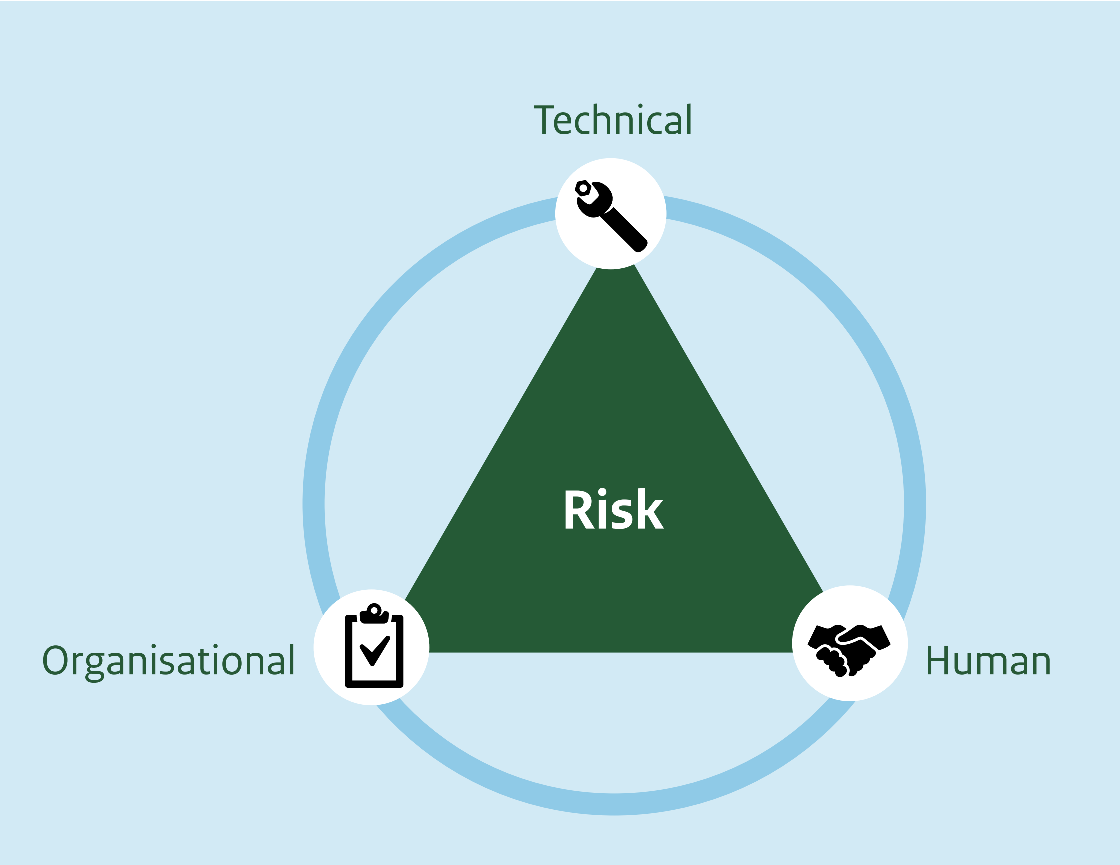
4. The management of accidents that result in core melt. The aim is to limit the impact, including the emission of radioactivity. This includes emergency procedures, as well as additional options for connecting up emergency cooling water and electricity.

5. Steps should be taken to mitigate any radiological impact on the surrounding area in the event of radioactive emissions. These include effective preparation for accidents and having a trained response organization on call that is part of the national crisis management structure.

The Defence-in-Depth concept must be incorporated into the design of every new nuclear facility as effectively as possible. For instance, ample use must be made of redundant, diverse, spatially separated safety systems. These safety systems must function both during normal operations and during unusual events.

The Defence-in-Depth concept must be incorporated into the design of every new nuclear facility as effectively as possible.

The measures taken at each level of the Defence-in-Depth concept can be roughly divided into three factors: technical, organizational, and human. The ANVS's regulatory activities focus on each of the five safety levels, and – within these levels – on each of the above three factors. In practice, these factors are not used or assessed independently of one another. They coexist, and are often interwoven to a great extent.



Risks are managed by implementing technical, organizational, and human measures.

Technical

The safety of a nuclear facility's technology (or of its design) is initially assessed by the ANVS prior to the start of construction. From then on, the licensee is obliged to make ongoing efforts to achieve further safety improvements. For instance, in the late 1980s, when the Borssele Nuclear Power Plant had already been in operation for a number of years, the design of the nuclear power plant was modified, enabling it to better withstand the hazards posed by earthquakes and floods. Every facility is regularly inspected to check that its safety systems and safety barriers still meet their design requirements.

Organisational

The organisational aspects include measures such as drawing up procedures, training workers, and having the correct certificates. These measures are important in terms of operating the facility safely, ensuring that the facility is properly maintained, procuring the correct parts, and installing them correctly. This safety aspect also includes various inspection programmes, such as a plant programme, the ageing management programme, and the monitoring programme.

Human

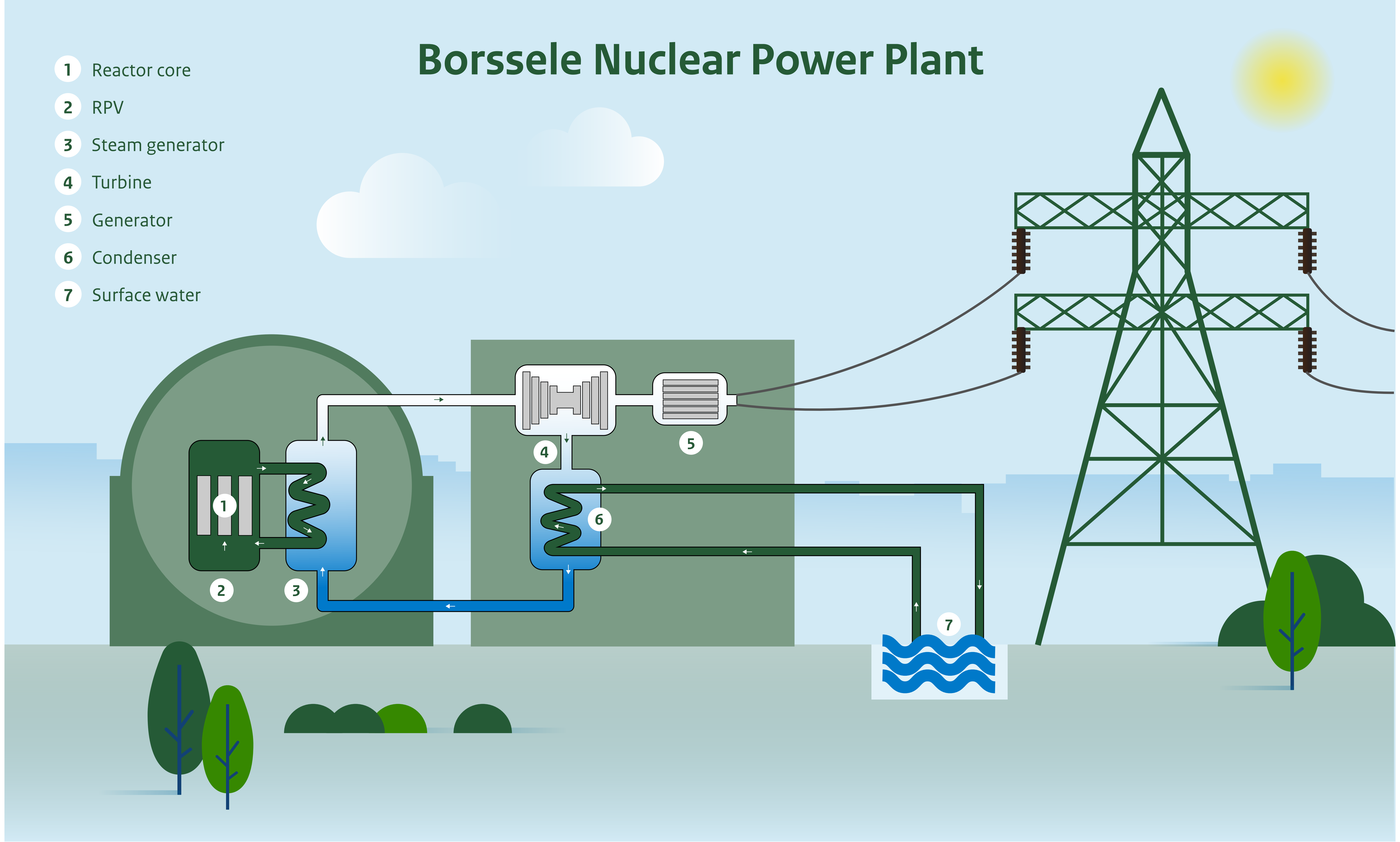
Behaviour refers to the applicable company-specific rules (both written and unwritten) and to the prevailing safety culture within the facility's organization. Safety culture covers the entire range of characteristics and attitudes (both of individuals and of the organization itself) that ensure a continued focus on protection and safety, as an overriding priority. As an aspect of behaviour, the safety culture within a facility has taken on a more prominent role in recent years. Leadership, for example, is currently the focus of a great deal of attention. The licensee must ensure that their corporate culture remains solid and effective, and they must make improvements where necessary. An evaluation (assessment) of the safety culture can show which parts of the organization are performing adequately, and which parts are not doing quite so well. This makes it possible to take targeted measures to improve the safety culture.

3.2 Borssele Nuclear Power Plant

3.2.1 Operation of the Borssele Nuclear Power Plant
In the reactors of nuclear power plants, uranium atoms are split to produce heat. That heat is then used to generate steam. That steam, in turn, is used to drive a turbine that generates electricity. The fission of uranium produces radioactive materials that require a separate set of safety provisions.

The Borssele Nuclear Power Plant has a net electrical power output of 485 Megawatts (MW). The plant, which has been in operation since 1973, is evaluated every ten years on the basis of state-of-the-art developments. The results of these evaluations are used to make further safety improvements.

The licensee is EPZ. Various committees monitor the plant's nuclear safety. Within EPZ itself, there is the Reactor Safety Committee. There is also the External Reactor Safety Committee (ERBVC). These committees specifically supervise safety, safety policy, assessment against – and compliance with – international safety standards and legislation. The licence imposes certain requirements on these committees. This is regulated by ANVS.



Simplified diagram showing the operation of the Borssele Nuclear Power Plant.

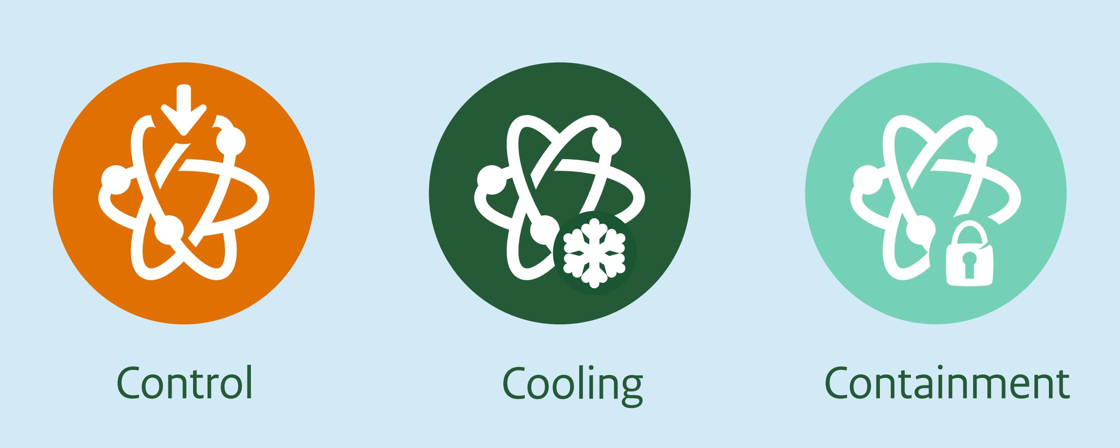
Now that the Borssele Nuclear Power Plant's design lifetime has been extended to 31 December 2033, managing the ageing of the facility (and its parts) remains an issue. EPZ has an ageing management process, which it has integrated into its maintenance programme. This programme is designed to ensure that those parts of the facility that are subject to a geing are periodically inspected and that they are maintained or replaced in a timely manner.

Every year, EPZ's alarm organization carries out a series of drills in which all of the internal and external parties involved participate. By this means, EPZ fulfils the legal requirement that it must be prepared for incidents.

- The regulators in other countries that operate the same type of nuclear power plant (KWU Siemens) consult one another on an annual basis. They use these consultation sessions to inform one another about their operations and about any malfunctions. In this way, they help one another to make continuous improvements to safety.

3.2.2 Developments at the Borssele nuclear power plant in 2019

In 2019, the nuclear power plant functioned within normal parameters. There were no incidents or accidents that posed a risk to the three safety functions – controlling reactivity, cooling, and containment – which must be guaranteed at all times.



The three safety functions are control, cooling, and containment.

In 2019, the following measures (including those in the context of the 'continuous improvement' of safety) were taken:

Technology

- EPZ's licence requires that an investigation be carried out into the ageing of the reactor pressure vessel (RPV). The results indicate that the reactor pressure vessel (RPV) is in good condition and there are no indications that the RPV cannot be used safely up to the end of 2033. In 2019, the results of this investigation were assessed and endorsed by the ANVS.

- The requirements of EPZ's licence include plant programmes, preventive maintenance, surveillance, and in-service inspections (ISI). These help to manage the operational risks. The fifth interval of the ISI programme was completed in 2019, with the approval of the ANVS. The ISI programme is designed to check the technical condition of the facility. EPZ and the ANVS actively coordinate with one another concerning the content of the ISI programme.

- Its licence requires EPZ to have a 'Technical specifications' document in its possession. This sets out all of the requirements to be met by systems, components, and the organization if these are to comply with the key principles of the safety analysis. In recent years, the technical specifications have been extensively revised by EPZ and reassessed by the ANVS. These revisions have made the texts clearer. They include Operational Experience Feedback (OEF). This helps the organization to manage the nuclear power plant safely.

- In 2018, EPZ experienced a malfunction (INES level 1) in its reactor safety system, which prompted a further investigation into the exact cause. One improvement measure identified by that investigation was that various circuit boards in the reactor safety system needed to be replaced. This improvement measure has now been implemented, further mitigating the risk of another malfunction (which was already quite low). This process was carried out under the supervision of the ANVS.

- In 2019, a transformer malfunction resulted in a power failure in part of the external power supply, which powers systems that are connected to an emergency power grid. These systems serve no purpose during normal operation, however they are constantly ready to intervene, if necessary. The emergency power generators kicked in automatically within ten seconds, to compensate for the power failure. Thus, in this case, the facility responded as expected. The ANVS has rated this malfunction as an INES 0 event.

- In a number of buildings, the lightning protection systems have been improved. EPZ completed this work in accordance with the latest standards. This improvement measure was prompted by the conclusions of the 2013 PSR.

- All but one of the improvement measures prompted by the stress test (see Chapter 2) were implemented in 2019. The remaining improvement measure was implemented in 2020. The latest analyses to demonstrate that the plant can withstand a design earthquake, have now been completed[19].

Procedures

- In 2018, the ANVS granted a licence to EPZ which made WENRA's Safety Reference Levels (SRLs) mandatory, via the licence. Prior to that, EPZ was already largely compliant with the new requirements. In 2019, EPZ submitted an implementation plan to the ANVS indicating how it planned to implement the remaining SRLs. The ANVS has now approved this implementation plan.

- During an inspection, the ANVS detected an administrative violation. This meant that the actual situation at the facility had not been correctly described in the licence. The application to amend the licence on that point brings this violation to an end. In this case, safety in the actual situation was an improvement compared to the situation that had been described.

Behaviour

- In 2019, the ANVS carried out inspections of *Human and Organizational Factors* (HOF) within EPZ's waste processing and radiation protection teams. These inspections showed that EPZ needed to make further improvements to the safety culture in these teams. Measures have now been taken to this effect.

3.3 NRG: The High Flux Reactor and other NRG facilities

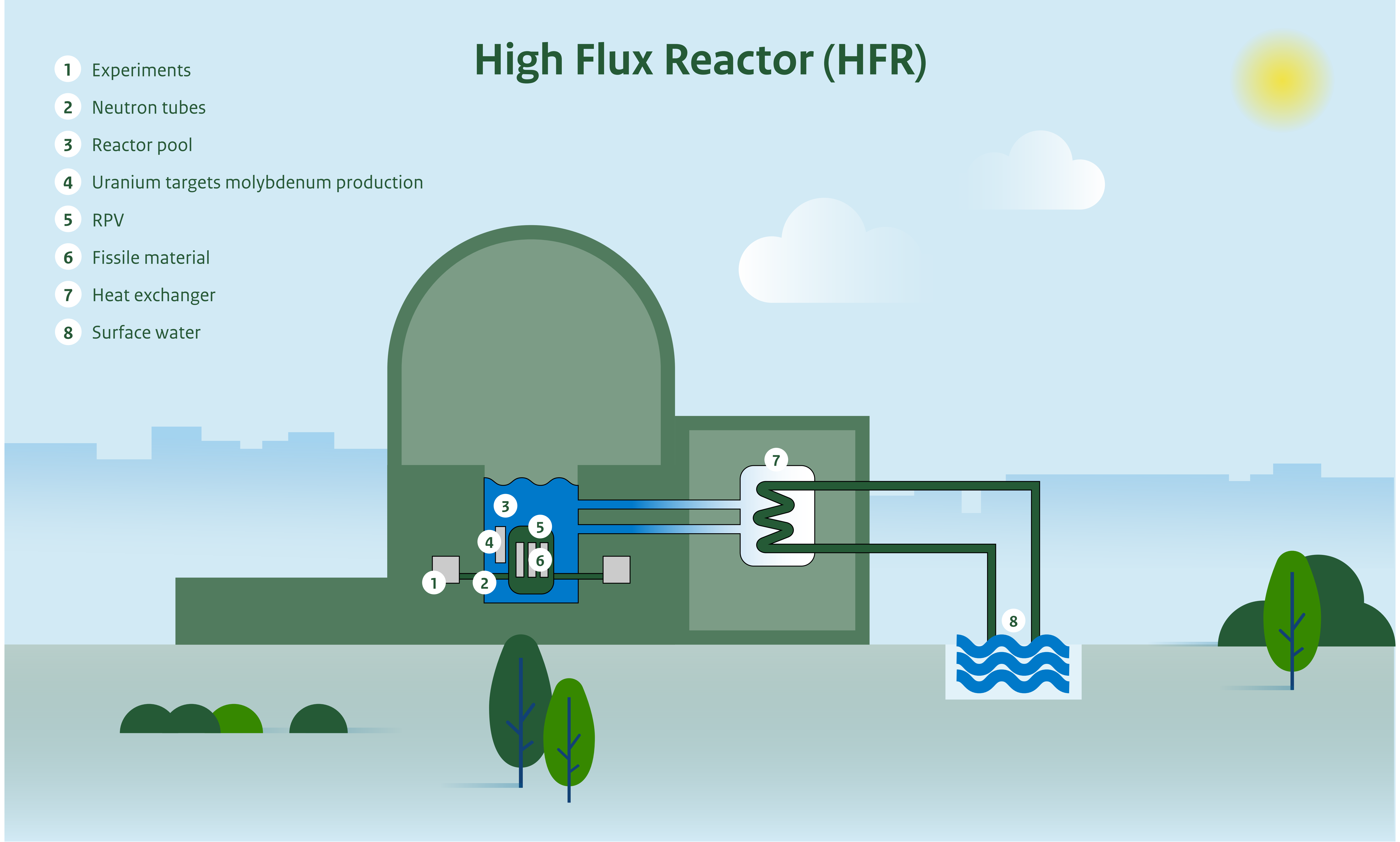
NRG holds two Nuclear Energy Act licences: one for the High Flux Reactor (HFR) and another for the remaining nuclear facilities on the Petten Research Centre site (OLP).

NRG has a Reactor Safety Committee (RVC). This is an independent committee, whose tasks include assessing and approving amendment plans for the facility. The ANVS inspects procedures throughout NRG, such as the management of changes to facilities and to the organization, the performance of the RVC, and the effectiveness of independent supervision within NRG.

In 2019, NRG set up the Quick Response Team (the company fire department). Every year, the alarm organization carries out a series of drills in which the internal and external parties involved participate. This is one way in which NRG fulfils the legal requirement that it must be prepared for incidents.

3.3.1 High Flux Reactor

The High Flux Reactor is a 'tank in pool' type research reactor, which has been in operation since 1961. The reactor is used for materials research and for the production of radioisotopes for industrial and medical use. The HFR has a licensed thermal power output of 50 MW.



Simplified diagram showing the operation of the High Flux Reactor (HFR) in Petten.

3.3.2 Other facilities

The Low Flux Reactor (LFR)
The LFR is a reactor that was used for education and training purposes, and for materials science research. The LFR was in service from 1960 to 2010, and has since been decommissioned and removed. The disassembly of the LFR was completed in 2019. The ANVS's inspections did not reveal any shortcomings in nuclear and radiation safety during decommissioning.

Hot Cell Laboratories (HCL)
The HCL include the *Research Laboratory* (RL) and the *Molybdenum Production Facility* (MPF). Workers at the RL carry out research in the field of fissile materials and construction materials. Radioisotopes (for medical or other purposes) are also pre-processed, packaged, and prepared for transport. Furthermore, low-level and intermediate-level radioactive waste is conditioned and packaged. In the MPF, chemical processes are used to release the medically useful isotopes Molybdenum-99 and Xenon-133 from the uranium targets that had been irradiated in the HFR. This facility also processes uranium targets that have been irradiated in other research reactors.

The STEK hall, which is part of the HCL complex, is used to store solid and liquid radioactive materials that meet the criteria for disposal and are ready for transport, before they are handed over to the Central Organisation for Radioactive Waste (COVRA).

Decontamination and Waste Treatment Facility (DWT)
Decontamination and Waste Treatment (DWT) facility is made up of four buildings. These are the Decontamination Building, the Water Treatment Building, the Waste Transfer Unit Building, and the Solid Waste Treatment Building. The DWT treats, processes, and stores radioactively contaminated materials, objects, and waste. Here, radioactive waste is also prepared for transport.

Waste Storage Facility (WSF)
The WSF is a warehouse for the temporary storage of radioactive waste. This radioactive waste is stored in the WSF's basement areas. Historical waste is also stored in the WSF. Historical waste consists of various types of solid radioactive waste, mainly from experiments conducted in the HFR in the 1970s, 1980s, and 1990s. This waste is taken from the WSF storage facility on a project basis, after which it is sorted and characterized in the HCL's hot cells. It is then repackaged in preparation for transport to COVRA. This historical waste is scheduled to be completely removed by 2027. The ANVS is regulating the safety and progress of this complex project.

3.3.3 Development of operations at HFR and the other facilities in 2019

In 2019, the HFR functioned within normal parameters. At no time were there any incidents or accidents that posed a risk to the three safety functions, which must be guaranteed at all times. Nor were there any developments at the Petten Research Centre that might pose safety risks. In the autumn of 2019, based on the improved safety situation and on the inspection results at that time, the ANVS terminated its increased supervision (which had been in force since 2012).

At the request of the ANVS, the IAEA carried out a follow-up mission to the HFR – the *Integrated Safety Assessment of Research Reactors* (INSARR) – from 8 to 11 April 2019. The team concluded that the vast majority of recommendations made by the original missions have been implemented in full or almost completely.[20] The INSARR recommendations help to further improve operational safety. One key concern that was still open and that is currently being worked on is the revision of the safety analysis report. Another is the handling of documents submitted to the Reactor Safety Committee.

In 2019, the following measures were taken in the context of the 'continuous improvement' of safety:

Technology

- The polar crane in the HFR's reactor room was replaced in 2019. This change required a great deal of preparation, as the polar crane is located right above the reactor. The ANVS's regulatory activities spanned the period from design, the '*functional acceptance test* (FAT)', to the '*site acceptance test* (SAT)'. The crane has been set up such that lifting takes place within a limited area, making it technically impossible to lift loads above the reactor and the fuel rods. This reduces the risks of accidents involving a radiation impact. By installing the new polar crane, NRG is in compliance with the licensing requirement to continue to comply with state-of-the-art developments.

- The last PSR carried out by NRG for the HFR was for the 2001-2014 evaluation period. The final measures from this PSR for the HFR were implemented in 2019. For instance, NRG created a watertight barrier to manage the risk of water entering the Reactor Annex (RBG). This measure will ensure that safety-related systems in the RBG remain intact.

- The PSR of the Petten Research Centre's Hot Cell laboratory was almost fully completed in 2019. In the course of the evaluation process, a number of points for improvement have been implemented. The ANVS will assess the final report of the PSR and the improvement plan proposed by NRG, and will regulate the implementation of this plan.

- In 2019, the ANVS issued a licence for changes pertaining to the temporary storage of radioactive materials and fissile materials in the STEK hall, and to changes to the facility boundary.

Procedures

- In 2019, NRG carried out a *Probabilistic Safety Assessment* (PSA-L1) for the HFR, in accordance with best practices. Performing PSAs is standard practice at nuclear power plants. The HFR is the first research reactor in the world to have undergone a PSA. The ANVS regulated the implementation of this PSA

- In 2019, in the context of ageing management and the continued safe operation of the HFR, NRG pushed ahead with the development of an ageing management programme. The latest state-of-the-art developments will be included in this programme and its further specification.

Behaviour

- The INSARR follow-up mission was combined with an *Independent Safety Culture Assessment* (ISCA) follow-up mission. The original ISCA mission took place in 2017. The safety-culture follow-up mission, which examined NRG as an organization, found that a number of safety-enhancing developments had taken place. For instance, NRG's management has implemented an IAEA safety leadership programme. It has also held a workshop in '*Nuclear Professionalism*' for all workers, to improve their views concerning their roles and tasks. This workshop is repeated periodically, for the benefit of new workers. In those areas where there was still room for improvement, the key concerns are the management system, the performance of the Reactor Safety Committee, and people's perceptions of their workload. Improvements on these points are being implemented.

Other matters

In 2019, within NRG and elsewhere, a major focus was managing the limited tritium contamination of groundwater beneath the Petten Research Centre site. Notifications about this contamination were received in 2013 and 2018. NRG carried out the requisite remediation in-house. The contamination in question had no impacts in terms of the safety of people and the environment.

3.4 Reactor Institute Delft: Higher Education Reactor

3.4.1 Operation

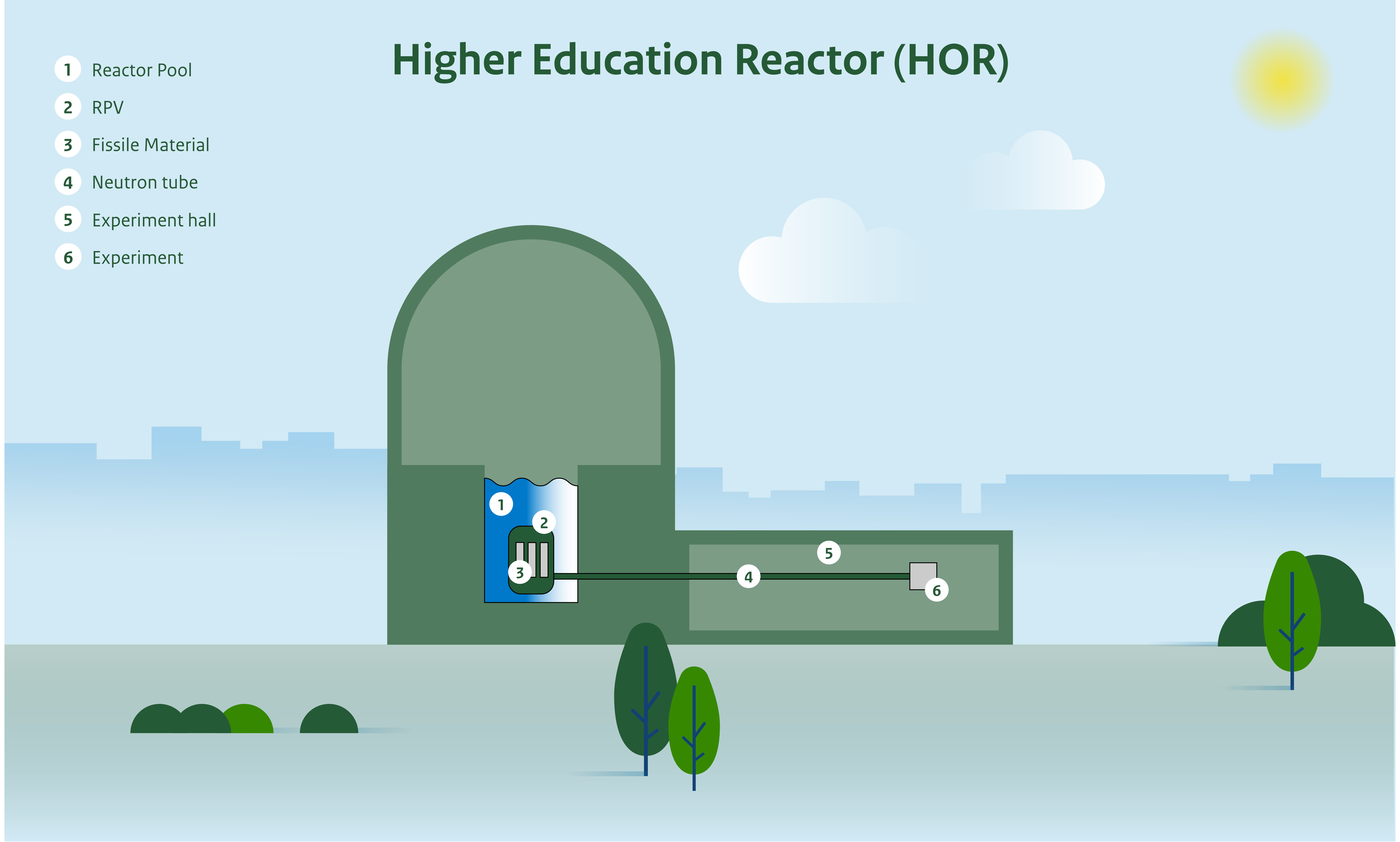
The Higher Education Reactor (HOR) is the research reactor of the Reactor Institute Delft (RID) – part of Delft University of Technology (TUD) – which is the licensee. It is an 'open-pool' type reactor, with a licensed thermal power output of 3 MW. The HOR does not generate power as it is intended purely for scientific research. In the summer of 2019, the reactor was shut down for maintenance and for the installation of a cold neutron source. This was its status throughout the remainder of 2019.

3.4.2 RID developments in 2019

In 2019, the RID operated the research reactor within 'within normal parameters'. At no time were there any incidents or accidents that posed a risk to the three safety functions, which must be guaranteed at all times.

In January 2019, the ANVS granted the Delft University of Technology a definitive change licence for the cold neutron source. The work involved was scheduled to take place from the summer of 2019 to the end of 2020. The installation of a cold neutron source alongside the reactor core is part of the 'OYSTER project'.[21]

In 2019, the Delft University of Technology implemented the following measures in the context of the 'continuous improvement' of safety:



Simplified diagram showing the operation of the Higher Education Reactor (HOR) in Delft.

Technology

- The OYSTER project coincided with major maintenance work on systems and buildings.

Behaviour

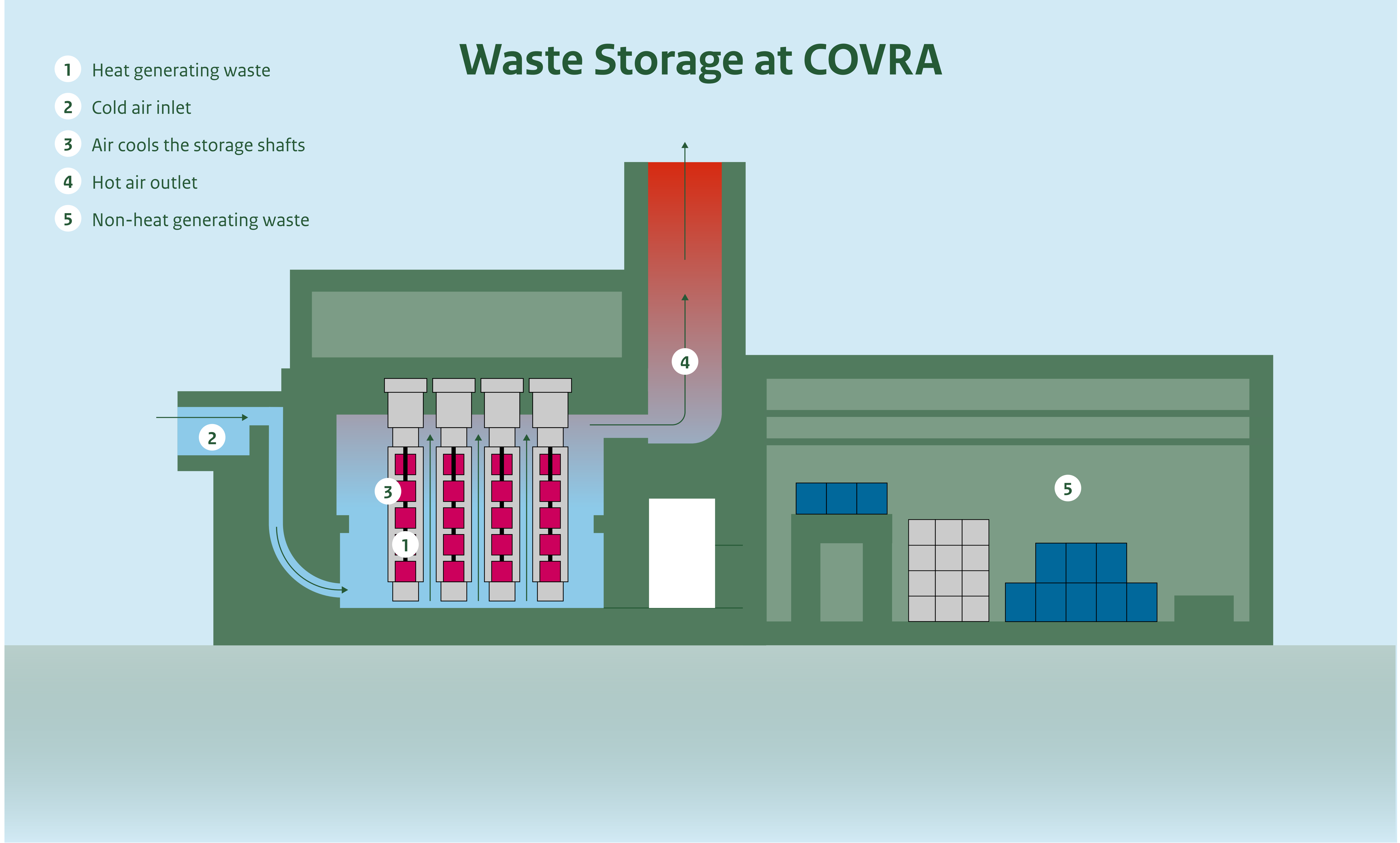
- The RID's organizational structure was modified in 2019. This move was prompted by personnel changes within the Delft University of Technology and within the RID itself. This mainly concerned the division of responsibilities between the RID's various managers. This modification was assessed and approved by the ANVS.

3.5 COVRA

3.5.1 Operation

In the Netherlands, the Central Organisation for Radioactive Waste (COVRA) bears sole responsibility for the central collection, processing, and storage of radioactive waste. COVRA's specially designed storage facilities are capable of handling low-level, intermediate-level, and high-level radioactive waste. Unlike low-level and intermediate-level radioactive waste, the issue of decay heat has to be taken into account when storing some types of high-level radioactive waste (HLW). Such large amounts of heat can be generated that cooling systems are needed to ensure safe storage.

In the High-level Radioactive Waste Treatment and Storage Building (HABOG), heat-generating HLW is



Simplified diagram of the operation of the High-level Radioactive Waste Treatment and Storage Building (HABOG) at COVRA in Nieuwdorp.

cooled by means of natural ventilation. The HABOG contains three storage compartments for the storage of heat-generating HLW. An extension designed to contain two additional storage compartments is currently under construction. There are another three storage bunkers for the storage of non-heat-generating HLW, as well as facilities for the reception and treatment of HLW. The HABOG, which is constructed of reinforced concrete, has ventilation ducts that allow for cooling by means of natural convection.

3.5.2 Developments at COVRA in 2019

In 2019, COVRA took the following measures in the context of the 'continuous improvement' of safety:

The ANVS and COVRA coordinated the PSR's scope and level of detail in 2019. They also initiated the evaluation itself, which ran from 2009 to 2018. COVRA already complies with the safety requirements, but the results of the evaluation (together with the improvements) ensure a further increase in safety.

Technology

- In 2019, COVRA carried out construction work to expand the existing HABOG. The new compartments use the same design as the current HABOG compartments. The ANVS has already approved the safety of this design, which still meets the most up-to-date safety requirements. The construction work in 2019 had no negative impact on nuclear safety, as it took place outside the existing HABOG. Neither COVRA's internal supervision nor inspections by the ANVS revealed any irregularities while this work was being carried out.
- In 2019, COVRA took further steps to modernize the Quality Assurance System by developing it into an Integral Management System (IMS), to keep up with state-of-the-art developments. This modernization work supports risk management.

3.6 Urenco

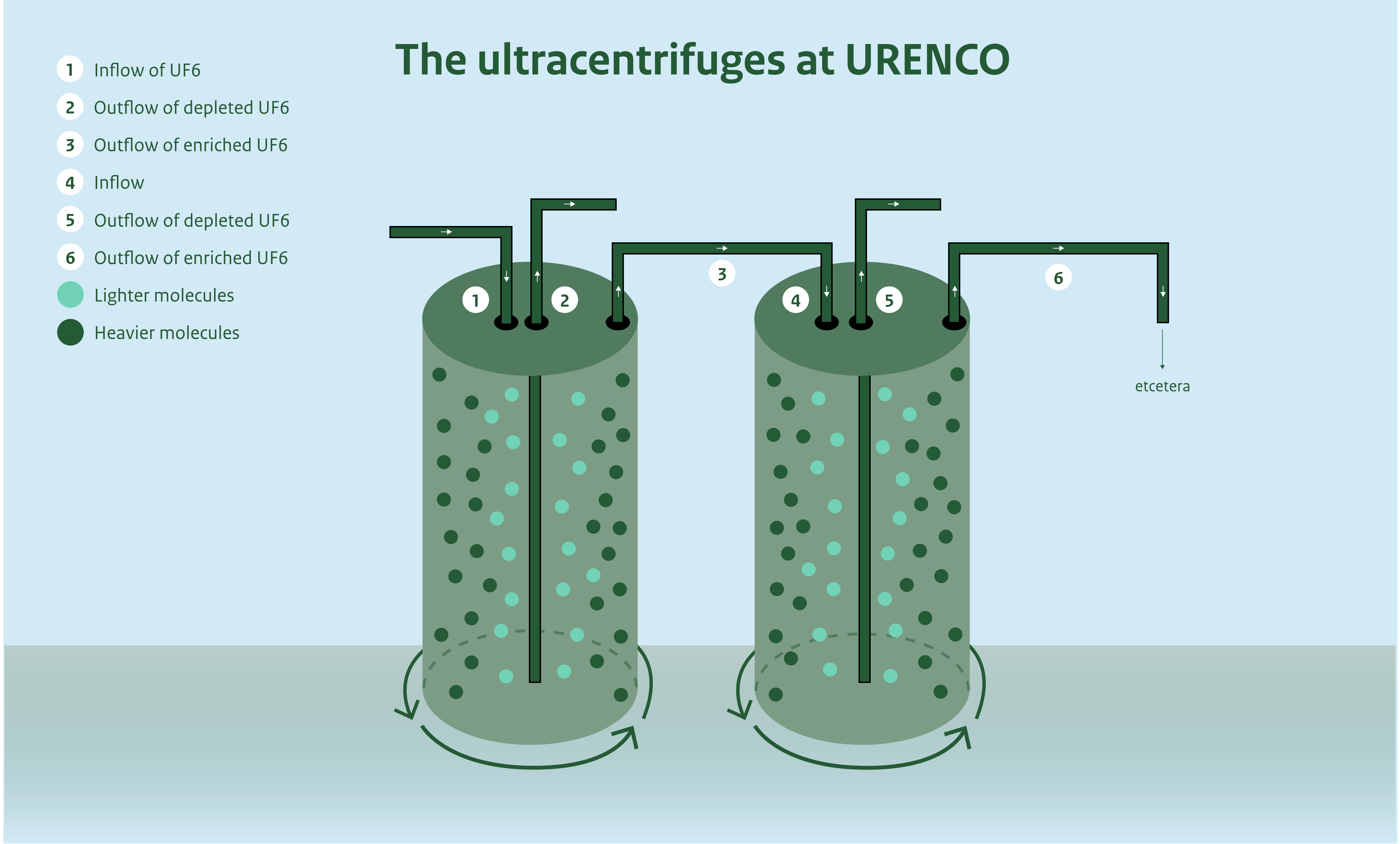
3.6.1 Operation

URENCO Nederland is a company that produces low-enriched uranium and stable (non-radioactive) isotopes. Low-enriched uranium is used to fuel nuclear power plants throughout the world. URENCO uses ultracentrifuges to enrich uranium, and in the production of stable isotopes. Depleted uranium (the residual product of enrichment) is either enriched again or transported to COVRA, depending on market conditions.

3.6.2 Developments at URENCO in 2019

In connection with the maintenance and cleaning of uranium-contaminated components and transport cylinders, URENCO is fitting out a new area with new systems, such as cleaning equipment and evaporators. The technology to be used there is the same as in the old workshops. After assessing the safety aspects of this change, the ANVS concluded that it will have no impact on safety.

In 2019, URENCO took the following measures in the context of the 'continuous improvement' of safety:



Simplified diagram showing the operation of the ultracentrifuges at URENCO in Almelo (UF6 = uranium hexafluoride).

Procedures

- In 2019, URENCO made some improvements to its processes and its management system. For example, the change management process has been improved, even though it was already compliant with internationally accepted standards. This improvement more effectively ensures the involvement of all safety-related parties.

Behaviour

- In 2019, the ANVS conducted an inspection into incidents and near-incidents in the workplace. The ANVS determined that the "Improving implementation in the workplace" project (which was initiated by URENCO) was in line with these goals, as was the internal supervision to which it was subject.

3.7 Dodewaard Nuclear Power Plant

3.7.1 Background

The Dodewaard Nuclear Power Plant was in operation from 1969 to 1997. The power plant is now in safe enclosure, and the licensee – Joint Nuclear Power Plant Nederland (GKN) – has a licence to this effect. Between 1997 and 2005, GKN shut the facility down and all fissile material was removed. This means that the vast majority of the radioactivity that was previously present in the plant has now disappeared. A 40-year enclosure period commenced on 1 July 2005. During this period, any remaining radioactivity will diminish.

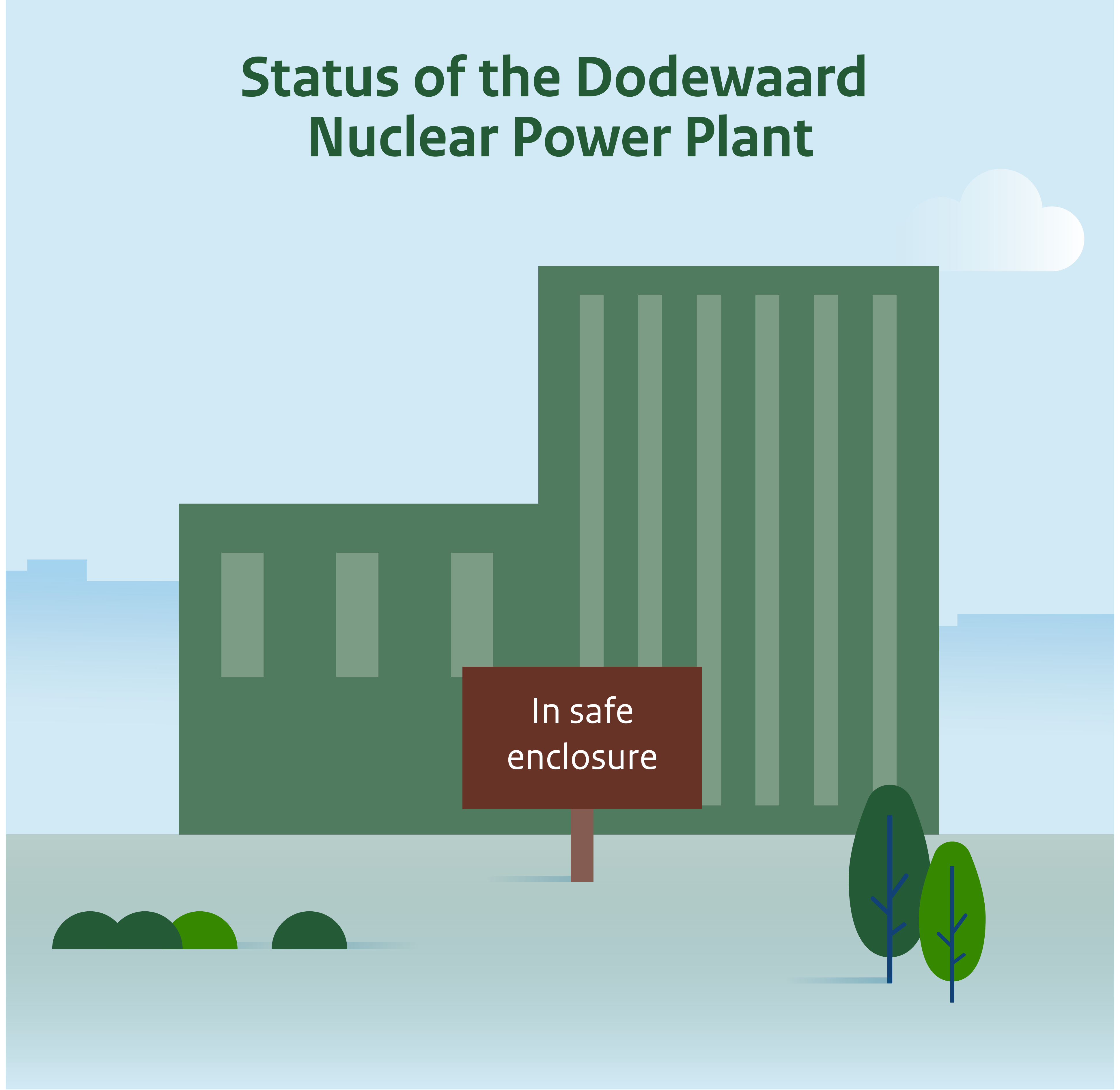
The Dodewaard Nuclear Power Plant has shut down all non-essential systems and has done as much cleaning as possible. Various structural changes have also been made, and new systems have been installed to guarantee responsible safe enclosure.

Following the disposal of the fissile materials, the nuclear safety aspect will no longer be of any significance for the remainder of the enclosure period. Here, the only aspect of any significance is radiation protection. The licence is designed to cover the management of the buildings and the radioactive components and materials, such that they pose no risk to the surrounding area.

Every year, the alarm organization carries out two drills in which the internal and external parties involved participate. By this means, GKN fulfils the legal requirement that it must be prepared for incidents.

3.7.2 Developments at Dodewaard in 2019

In 2019, the ANVS carried out an inspection of aspects such as the quality of the management organization, and radiation protection. This led to an improvement in the areas of maintenance and the testing of monitoring equipment.



The Dodewaard Nuclear Power Plant is in safe enclosure.

3.8 Overview of unusual events

The table below summarizes all unusual events that were subject to a notification requirement at Dutch nuclear facilities in 2019. In 2019, none of the facilities experienced an event rated at the INES 1 level, or above. In total, there have been 11 events at the INES 0 level. Events that are categorized as INES 0 have no impact on people and the living environment. These are of very limited significance in terms of nuclear safety and radiation protection within the facility.

This summary was previously published as part of the 2019 report on unusual events at nuclear facilities. It is available on the ANVS's website, together with further information.[22]

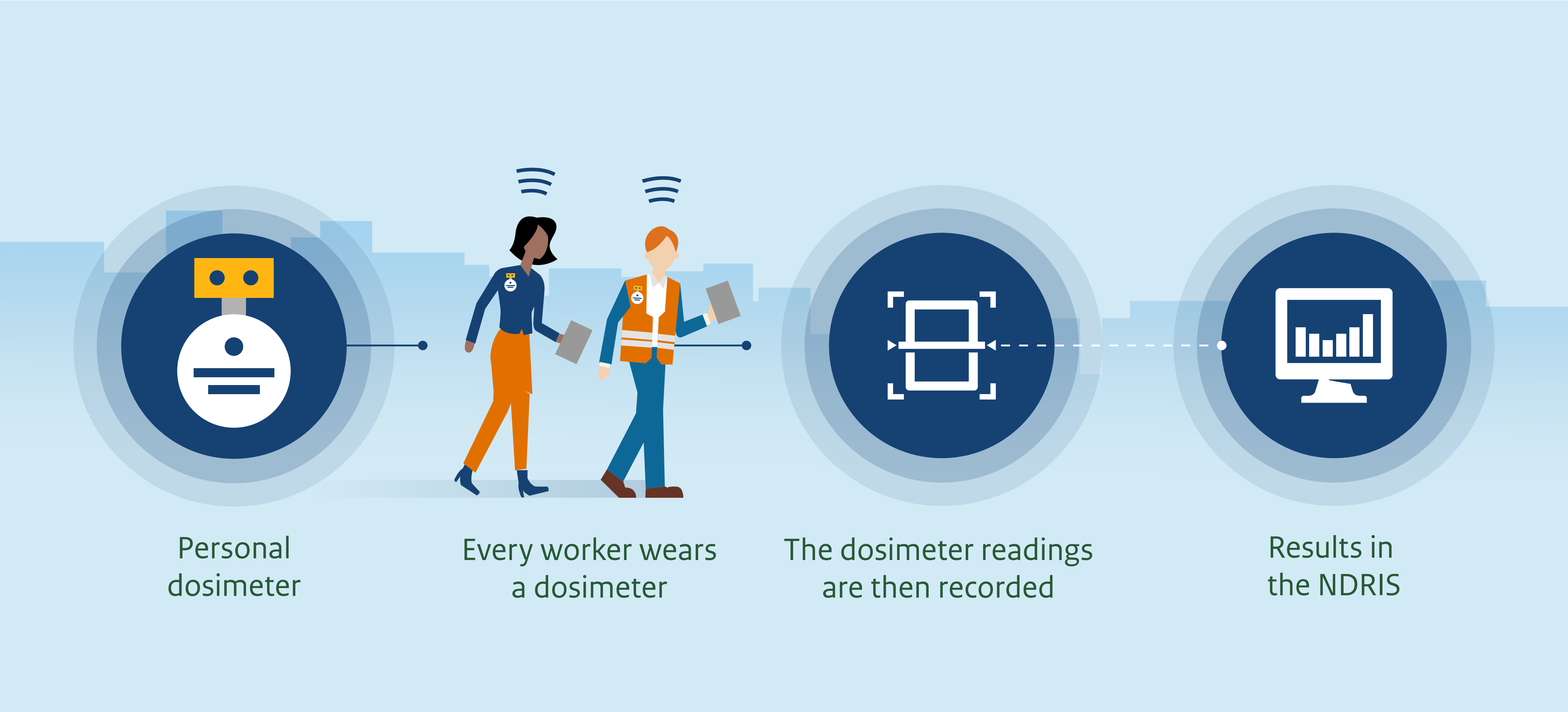
Facility	Number of unusual events that were subject to a notification requirement in 2019	Consisting of:		
		INES-level 0	INES-level 1	INES-level > 1
Borssele Nuclear Power Plant (KCB), Borssele	1	1	0	0
High Flux Reactor (HFR), Petten	2	2	0	0
Other NRG facilities, Petten	7	7	0	0
Central Organisation for Radioactive Waste (COVRA), Nieuwdorp	1	1	0	0
Higher Education Reactor (HOR), Delft	0	0	0	0
URENCO Nederland, Almelo	0	0	0	0
Dodewaard Nuclear Power Plant (KCD), Dodewaard	0	0	0	0
Total nuclear facilities	**11**	**11**	**0**	**0**

Table 1: The total number of unusual events that were subject to a notification requirement at each company in 2019, categorized by INES level.

3.9 Results of exposure/discharges in 2019
As indicated in Chapter 2, Dutch legislation and regulations (and the licences) impose dose limits for the protection of workers and the population. The workers at all nuclear facilities in the Netherlands are subject to a dose limit of 20 millisieverts per year. Both the companies involved and the ANVS (in collaboration with RIVM) continuously monitor the situation, to confirm compliance with the dose limits. To comply with the optimization requirement (ALARA principle), companies are also obliged to set their own *dose constraints*. These are limit values, which are lower than the actual dose limits. They are goals that the company is striving to meet. They vary from one facility to another. Further details are given below, on a case-by-case basis.

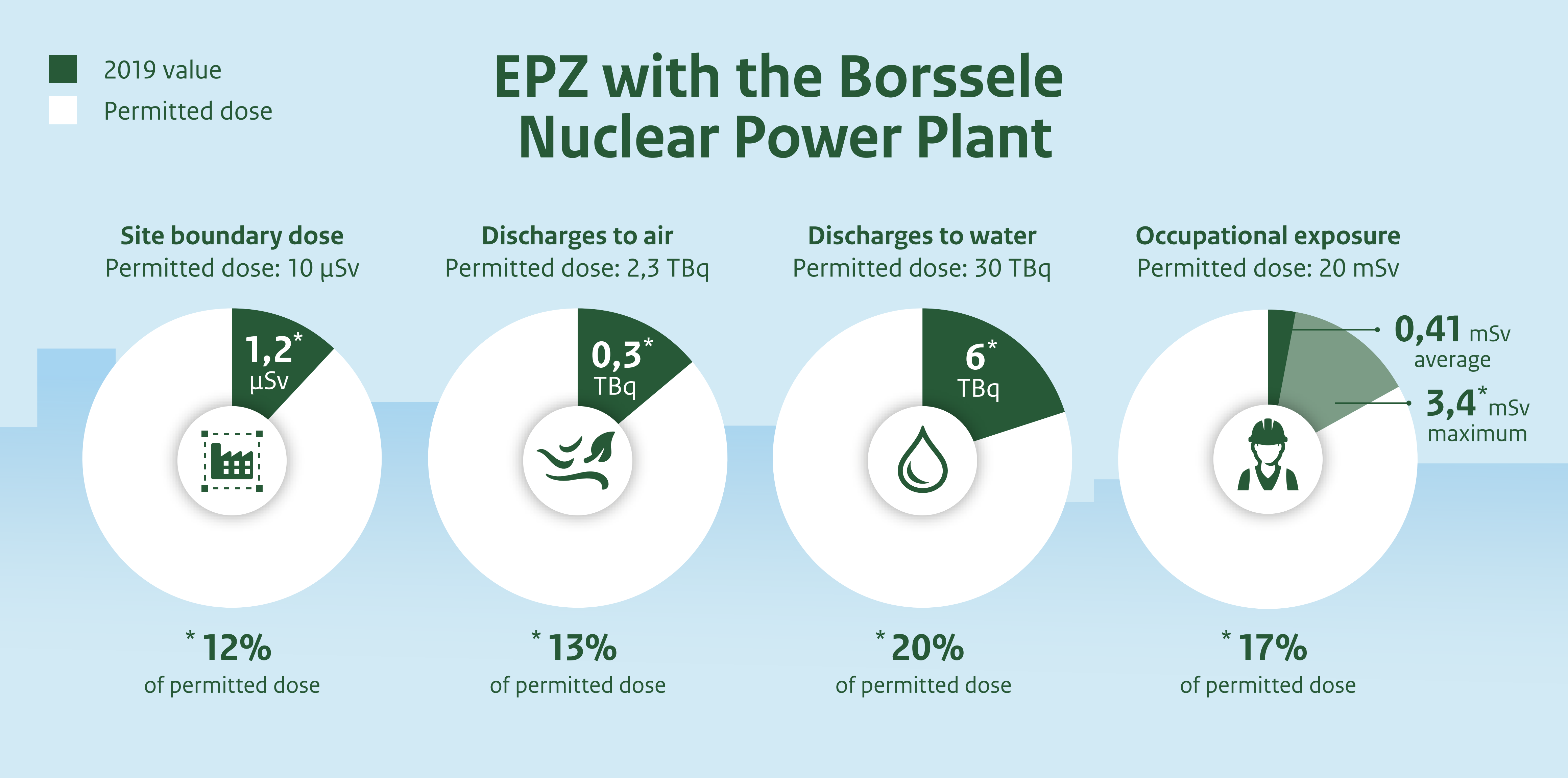
Monitoring dose limits within the facility
The licensees are obliged to continuously monitor compliance with worker dose limits and dose constraints. They do so by monitoring the workplaces and by equipping workers with personal dosimeters issued by a recognized dosimetric service. They record the personal monitoring results in a national dose registration and information system.[23]

Checks of discharge limits outside the facility
Nuclear facilities continuously check and monitor any discharges into the air and water. They periodically report the results of these measurements to the ANVS. RIVM periodically carries out radiation measurements at the site boundaries of all nuclear facilities, on behalf of the ANVS.

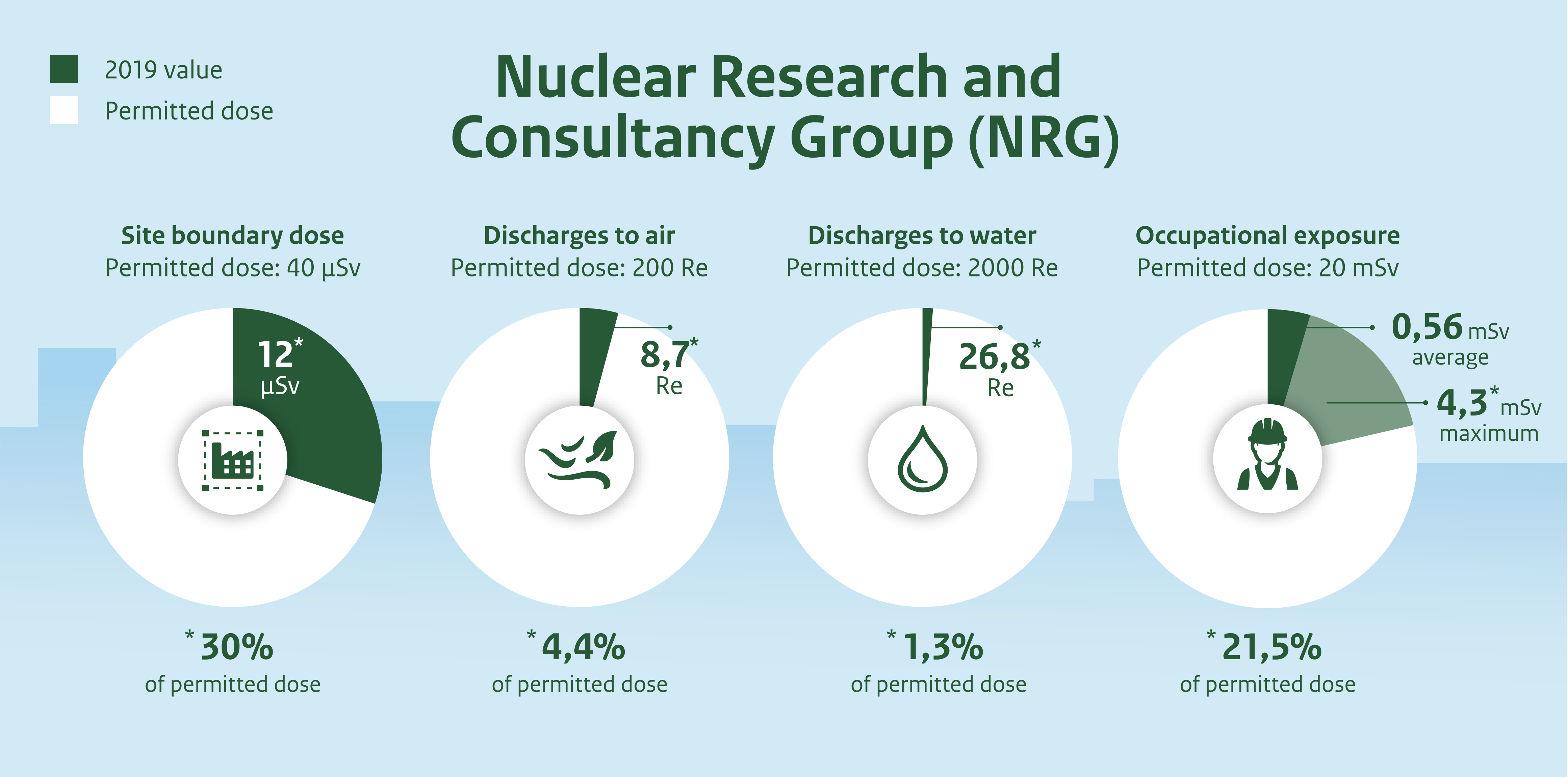


Workers are continuously monitored to ensure that they comply with the annual dose limit of 20 millisieverts. The results are recorded in the National Dose Registration and Information System (NDRIS).

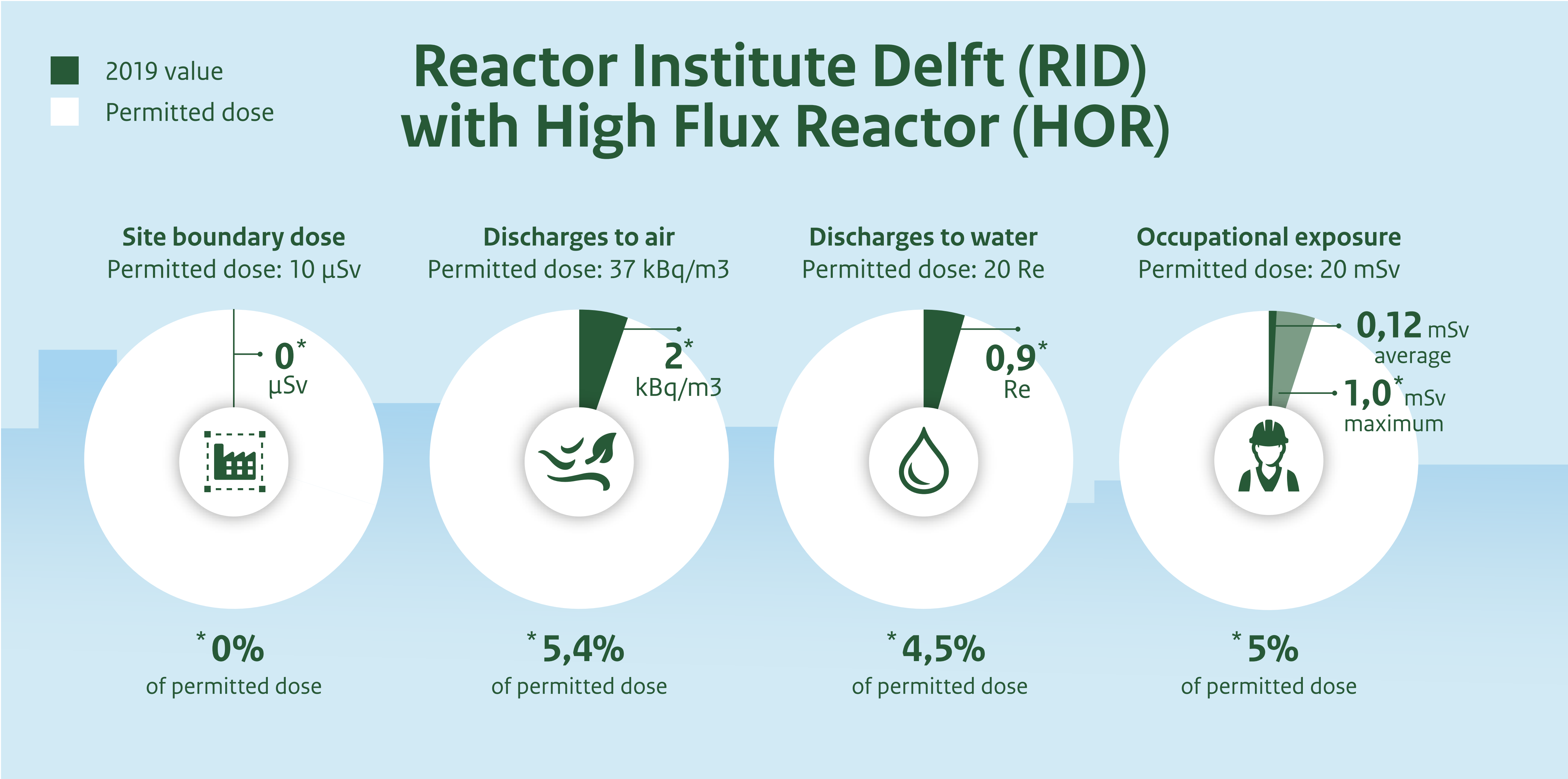
Exposure and discharge results in 2019
All nuclear facilities in the Netherlands operate below (or well below) the dose limits and dose constraints when it comes to worker exposure to radiation, site boundaries, and any discharges of radioactive substances to air and water. The results of occupational exposure and discharges are summarized below, per nuclear facility. The ‘permitted dose’ is included in the figures. Discharges to air and water, as well as the site boundary dose, are subject to the limits permitted under the licence. These can vary from one nuclear facility to another. The worker dose limit corresponds to the generally applicable statutory limit. The results of occupational exposure concern the maximum individual dose and the mean for all workers.



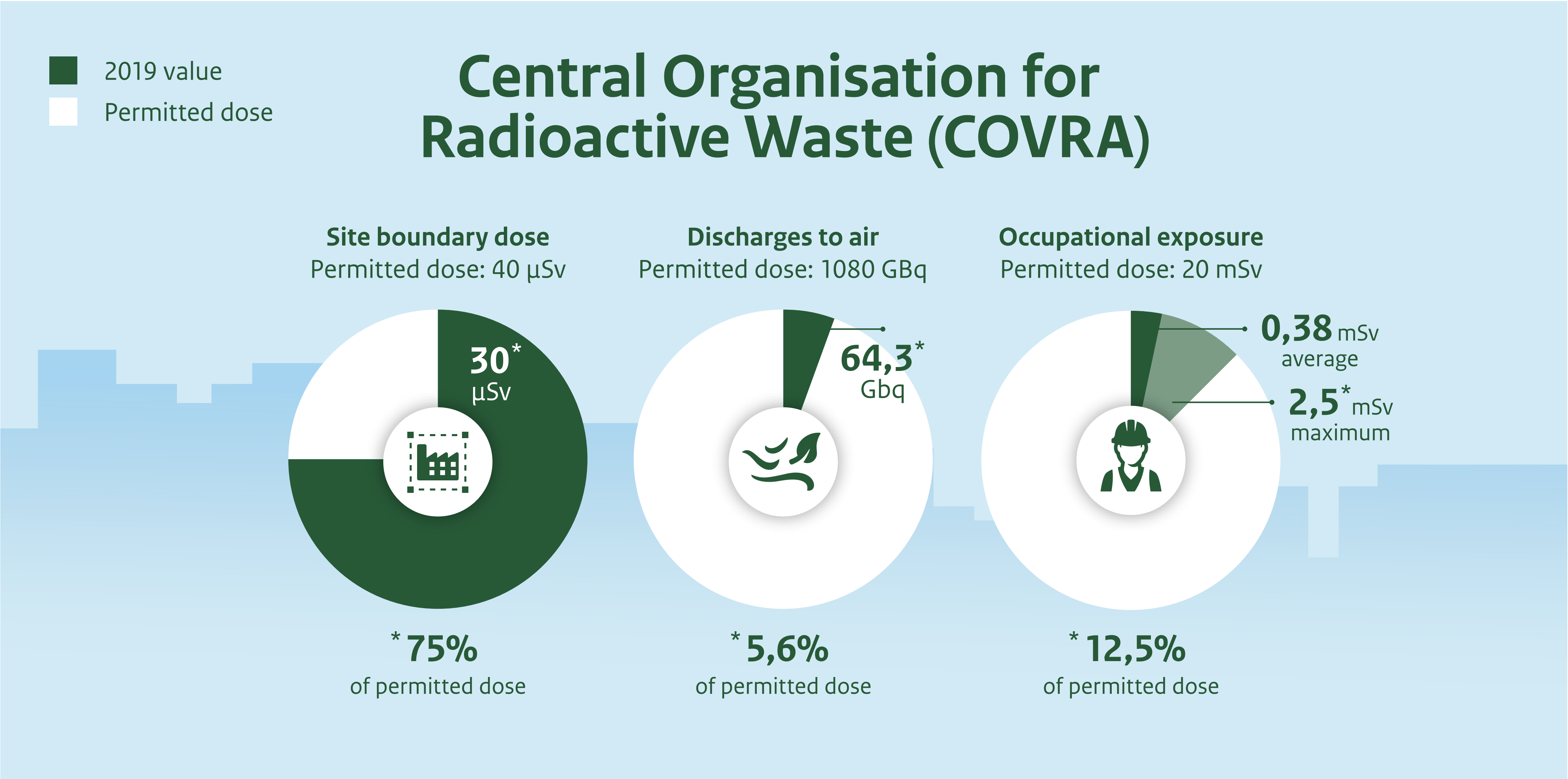
EPZ summary of the results of exposure and discharge at the Borssele Nuclear Power Plant in 2019.



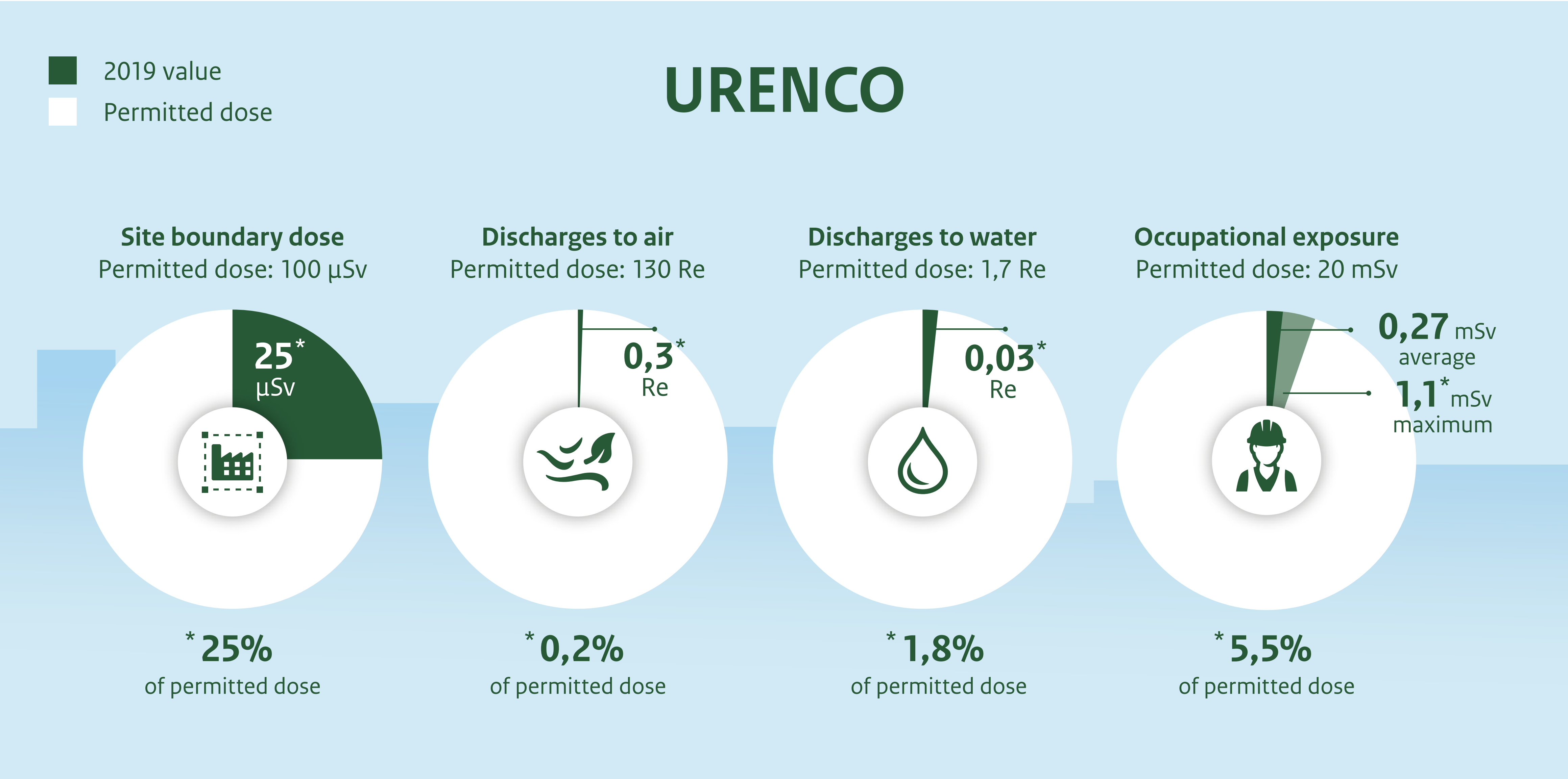
NRG summary of the results of exposure and discharge at the High Flux Reactor (HFR) in 2019.



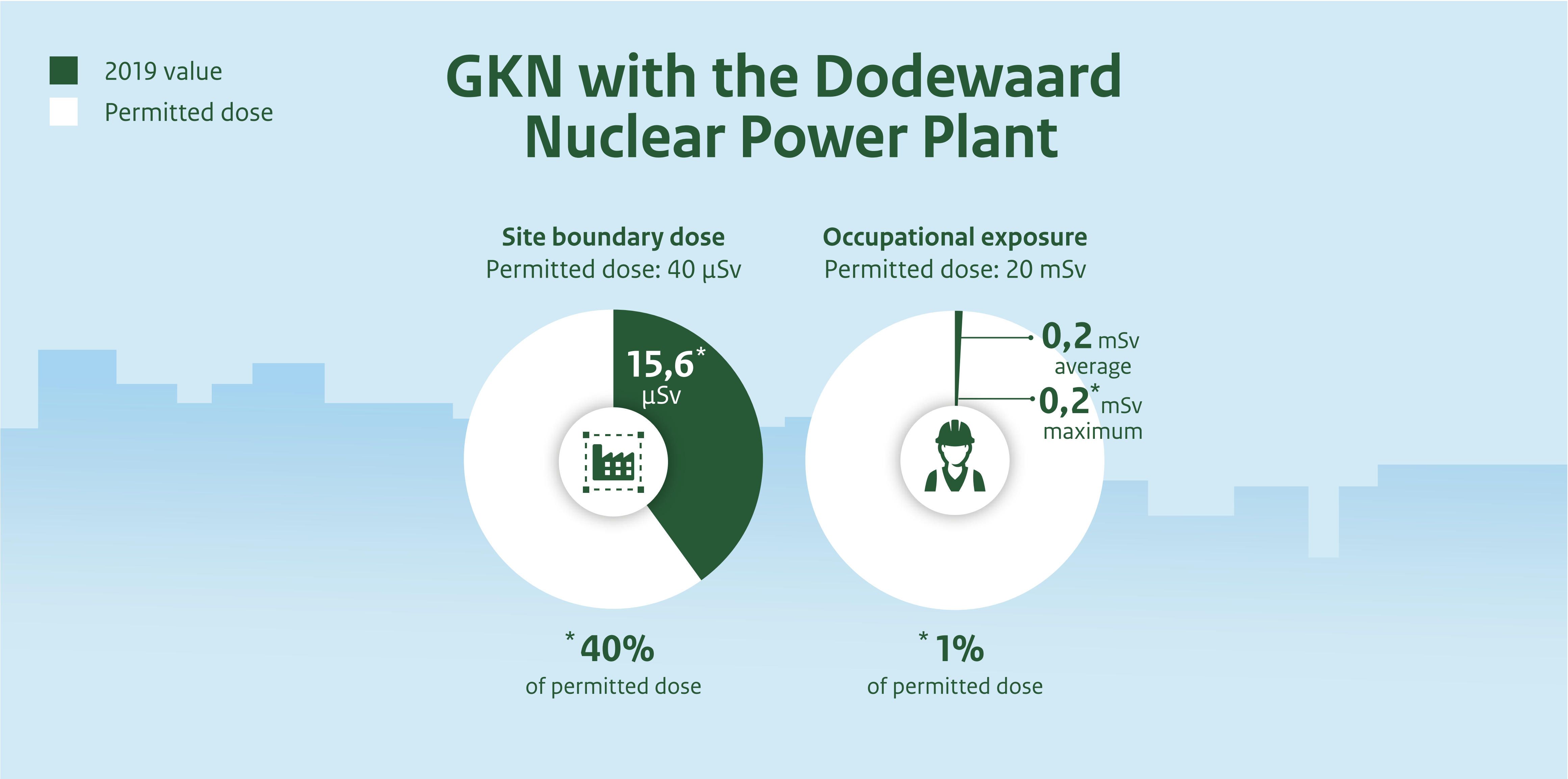
Reactor Institute Delft summary of the results of exposure and discharge at the Higher Education Reactor (HOR) in 2019. The reported value of the site boundary dose is based on an active measurement. Additional measurements carried out as checks present the same picture. The site boundary dose is below the limit permitted under the licence.



Central Organisation for Radioactive Waste summary of the results of exposure and discharge in 2019.



URENCO summary of the results of exposure and discharge in 2019.



GKN summary of the results of exposure and discharge at the Dodewaard Nuclear Power Plant in 2019. This summary does not include discharges to air and water as these are much less than 1% of the limit permitted under the licence.

04
Conclusion

By developing The *State of Nuclear Safety and Radiation Protection* series of publications, and in this initial report in particular, the ANVS is placing the safety of Dutch nuclear facilities under the spotlight. This report on the *State of Nuclear Safety and Radiation Protection* presents the international system that is designed to guarantee nuclear safety, and to protect people and the environment against ionizing radiation. The ANVS also describes the safety situation at the nuclear facilities in 2019.

The international system of treaties, directives (including European Directives) and supporting documents (often of a technical nature) provides various instruments that are designed to guarantee nuclear safety. Many of these instruments have been implemented in Dutch legislation and regulations. The construction and operation of a nuclear facility requires a licence, based on the Nuclear Energy Act. As an independent authority in the area of nuclear safety and radiation protection in the Netherlands, the ANVS is empowered to grant such licences and to supervise compliance with them. Where necessary, it can also take enforcement action.

The primary responsibility for a facility's nuclear safety lies with the licensee. Safety measures must be taken to prevent accidents or – if accidents do occur – to limit their impact. Furthermore, licensees are required by law to continuously review safety measures at their facilities. If there is room for improvement, they are also required to introduce measures to further improve nuclear safety. The system is characterized by an interlinked system of checks and balances between national and international organizations and licensees.

The main conclusions concerning nuclear safety at the various facilities in 2019 are as follows:

- The licensees have all operated their facilities safely, and no accidents have occurred. Throughout the year, the three safety functions of nuclear safety (controlling reactivity, cooling the fissile materials, and containing the radioactive materials or fissile materials) were guaranteed. As far as reasonably achievable, the safety provisions at the facilities are state-of-the-art.

- In 2019, a total of eleven unusual events rated at the 'INES 0' level occurred. All events involving sources of ionizing radiation that have – or could have – an impact on the safety of people and the living environment are classified in terms of the International Nuclear and Radiological Event Scale (INES), which is used throughout the world. Events that are categorized as INES 0 have no impact on people and the living environment. These are of very limited significance in terms of nuclear safety and radiation protection within the facility. In 2019, none of the facilities experienced an event rated at the INES 1 level or above.

- All of the licensees made adequate efforts to keep occupational exposure to ionizing radiation and the discharge of radioactivity to air and water, as low as reasonably achievable. At every licensee's site, occupational exposure to ionizing radiation is within statutory limits, and within their self-imposed dose constraints. The discharges of radioactivity to air and water remained well below the set limits.

04 Conclusion

In 2019, the licensees implemented measures designed to improve safety still further. These measures derive from the licensees' statutory obligation to make every effort to continuously improve safety. Many of these improvement measures can be traced back to recommendations made following international missions and peer reviews, or to the ten-year periodic safety reviews (PSR) conducted by the licensees.

The importance of nuclear safety and radiation protection is not limited to nuclear applications alone. Future *State of Nuclear Safety and Radiation Protection* reports will also cover the safety situation with regard to other uses of radiation.

End notes

1 The IAEA Safety Standards, including Fundamentals, Requirements and Guides for nuclear safety.

2 Directive 2009/71/EURATOM establishing a Community framework for the nuclear safety of nuclear installations: eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0071&from=EN.

3 Report of unusual events at Dutch nuclear facilities during 2019: www.rijksoverheid.nl/documenten/rapporten/2020/06/29/rapportage-ongewone-gebeurtenissen-nucleaire-installaties-2019 (in Dutch).

4 Also publicly available at the ANVS website: www.autoriteitnvs.nl/documenten/rapporten/2020/06/29/rapportage-ongewone-gebeurtenissen-nucleaire-installaties-2019 (in Dutch).

5 Safety of Nuclear Facilities Regulations: wetten.overheid.nl/BWBR0039625/2018-02-06 (in Dutch).

6 Safety of Nuclear Facilities Regulations: wetten.overheid.nl/BWBR0039625/2018-02-06 (in Dutch).

7 Euratom, Convention on Nuclear Safety eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:21999A1211(01)&from=EN.

8 Convention on Nuclear Safety: www.iaea.org/sites/default/files/infcirc449.pdf.

9 As is the case with the Electricity Production Company South-Netherlands (EPZ): www.autoriteitnvs.nl/onderwerpen/kerncentrale-borssele-epz/documenten/vergunning/2018/12/12/definitieve-vergunning-epz-i.v.m.implementatie-wenra-reference-levels (in Dutch).

10 Safety of Nuclear Facilities Regulations: wetten.overheid.nl/BWBR0039625/2018-02-06 (in Dutch).

11 Safety of Nuclear Facilities Regulations: wetten.overheid.nl/BWBR0039625/2018-02-06 (in Dutch).

12 See www.autoriteitnvs.nl/onderwerpen/irrs-missie-nederland/nieuws/2018/11/25/het-iaea-stelt-dat-nederland-het-regelgevend-kader-aanzienlijk-heeft-versterkt (in Dutch).

13 Nuclear Energy Act: wetten.overheid.nl/BWBR0002402/2018-10-16 (in Dutch).

14 The *Environmental Management Act* describes the Environmental Impact Assessment (EIA) procedures.

15 Decree on Basic Safety Standards for Radiation Protection, Chapter 2, Section 2.9: : wetten.overheid.nl/BWBR0040179/2018-07-01 (in Dutch).

16 ANVS Regulation and Intervention Strategy: www.autoriteitnvs.nl/documenten/publicatie/2017/08/01/toezicht--en-interventiestrategie-anvs (in Dutch).

17 ANVS Course Document: www.autoriteitnvs.nl/documenten/publicatie/2017/08/01/koersdocument-anvs (in Dutch).

18 Notification Criteria Guidelines for Nuclear Facilities: www.autoriteitnvs.nl/documenten/richtlijn/2019/05/22/handreiking-meldcriteria-nucleaire-inrichtingen (in Dutch).

19 The design of the plant allows for an earthquake of a certain magnitude, the so-called 'design earthquake'.

20 www.autoriteitnvs.nl/actueel/nieuws/2019/07/02/definitieve-rapporten-insarr-missie-en-isca-missie-openbaar (in Dutch).

21 For a further explanation, see: magazines.autoriteitnvs.nl/nieuwsbrief-anvs/2020/03/toezicht-op-modernisering-onderzoeksreactor-delft (in Dutch).

22 Available at: www.autoriteitnvs.nl/documenten/rapporten/2020/06/29/rapportage-ongewone-gebeurtenissen-nucleaire-installaties-2019 (in Dutch).

23 The National Dose Registration and Information System (NDRIS), see also: www.ndris.nl (in Dutch).

The *State of Nuclear Safety and Radiation Protection* is commissioned by

The Authority for Nuclear Safety and Radiation Protection (ANVS)

December 2020

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