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IMPLEMENTATION OF THE OBLIGATIONS OF THE JOINT CONVENTION ON THE SAFETY OF SPENT FUEL MANAGEMENT AND ON THE SAFETY OF RADIOACTIVE WASTE MANAGEMENT

SEVENTH NATIONAL REPORT OF SWITZERLAND IN ACCORDANCE WITH ARTICLE 32 OF THE CONVENTION, OCTOBER 2020

Implementation of the Obligations of the

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

Seventh National Report of Switzerland
in Accordance with Article 32 of the Convention

October 2020

Contents

Section A Introduction

A.1 Country and State

Switzerland is situated in central Europe and has a total surface area of 41 285 km² and a population of roughly 8,5 million. Structurally, Switzerland has evolved into a federal State with 26 member states, known as cantons. The federal authorities have responsibility under the Constitution for certain central functions. All other legislative power remains with the cantons, which therefore retain a high degree of autonomy. Municipalities and communities also enjoy considerable rights of self-government. At each level, a significant number of political rights are guaranteed to the people.
The Federal Council consists of seven ministers of equal rank, acting as the federal government. Ministers are elected by the Swiss Parliament. The Parliament consists of two chambers: the National Council represents the population as a whole. It has 200 members elected for a term of four years. The Council of States has 46 members representing the Swiss cantons.
The electorate has the constitutional right to introduce and sanction changes to the Federal Constitution and a right to express itself in referenda on federal legislation. The electorate can also request changes or additions to the Federal Constitution through a popular initiative signed by at least 100 000 voters. Any change to the Constitution must be submitted to an obligatory national referendum; the majority of cantons as well as the majority of the individual voters must be favourable to the change otherwise the Constitution remains unchanged. If a minimum of 50 000 voters challenge a decision by parliament to pass a new federal law or change an existing law, the issue is put to a facultative national referendum. The federal rules on popular initiatives and referenda are replicated in cantonal constitutions.
Total energy consumption in Switzerland was about 834 210 TJ in 2019. Electricity consumption accounts for about 24.7 % of energy consumption. The main sources of electricity in Switzerland are hydroelectric (56.4 %) and nuclear power (35.2 %).

A.2 Statutory Basis of Nuclear Power

Starting in the 1950s, the use of nuclear energy technology was left to the private sector. However, the legislative framework to ensure safety and radiation protection was exclusively established at the federal level. As a first step, an article was added to the Swiss Constitution, which was approved by a vote of the Swiss population in 1957. The Atomic Energy Act came into force in 1959 on the basis of this article. In 2005, a new Nuclear Energy Act and its related ordinance entered into force to replace the Atomic Energy Act of 1959. Under the new Nuclear Energy Act, the unconditional authority of the Federal Council to grant general licences for new NPPs was abolished and decisions on general licences for new nuclear facilities are subject to a facultative national referendum. In addition, the Federal Government was given full legal responsibility for licensing geological waste repositories.

A.3 The Regulatory Authority

The first experimental nuclear reactor started operation in Switzerland in 1957. At that time, no regulatory authority was established in Switzerland. The canton in which a reactor was located was responsible for its safety. The first nuclear regulator in Switzerland was the Swiss Federal Nuclear Safety Commission set up in 1960. Between that date and 1982, its secretariat evolved in several stages into an independent authority. In 1964, the Federal Council decided to create the Department for the Safety of Nuclear Facilities, which later became the Swiss Federal Nuclear Safety Inspectorate. The duties of the regulatory body were formally defined in an ordinance published in 1982. Until the end of 2008, the Swiss Federal Nuclear Safety Inspectorate was part of the Swiss Federal Office of Energy (FOE).
The fact that the Swiss Federal Nuclear Safety Inspectorate reported directly to the Swiss Federal Office of Energy contravened the independence stipulated in both the Swiss Nuclear Energy Act of 2005 and

the Convention on Nuclear Safety. The Act on the Swiss Federal Nuclear Safety Inspectorate (ENSI) – approved in 2007 – created a statutory framework for making the Swiss Federal Nuclear Safety Inspectorate formally independent of the Swiss Federal Office of Energy. This was achieved on 1 January 2009 when ENSI became an independent authority constituted under public law. ENSI itself is supervised by an independent body, the ENSI Board. The Board is elected by the Federal Council to whom it reports directly.

A.4 Nuclear Power Plants

As nuclear power production is part of the private sector, there is no national nuclear programme as such. During the 1960s, a series of projects for NPPs were initiated and four of them were realised. This resulted in the current five units, which were commissioned between 1969 and 1984. Two projects were cancelled.

Because of Switzerland's mountainous landscape, the number of suitable sites for NPPs is limited. Two sites are located near the German border; Leibstadt is situated 0,5 km and Beznau 5 km from the border. The other two sites, Mühleberg and Gösgen, are located about 40 km from the French and 20 km from the German border, respectively. The geographic location of all Swiss nuclear facilities is shown on the map in Figure 1.

Licensing procedures for three new units on existing sites were ongoing in Switzerland before the 2011 Fukushima Daiichi Nuclear Power Plant accident in Japan. The Federal Council suspended these procedures shortly after the Fukushima accident. Over the course of 2011, the Federal Council and the Swiss Parliament decided to phase out nuclear energy by abandoning the building of new plants, but the existing plants should continue to operate as long as they can do so safely. In October 2016, the energy companies Axpo, Alpiq and BKW withdrew their general license applications for replacement nuclear power plants.

In October 2013, the energy company BKW Energy Ltd decided to shut down Mühleberg NPP by the end of 2019. BKW submitted the decommissioning project for review in December 2015, which was assessed by ENSI in August 2017. As a result, ENSI formulated certain incidental provisions that were considered necessary for the implementation of the decommissioning of the NPP. Taking these incidental provisions

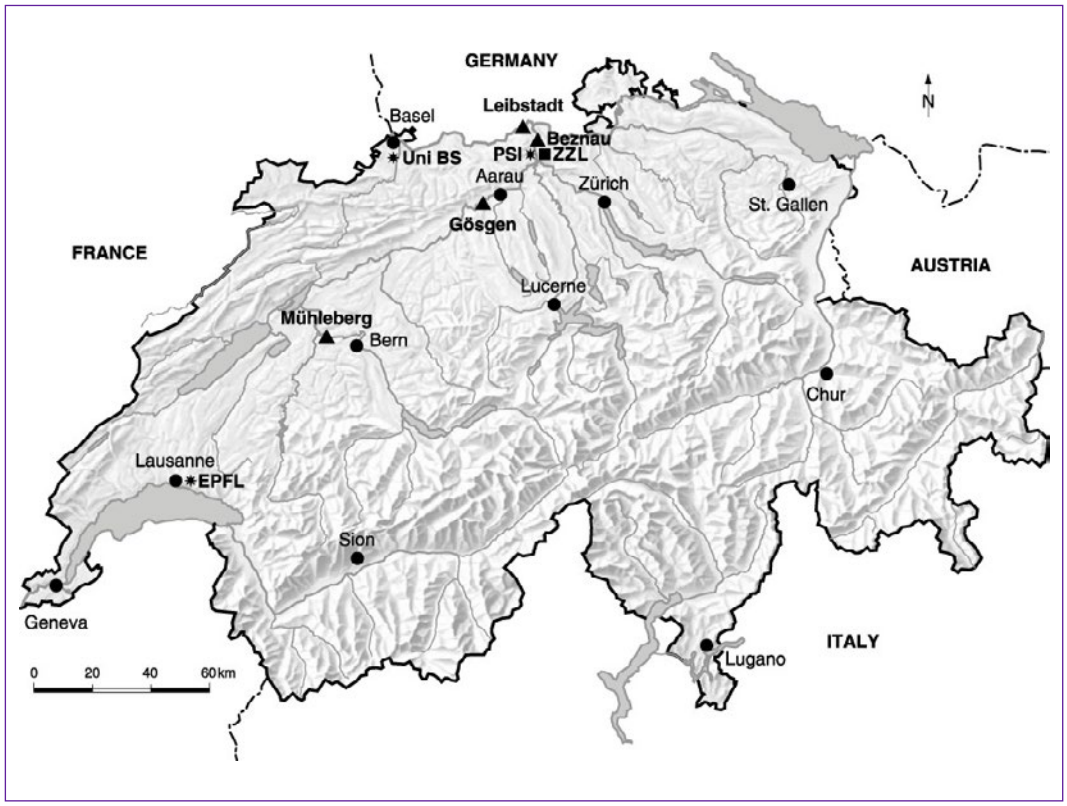


Figure 1:
Geographic location of Swiss nuclear facilities. Triangles mark the NPP sites. Asterisks mark experimental and research facilities. Squares mark facilities for nuclear waste management. The dots are major cities.

into account, all necessary requirements for issuing the decommissioning order were thus fulfilled from ENSI's point of view. Based on the assessments of ENSI and other authorities, the Federal Department of the Environment, Transport, Energy and Communications (DETEC) issued the decommissioning order in June 2018. On 20 December 2019, the Mühleberg NPP ceased power operation. After final cessation of power operation, the spent fuel elements from the reactor core are transferred to the spent fuel pool. In the meantime, all measures to establish a safe technical postoperation are being implemented (see Section F.6). Decommissioning is expected to be completed after 15 years.
The nuclear phase-out has been discussed as part of the parliamentary debate on the Energy Strategy 2050, which required a partial revision of the Nuclear Energy Act. Following these discussions, both chambers of the Parliament have decided to refrain from restricting the operational lifetimes of the Swiss nuclear power plants. In November 2016, a popular initiative to limit operational lifetime of the Swiss NPPs to 45 years was rejected by the voters in a referendum. In May 2017 the Energy Strategy 2050 was accepted by the Swiss people in a popular vote. It will lead to a gradual withdrawal from nuclear energy and aims at reducing the energy consumption and dependence on fossil energies from abroad, while increasing the proportion of local renewable energy sources.

A.5 Facilities for Nuclear Education, Research and Development

The Paul Scherrer Institute (PSI) is the largest research institute for natural and engineering sciences in Switzerland, conducting cutting-edge research in three main fields: matter and materials, energy and environment and human health. PSI develops, builds and operates complex large research facilities. It is part of the Domain of the Swiss Federal Institutes of Technology.
One topic of energy research at the PSI is the safe use of nuclear energy. A key focus here is on further improving our understanding of the processes in existing and future nuclear power plants, to help ensure that they are operating safely. Another topic is research related to spent fuel and radioactive waste management. In order to maintain vital nuclear knowhow in Switzerland PSI engages itself substantially in the Swiss master program «Nuclear Engineering» of the Swiss Federal Institutes of Technology in Zurich (ETHZ) and Lausanne (EPFL).
Regarding nuclear research infrastructure there are four sites at PSI that fall under the definition: the former research reactors DIORIT, SAPHIR, and PROTEUS which are in various stages of decommissioning and the Hot Laboratory, where nuclear research is still taking place.
Apart from the above-mentioned former research reactors at PSI, there are two small teaching reactors ($P < 2\ kW_{th}$) at the University of Basel and at the Swiss Federal Institute of Technology in Lausanne. The reactor in Basel was shut down permanently in late 2013. In 2015, the remaining highly enriched uranium from the reactor was sent back to the USA. The University of Basel submitted the decommissioning project for review in February 2017. Based on ENSI's assessment of April 2018, DETEC issued the decommissioning order in February 2019. Dismantling of the facility began in June 2019 and was completed in December 2019. The zero-power (100 W) teaching reactor in Lausanne is still in operation.
The former Lucens experimental NPP was decommissioned and dismantled after suffering a partial core-meltdown in 1969. With the exception of a small radioactive waste storage area, this site was declassified and released for non-nuclear activities in March 1995. In 2003 the radioactive waste from this storage area was transported to the Central Interim Storage Facility in Würenlingen (ZZL). The site was completely released from nuclear legislation by the Federal Council in 2004.
In 1989 the Federal Council decided that the Department of Nuclear Physics at the University of Geneva had completed the decommissioning of the research reactor AGN-201-P and released the site from the former atomic legislation. The fuel elements were transferred to PSI and later back to the USA.

A.6 Radioactive Waste

Each NPP has facilities for the conditioning and interim storage of radioactive waste resulting from its operation. At the Beznau NPP site, there is an additional facility for the dry storage of spent fuel elements

(ZWIBEZ) which became operational in 2008. At the Gösgen NPP, a separate building for the wet storage of spent fuel elements was commissioned in April 2008 (Nasslager). In 2017 a new building dedicated, amongst others, to a sorting station for solid radioactive waste and to interim storage of large components to be dismantled from the plant, has been commissioned in the Leibstadt NPP.

On behalf of the Swiss Confederation PSI operates the National Collection Centre for all non-NPP radioactive waste, i. e. waste coming from medicine, industry and research. This includes facilities for the treatment and conditioning of this radioactive waste and the Federal Interim Storage Facility (BZL). Between 1974 and 2002 PSI operated a pilot plant to incinerate low radioactive waste. In July 2011, PSI submitted a project for the decommissioning of its pilot incinerator plant. After a detailed review of the decommissioning project, the licensing authority (DETEC) issued the decommissioning order in 2014.

In Würenlingen, the Central Interim Storage Facility for radioactive waste (ZZL) was constructed by the utility-owned company Zwilag. In addition to storage capacity for spent fuel, vitrified high-level waste and other intermediate- and low-level radioactive waste, the ZZL includes facilities for the conditioning of specific waste streams and the incineration or melting of low-level waste (plasma incinerator). The storage facility started active operation in June 2001. The conditioning facilities have been available for active operation since December 2003. Test campaigns of the plasma incinerator with radioactive waste started in 2004. In September 2009 a permit for the permanent operation of the plasma incinerator was granted by ENSI.

The producers of radioactive waste, *i. e.* the NPP operators and the Swiss Confederation (responsible for the waste from medicine, industry and research) have formed the National Cooperative for the Disposal of Radioactive Waste (Nagra) which is responsible to prepare and implement solutions for the disposal of all radioactive waste categories. In 1985, Nagra submitted the documentation for project «Gewähr» aimed at demonstrating the feasibility of the safe implementation of two repositories, one for low-level and short-lived intermediate level waste (L/ILW) and one for high-level and long-lived intermediate level waste. For a repository for L/ILW at Oberbauenstock, the proposed demonstration of feasibility was accepted by the Federal Council after review by the federal authorities. The application for a general licence for a repository for L/ILW at the Wellenberg site in the canton of Nidwalden was submitted in 1994. The cantonal legislation required a mining concession for the construction of such a repository. The granting of this mining concession was rejected by the citizens of the canton in 1995. A new application for a mining concession relating only to an exploratory drift was submitted in January 2001 and rejected once again at a cantonal referendum in September 2002. The NPP operators subsequently abandoned the Wellenberg project.

The feasibility study based on a repository for high-level and long-lived intermediate level waste in the crystalline basement of Northern Switzerland, which was submitted by Nagra 1985 as part of project «Gewähr», was acceptable with respect of demonstrating safety and technical feasibility but not convincing with respect to siting feasibility (the possibility to find a site with the required properties). The Federal Council then decided that research should be continued and extended to sedimentary rocks. As a result of a broad selection process, Nagra chose the Opalinus clay formation in the north of the canton of Zurich for further geological investigations. The results of these investigations formed the basis for the required feasibility demonstration, which was submitted for review to the federal authorities in December 2002. The technical review by the competent Swiss authorities was concluded in August 2005 followed by a broad public consultation. The Federal Council approved the feasibility demonstration in 2006.

A comprehensive site selection process for a repository for high-level waste and a repository for low and intermediate-level waste has been started under the guidance and supervision of the federal authorities in 2008, see Section B.2.

A.7 Overview of the spent fuel and radioactive waste management

Table A.1 below provides an overview of the situation regarding spent fuel and radioactive waste management in Switzerland.

Table A.1: *Management of radioactive waste and spent fuel in Switzerland*

Type of Liability	Long-Term Management Policy	Funding of Liabilities	Current Practice/Facilities	Planned Facilities
Spent Fuel	Deep geological disposal Ban on reprocessing in the Energy Strategy 2050	Funding of Liabilities is always in the responsibility of the NPP-owners After final shut-down: Waste Management Fund	Interim storage	Deep geological repository for SF and HLW
Nuclear Fuel Cycle Wastes	Deep geological disposal	Funding of Liabilities is always in the responsibility of the NPP-owners After final shut-down: Waste Management Fund	Interim storage	Deep geological repository for L/ILW or for SF and HLW
Application Wastes	Deep geological disposal	Swiss Confederation collects and manages waste	Annual collection Conditioning and interim storage at PSI	New interim storage facility at PSI Deep geological repository for L/ILW
Decommissioning	No longer used facilities must be decommissioned	Funding of Liabilities is always in the responsibility of the NPP-owners After final shut-down: Decommissioning Fund (for NPPs)	Decommissioning of small nuclear facilities at PSI and at the University Basel Decommissioning of NPP Mühleberg	
Disused Sealed Sources	Recycling if possible, otherwise management as radioactive waste	Polluter pays principle Orphan sources: Swiss Confederation covers costs	Annual collection Export for recycling or conditioning and interim storage at PSI	Deep geological repository for L/ILW

A.8 Summary of results from the previous review

Challenges for Switzerland

Table A.2 below provides the challenges identified for Switzerland during the sixth Review meeting of the Joint Convention.

Table A.2: *Challenges identified during the 6th Review Meeting*

Challenges:	Reference in present report:
Site selection process for deep geological repositories for SF & HLW, and for L/ILW	See Section B.2
Long-term dry storage of SF	See Section K: Activities with respect to transport dual purpose casks after long-term storage

Overarching issues

Several overarching issues were identified during the sixth Review Meeting of the Joint Convention. The Contracting Parties agreed that National Reports for the next Review Meeting should address, as appropriate, the actual measures that have been taken in implementing the following issues.

(i) Implementation of national strategies for spent fuel and radioactive waste management

Information about the actual measures that have been taken for the implementation of this issue can be found in Sections B.1 and B.2.

(ii) Safety implications of long-term management of spent fuel

Information about the actual measures that have been taken for the implementation of this issue can be found in Section K: Activities with respect to transport dual purpose casks after long-term storage.

(iii) Linking long term management and disposal of disused sealed radioactive sources

Information about the actual measures that have been taken for the implementation of this issue can be found in Section J.

(iv) Remediation of legacy sites and facilities

Information about the actual measures that have been taken for the implementation of this issue can be found in Section H.2.2.

Section B Policies and Practices (Article 32 Paragraph 1)

In accordance with the provisions of Article 30, each Contracting Party shall submit a national report to each review meeting of Contracting Parties. This report shall address the measures taken to implement each of the obligations of the Convention. For each Contracting Party the report shall also address its:

(i) spent fuel management policy;
(ii) spent fuel management practices;
(iii) radioactive waste management policy;
(iv) radioactive waste management practices;
(v) criteria used to define and categorize radioactive waste.

The main sources of radioactive waste in Switzerland are the NPPs, which generate the following waste streams:

- Waste from the former reprocessing of spent fuel (vitrified high-level waste (HLW) and alpha-toxic waste (ATA)) and spent fuel.
- Waste from the operation of the NPPs (low and intermediate-level waste (L/ILW)).
- Waste from the later decommissioning of the NPPs (L/ILW).

Further radioactive waste arises from the use of radionuclides in medicine, industry and research, including the decommissioning of research facilities. These are almost exclusively L/ILW, but some alpha-toxic waste is also generated at the Paul Scherrer Institute (PSI). Switzerland has no uranium mines and no enrichment, fuel fabrication or reprocessing plants and thus no further sources of radioactive waste.

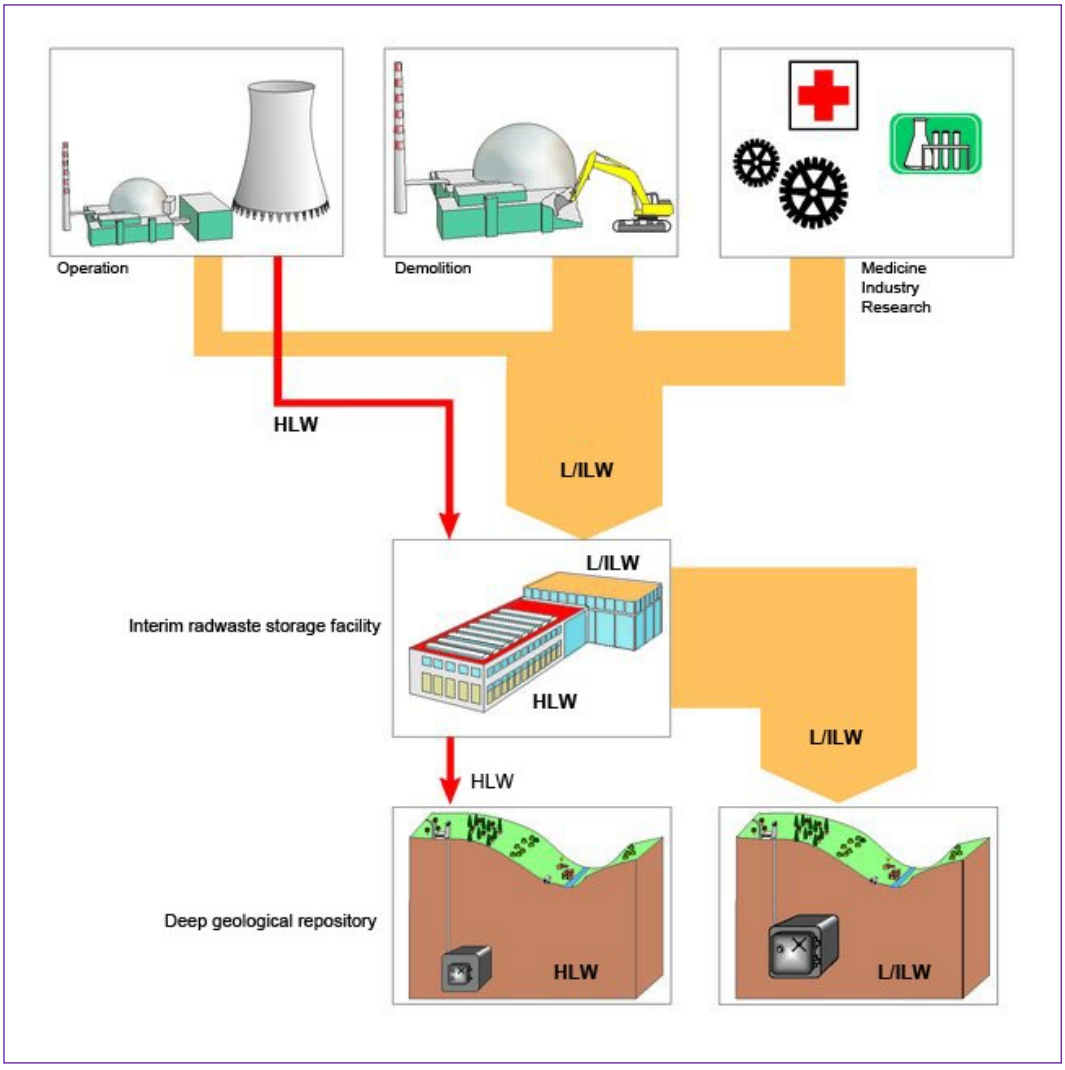


Figure 2: *Main waste flows in Switzerland's radioactive waste management concept (Source: ENSI)*

B.1 Spent Fuel Management (Clauses i and ii)

In Switzerland, four nuclear power reactors (3 PWR, 1 BWR) at three sites (Beznau, Gösgen and Leibstadt) are in operation, totalling around 3015 MWe. The NPP of Mühleberg (BWR) ceased power operation permanently on 20 December 2019.

In 2003, the parliament decided to introduce a 10-year moratorium on the export of spent fuel for reprocessing which started in July 2006. Before the start of the moratorium, the utilities were free to choose between reprocessing and direct disposal of the spent fuel. The Nuclear Energy Act states a series of conditions which must be fulfilled for an authorisation of the export of spent fuel for reprocessing to be granted. The conditions include an agreement with the country of destination, the existence in that country of an adequate facility corresponding to the international standards and the fact that the country of destination has ratified the Convention on Nuclear Safety and the Joint Convention.

Since the start of the moratorium, no spent fuel has been exported for reprocessing. In July 2016 the moratorium has been prolonged by Parliament decision for another four years. Export of spent fuel for reprocessing has finally been prohibited since 2018 (Nuclear Energy Act, Article 9). Since the ban of reprocessing spent fuel has to be managed as radioactive waste.

The reprocessing took place abroad (France and UK). Plutonium and uranium gained from reprocessing has been used for fuel fabrication and recycled in Swiss NPPs. The radioactive waste arising from reprocessing has been returned to Switzerland (see Section B.2). The contracts between the Swiss NPP operators and the foreign reprocessing companies cover roughly 1200 t of spent fuel. Before the start of the moratorium, about 1139 t of spent fuel had been shipped from the Swiss NPPs to the reprocessing facilities in France and the UK. All Swiss fuel has already been reprocessed. All radioactive waste had also been returned to Switzerland

For the interim storage of spent fuel and radioactive waste returned from reprocessing abroad, a dry storage building at Beznau NPP (ZWIBEZ) and a Central Interim Storage Facility (ZZL) (Figure 3) have been built. In addition, a building for the wet storage of spent fuel at Gösgen NPP (Nasslager) was commissioned in April 2008.

Figure 3:
Central Interim Storage Facility for radioactive waste (ZZL) in Würenlingen. The facility is operated by the utility-owned company Zwilag (Photo: ENSI).

B.2 Radioactive Waste Management (Clauses iii and iv)

According to the Nuclear Energy Act, the producers of radioactive waste are responsible for its safe management and disposal and have to bear the costs. The responsibility for conditioning and interim storage of radioactive waste from NPPs remains with the NPP operators. The Swiss Confederation has taken over the responsibility for the collection, conditioning, storage and disposal of radioactive waste generated by the use of radioisotopes in medicine, industry and research. The producers of these radioactive wastes are charged a service fee.

The nuclear energy legislation and the corresponding regulations require the raw waste to be minimised and conditioned as soon as possible. On 7 December 2018, the Federal Council approved the partial

revision of the Nuclear Energy Ordinance. It regulates the decay storage up to 30 years of very low-level radioactive waste. The revision clarifies the responsibilities for the approval of decay storage. The decay storage of such very low-level waste is also possible outside of nuclear facilities. All radioactive waste has to undergo final disposal in repositories placed in suitable geological formations; surface and near-surface disposal is excluded. The producers of radioactive waste, i. e., the NPP operators and the Swiss Confederation (for the waste from medicine, industry and research) have formed the National Cooperative for the Disposal of Radioactive Waste (Nagra) which is responsible to prepare and implement solutions for the disposal of all radioactive waste categories. Nagra also has to assess and attest the suitability for disposal of each type of waste package to be produced. Each conditioning process needs an approval from the regulatory authority prior to its application.

Two geological repositories are foreseen (Figure 2), one for low and intermediate-level waste (L/ILW); and the other for high-level waste (HLW, including spent fuel if not reprocessed) and long-lived intermediate-level waste – with the option of the two repositories being located at the same site. The nuclear energy legislation requires the demonstration of the feasibility of safe and permanent disposal of radioactive waste in Switzerland. This demonstration was conducted many years ago (Project «Gewähr», submitted in 1985) for low- and intermediate-level waste. For high-level and long-lived intermediate-level waste, the feasibility study by Nagra (Project Opalinus Clay, submitted in 2002) was approved by the Federal Council (federal government) in 2006.

Since no repositories are in operation yet, all radioactive waste is currently stored in interim storage facilities. Each NPP has conditioning facilities and interim storage capacity for its own operational waste. Additional storage capacity is available in the Central Interim Storage Facility (ZZL). This facility also contains installations for the conditioning of specific waste categories and the incineration or melting of low-level waste. The radioactive waste from medicine, industry and research is collected, conditioned and stored at the National Collection Centre for all non-NPP radioactive waste at PSI.

The radioactive waste, which was returned from the reprocessing of Swiss spent fuel abroad, is stored at ZZL. By the end of 2016 all commitments for waste return from France had been fulfilled in the form of vitrified HLW (CSD-V), alpha-toxic waste with compacted structural elements (CSD-C) and vitrified medium-level liquid waste (CSD-B). By the same time, all vitrified HLW from UK had also been returned to Switzerland the amount of which also included a radiologically equivalent substitute for the according low- and intermediate-level waste.

Site selection process for geological repositories

Under the lead of the Federal Office of Energy (FOE), the Federal authorities established the concept for a site selection procedure for deep geological repositories, which was subject to broad public consultation in 2007, including entire Switzerland as well as neighbouring countries. Following revision in the light of comments received, the Federal Council (federal government) approved the site selection concept in April 2008[1].

The conceptual part of the site selection procedure for deep geological repositories defines the goals of the federal government and the procedures and criteria to be applied in selecting sites for deep geological repositories for all categories of waste in Switzerland. The main focus of the site selection process is on safety-based criteria, with land use and socio-economic aspects playing a subsidiary role. The conceptual part of the plan specifies a three-stage site selection process (Figure 4) and it defines the collaboration between all stakeholders as well as their roles. The FOE is the process-leading organization. It also outlines how different spatial planning and environmental impact assessment activities are coordinated and how the economic development of potential siting regions can be supported as well as the establishment of the so-called regional participation during stage 1. Each stage of the site selection procedure comprises a broad public consultation and concludes with an approval by the Federal Council.

Based on the results of the three-stage procedure, a repository site will be selected for each type of repository (with the option of the two repositories being located at the same site, the so-called combined repository). The entire procedure is expected to be completed by the end of 2029 with the issue of one

[1] The «Sectoral Part for Deep Geological Repositories: Conceptual Part» is available in English, French, German and Italian (http://www.radioactivewaste.ch → «Sectoral Plan for Deep Geological Repositories» → «Documents»)

Figure 4:
Selection of sites in 3 stages of the Swiss site selection procedure (Source: FOE).

or two general licences by the Federal Council. This will then be followed by the approval of the Parliament. Approval is also subject to a facultative national referendum. According to the current timetable it is expected that the repository for L/ILW will become operational approximately in 2050 and the repository for HLW in 2060.

Stage 1 started after the approval of the conceptual part of the Sectoral Plan by the Federal Council in 2008. The main goal of this stage was the identification of suitable geological siting regions for both repository types starting with a «white map of Switzerland». In consideration of the safety criteria defined by the regulatory authority, the implementer Nagra proposed three potential siting regions for a geological repository for HLW and six potential siting regions for a geological repository for L/ILW (Figure 5) in 2008. ENSI reviewed the documentation and agreed with all proposed geological siting regions. The Swiss Federal Nuclear Safety Commission (NSC) gave its comments on the Inspectorate's review and concurred with the proposed siting regions as well. A broad public consultation procedure was concluded at the end of 2010. The Federal Council approved the potential siting regions in 2011, thus ending stage 1 of the site selection process. For the proposed siting regions of this stage, only clay-rich host rocks were proposed to comply with the safety requirements in Switzerland.

For **stage 2,** the implementer had to assess the geological database needed to compare the potential repository sites on the basis of a provisional safety assessment and to clarify the necessity for supplementary geological investigations. The corresponding report was submitted in 2010 and reviewed by the regulatory authorities (ENSI, NSC) in 2011. The review resulted in a demand for additional investigations needed for stage 2. These investigations have been addressed by Nagra, the results reviewed by ENSI and discussed with the experts of the siting cantons, the NSC and the Expert Group on Radioactive Waste Disposal (EGT), which advises ENSI on geological aspects of radioactive waste disposal. In order to improve the knowledge of the underground geology in the siting regions, Nagra has performed a 2D-seismic campaign including 300 km of seismic profiles measured during winter of 2011/12.

The Nagra proposal for stage 2 was published by the FOE in January 2015. Nagra proposed the two siting areas Zürich Nordost and Jura Ost for both L/ILW and HLW for further detailed investigations in stage 3. In these siting areas, Opalinus Clay is proposed as the host rock formation to be pursued for both repository types. In the view of Nagra, the four other L/ILW siting areas (Südranden, Nördlich Lägern, Jura-Südfuss and Wellenberg; Figure 5) and the HLW siting region Nördlich Lägern are to be deferred in stage 2 as a result of clear disadvantages in comparison with the other siting regions.

Figure 5:
Geological siting regions proposed in stage 1 for a repository for high-level waste (orange) and low- and intermediate-level waste (green). Five of the siting regions are located in northern and one in central Switzerland. The red dots indicate the siting areas for the surface facilities designated by Nagra based on results of the regional participation process (Source: Nagra).

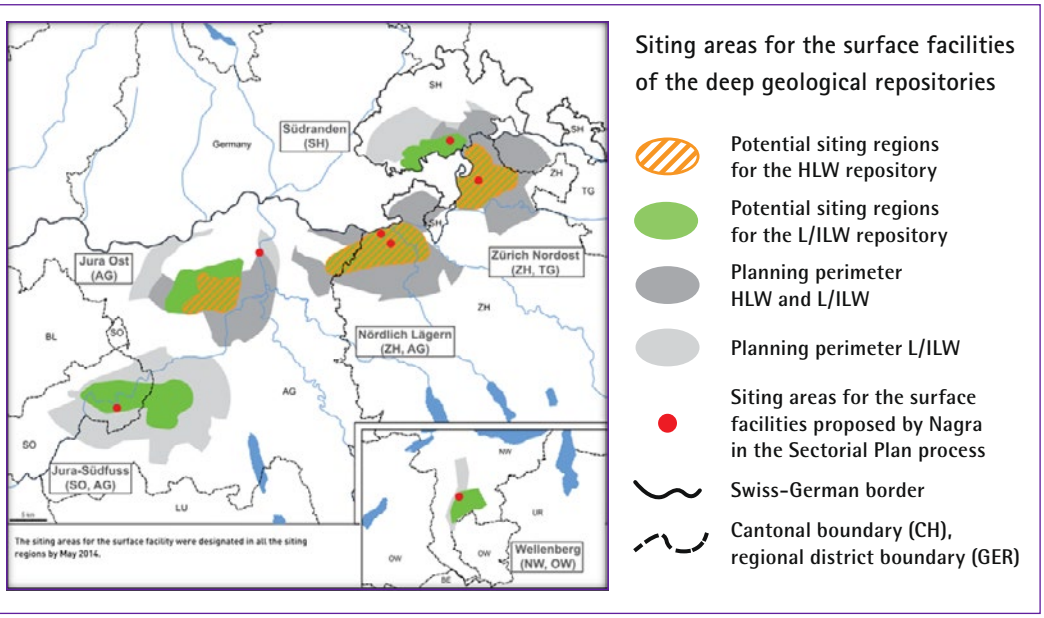
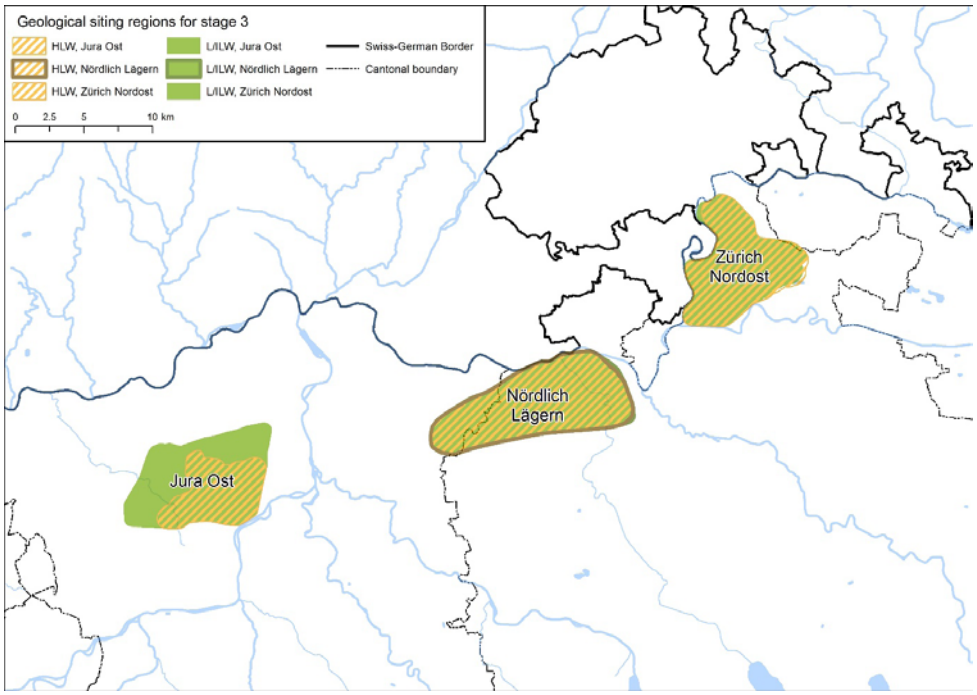


Figure 6:
Geological siting regions Jura Ost, Nördlich Lägern and Zürich Nordost for further investigation in stage 3 of the site selection procedure for a repository for high-level waste (orange hatched area) and low- and intermediate-level waste (green) (Source: ENSI).



In its review, published in April 2017, ENSI concluded that of the six L/ILW siting regions from stage 1 (Figure 5), the regions Südranden, Jura-Südfuss and Wellenberg are considered clearly less suitable due to identified clear disadvantages. Like Nagra, ENSI identified no clear disadvantages for the L/ILW and HLW siting areas of Zürich Nordost and Jura Ost. Unlike Nagra, however, it identified no clear disadvantages for the siting area of Nördlich Lägern. The deferment of the L/ILW and HLW siting region Nördlich Lägern was not considered to be reliable, which in the review of ENSI resulted in the proposal of three L/ILW and three HLW siting regions (Figure 6), all of which shall be investigated in more detail in stage 3. After a broad public consultation on the results of stage 2 (starting end of 2017), the Federal Council decided in November 2018 that the three siting regions Jura Ost, Zürich Nordost and Nördlich Lägern should be further investigated for both L/ILW and HLW in stage 3.

In preparation for **stage 3** ENSI specified its safety requirements for the site selection process and documentation for this last stage of the Sectoral Plan. Recommendations by the NSC, the EGT, the Committee of the Cantons (AdK) and the German Expert Group for the Swiss Deep Repository (ESchT) were also considered for issuing these requirements. Comparison of the sites is based on the geological situation in the siting areas, the site-specifically derived repository layout, the safety analyses and the qualitative assessment of the 13 safety criteria defined in the Sectoral Plan.

Due to the more stringent requirements for geological barriers and the longer time period for the assessment of a repository for HLW, the location for the HLW repository should be chosen first. Subsequently, the location for the L/ILW repository should be selected.

Based on the results of the geological investigations (see below) and the safety-related comparison of the three remaining siting areas, Nagra is expected to announce the locations for the HLW and the L/ILW repositories (or the location for a combined repository), which it intends to prepare general licence applications for, in 2022.

The location and layout of the surface facilities of the repository projects will be discussed between Nagra and the proposed siting regions, by detailed examination of the social and economic impacts of the repositories. Nagra will submit the general licence applications for the construction of the deep geological repositories by 2024, followed by the review of the federal authorities.

Geological field investigations

In winter 2015/2016 Nagra initiated 3D-seismic investigations in the two proposed siting regions Zürich Nordost (as an amendment to an already existing 3D-seismic pattern from 1997/1998) and Jura Ost. Since such investigations are non-destructive with respect to the intended host rock and its confining units, no federal licensing is required. In view of the upcoming result of ENSI's review, Nagra decided to also initiate 3D-seismic investigations in the siting region of Nördlich Lägern in winter 2016/2017. Both seismic campaigns could be completed successfully (with more than 95 % of the land owners accepting data acquisition on their estate). The processing and interpretation of the large datasets is still ongoing.

In addition to their seismic investigations, Nagra submitted 23 licence applications for drilling operations, covering a depth range between 800 and 1400 m and therefore penetrating the future host rock and confining units. Applications included 8 drilling sites in each of the siting regions of Zürich Nordost and Jura Ost and 7 sites in Nördlich Lägern. Borehole locations are planned to be mostly situated around the proposed disposal perimeters (Figure 7). All licence applications were assessed by the FOE, the Federal Offices for the Environment, for Spatial Development and ENSI and were subject to public consultation including cantonal authorities.

Based on preliminary results of the 3D seismic investigations, Nagra decided to withdraw two licence applications in Nördlich Lägern but submit an additional licence application closer to the revised disposal perimeter. As of September 2020, all licences applied, have been granted and are also legally valid. Drilling activities started in April 2019 (Figure 8) and it is expected that four to five vertical boreholes will be drilled as of October 2020.

A special focus of the geological field investigations for stage 3 is given to the youngest geological history of the siting regions. Therefore, Nagra has also initiated an extensive research program focussing on the Quaternary sediments as a record of geological processes during the last few million years, including 2D seismic lines along and across former glacial valleys as well as core drillings into such valley fillings (up to

a few hundred metres in depth). Similar to the previous investigations, the seismic investigations were not affected by Federal licensing, while for 15 boreholes, Federal licences had to be granted. As of October 2020, 14 of 15 Quaternary boreholes has been drilled.

Figure 7:
Locations of the drilling sites submitted in the licence application for drilling operations at the Jura Ost siting region (Source: Nagra).

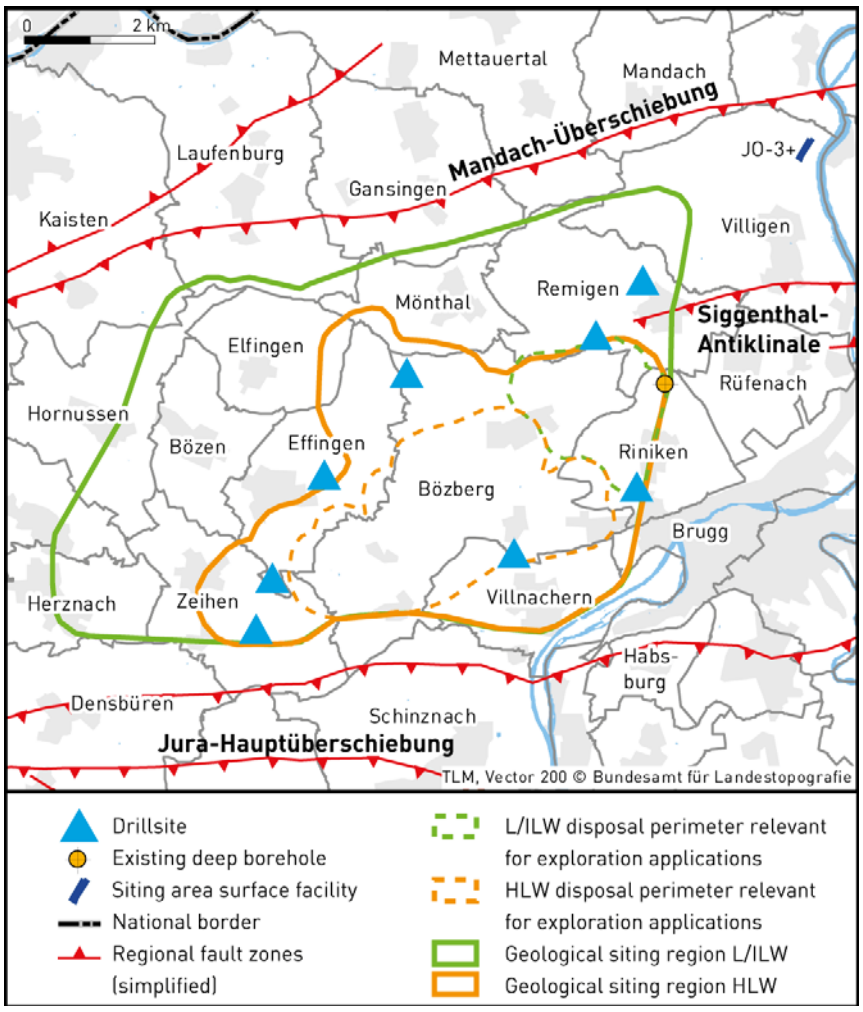


Figure 8:
Nagra drilling site «Trüllikon-1» (Photo Nagra)

Waste Management Program, RD&D-Program and cost estimates for decommissioning and waste management, incl. disposal

The Nuclear Energy Act requires those organisations that manage and dispose radioactive waste to periodically submit a waste management programme, which must include a financial plan up to the time at which the nuclear installations will be taken out of operation. Such waste management programme was submitted in 2008 for the first time by Nagra on behalf of the waste producers. The waste management programme was reviewed by ENSI and NSC in 2011 and approved by the Federal Council in 2013. As part of the approval, it was decided that the periodical submission of the waste management should be linked to the submission of the cost estimates for decommissioning and disposal and in future it should also contain a research, development and demonstration (RD&D) program. In 2016, Nagra therefore submitted updated reports including information on the waste management program and the RD&D-program. Swissnuclear, the organisation of Swiss nuclear operators, submitted a cost estimates for decommissioning and disposal (see section F2.2). The review of these reports by ENSI was published in April 2018 and the Federal Council approved the update of the waste management program in November 2018.

The next update of the waste management programme, the RD&D-program, as well as the cost estimates for decommissioning and waste management has to be submitted by 2021.

B.3 Categorization of Radioactive Waste (Clause v)

Material or waste is considered radioactive if it falls within the scope of application of the legislation on radiation protection as defined in the Radiological Protection Ordinance. A solid material is considered radioactive if at least one of the following criteria is fulfilled:

- The specific (Bq/kg) and absolute (Bq) activity of the material exceeds the nuclide specific clearance level specified in the Ordinance. For mixtures of nuclides, the various nuclides are weighted according to a summation rule.
- The surface contamination (Bq/cm^2) of the material exceeds the nuclide specific value specified in the Ordinance. For mixtures of nuclides, the various nuclides are weighted according to a summation rule.
- The dose rate at a distance of 10 cm from the surface of the material exceeds 0.1 μSv per hour, after deduction of the background.

Similar criteria are defined for liquids and gases.

The surface contamination has to be averaged over a surface of 100 cm^2. The limiting value is derived from consideration of skin exposure and of intake by ingestion and inhalation. The nuclide specific clearance levels have been completely updated in the revision of the Radiological Protection Ordinance, in order to adapt to the latest international recommendations. The Ordinance entered into force on the 1st of January 2018.

Material or waste which is not radioactive according to the criteria described above is either recycled or treated and disposed of as conventional waste in accordance with its non-radioactive waste category.

The Nuclear Energy Ordinance defines the following classification of radioactive waste:

- High-level waste (HLW): Vitrified fission product waste from the reprocessing of spent fuel, or spent fuel if declared as waste.
- Alpha-toxic waste (ATA): Waste with a concentration of alpha-emitters exceeding 20 000 Bq/g of conditioned waste.
- Low- and intermediate-level waste (L/ILW): Any other radioactive waste.

Section C Scope of Application (Article 3)

C.1 Reprocessing (Paragraph 1)

This Convention shall apply to the safety of spent fuel management when the spent fuel results from the operation of civilian nuclear reactors. Spent fuel held at reprocessing facilities as part of a reprocessing activity is not covered in the scope of this Convention unless the Contracting Party declares reprocessing to be part of spent fuel management.

There are no reprocessing facilities in Switzerland. Before the start of the moratorium and the ban on reprocessing (see Section B.1), about 1139 t of spent fuel had been shipped from the Swiss NPPs to reprocessing facilities in France and the UK. All Swiss fuel has already been reprocessed.

Spent fuel from NPPs is held in on-site storage ponds for some years. It is then transferred into transport and storage casks for dry interim storage at the Central Interim Storage Facility (ZZL) or at the Beznau NPP site.

All the radioactive waste arising from the reprocessing of Swiss spent fuel has been returned to Switzerland. The Convention applies to the management of radioactive waste from reprocessing returned to Switzerland.

C.2 Waste Containing only Naturally Occurring Radioactive Material (Paragraph 2)

This Convention shall also apply to the safety of radioactive waste management when the radioactive waste results from civilian applications. However, this Convention shall not apply to waste that contains only naturally occurring radioactive materials and that does not originate from the nuclear fuel cycle, unless it constitutes a disused sealed source or it is declared as radioactive waste for the purposes of this Convention by the Contracting Party.

According to the Radiological Protection Ordinance, NORM waste can be freely disposed of as long as its specific activity is under the NORM clearance limits of 1 Bq/g for the natural Uranium and the Thorium decay series and 10 Bq/g for material containing radioactive Potassium (K-40). NORM waste is not considered as radioactive waste according to the Swiss legislation. Waste baring activities above the NORM clearance limits can only be disposed of or released to the environment if the resulting effective dose does not exceed 0.3 mSv/year for members of the public. The Federal Office of Public Health (FOPH) controls that this condition is met in the frame of an obligatory request for consent prior to elimination or release to the environment of such waste. NORM waste is typically disposed of in landfills or incinerated. In certain cases, reuse is also possible.

C.3 Radioactive Waste within the Defence Programme (Paragraph 3)

This Convention shall not apply to the safety of management of spent fuel or radioactive waste within military or defence programmes, unless declared as spent fuel or radioactive waste for the purposes of this Convention by the Contracting Party. However, this Convention shall apply to the safety of management of spent fuel and radioactive waste from military or defence programmes if and when such materials are transferred permanently to and managed within exclusively civilian programmes.

The Swiss legislation applicable to radioactive waste management contains no exceptions for waste material originating from military applications. Such radioactive waste must be delivered to the National Collection Centre at PSI.

Only a small amount of radioactive waste has come from military applications. It has been conditioned and stored at PSI together with similar material from other sources and is considered to be radioactive waste for the purposes of the Convention.

This report shall also include:

(i) a list of the spent fuel management facilities subject to this Convention, their location, main purpose and essential features;

(ii) an inventory of spent fuel that is subject to this Convention and that is being held in storage and of that which has been disposed of. This inventory shall contain a description of the material and, if available, give information on its mass and its total activity;

(iii) a list of the radioactive waste management facilities subject to this Convention, their location, main purpose and essential features;

(iv) an inventory of radioactive waste that is subject to this Convention that:

(a) is being held in storage at radioactive waste management and nuclear fuel cycle facilities;

(b) has been disposed of; or

(c) has resulted from past practices.

This inventory shall contain a description of the material and other appropriate information available, such as volume or mass, activity and specific radionuclides;

(v) a list of nuclear facilities in the process of being decommissioned and the status of decommissioning activities at those facilities.

The first part of the present section gives an overview of the waste classes defined in Switzerland and gives their composition in relation to the IAEA definitions as outlined in the IAEA Safety Standard No. GSG-1. The second part gives the lists and inventories requested in Article 32 Paragraph 2.

D.1 Waste Register and Waste Classes

Swiss Waste Register (ISRAM)

The conditioning of radioactive waste requires an approval by the Swiss Federal Nuclear Safety Inspectorate (ENSI). The requirements on the conditioning process, the waste package type and its documentation are defined broadly in the Nuclear Energy Ordinance and in detail in the Regulatory Guideline ENSI-B05. The documentation includes a detailed description of the waste package type and its inventory.

The Swiss NPPs, the waste management facilities and Nagra have agreed on a common electronic data base called Information System on radioactive Material ISRAM, where this information is kept and continuously updated. Further to the description of the waste package types produced after its implementation, the data base has also been expanded to take account of the corresponding data on the then preexisting waste package types. It is also used by the NPPs to keep track of the raw waste on stock and by the NPPs and the Central Interim Storage Facility ZZL to keep the data on the spent fuel in storage. Thus, ISRAM provides the waste owners and Nagra with a complete and detailed account of the radioactive waste existing in Switzerland. ENSI is informed on the waste inventories periodically as prescribed and outlined in the legislation on nuclear energy.

Waste Classes

The Swiss legislation on nuclear energy established the following classification of radioactive waste:

- High-level waste (HLW): Vitrified fission product waste from the reprocessing of spent fuel, or spent fuel if declared as waste.
- Alpha-toxic waste (ATA): Waste with a concentration of alpha-emitters exceeding 20000 Bq/g of conditioned waste.
- Low- and intermediate-level waste (L/ILW): All other radioactive waste.

D.2 Facilities and Inventories

D.2.1 Spent Fuel Management Facilities (Clause i)

Besides the spent fuel pools in the five nuclear power reactor units at the four NPP sites, the following spent fuel management facilities exist in Switzerland:

ZZL: The Central Interim Storage Facility in Würenlingen, owned and operated by the Zwilag company, itself a subsidiary of the NPP companies. Its storage hall for dry storage of spent fuel and vitrified HLW can accommodate 200 dual purpose casks (DPCs) suitable for transport and storage. The storage facility started operation in 2001.

ZWIBEZ: The interim storage facility at Beznau NPP. The storage hall for spent fuel can accommodate 48 DPCs. The storage facility started operation in 2008.

Gösgen NPP wet storage facility (Nasslager): The external spent fuel pool on the Gösgen NPP site. This storage facility was built for a capacity of 1,008 spent fuel elements from Gösgen NPP. The facility started operation in April 2008. Only 50 % of the racks have been installed. For the second half it is planned to use a more compact rack-design which would allow for a total capacity of 1206 spent fuel elements.

D.2.2 Inventory of Spent Fuel in Storage (Clause ii)

As of the end of 2019, the inventories of spent fuel in the storage ponds of the NPPs were as follows (number of spent fuel elements):

- Beznau NPP: 665 (PWR type);
- Mühleberg NPP: 178 (BWR type);
- Gösgen NPP: 696 (PWR type);
- Leibstadt NPP: 1553 (BWR type);

In addition, ZWIBEZ, the dry interim storage facility at Beznau NPP, contained 13 DPCs with a total of 391 spent fuel elements of the PWR type.

As of the end of 2019, ZZL contained 41 DPCs with a total of 3064 spent fuel elements of the BWR type and four DPCs with a total of 148 spent fuel elements of the PWR type. One additional cask contains 349 fuel elements from the DIORIT research reactor.

Further data (masses, activities) concerning spent fuel in storage are given in Table D.1.

Table D.1: *Inventories of spent fuel in storage as of 31 December 2019*

Facility	Number of spent fuel elements stored	Total mass (t HM[1])	Total activity (Bq)
Beznau NPP (incl. ZWIBEZ)	1056	341,7	$7{,}3 \cdot 10^{18}$
Mühleberg NPP	178	31,2	$1{,}2 \cdot 10^{18}$
Gösgen NPP (incl. Nasslager)	696	281,1	$10{,}0 \cdot 10^{18}$
Leibstadt NPP	1553	262,2	$7{,}6 \cdot 10^{18}$
ZZL	3561	590,7	$7{,}8 \cdot 10^{18}$

[1] Tonnes of Heavy Metal

D.2.3 Radioactive Waste Management Facilities (Clause iii)

At present, the following radioactive waste management facilities exist in Switzerland:

Nuclear Power Plants: All Swiss nuclear power plants have on-site waste treatment and conditioning facilities as well as on-site stores for low- and intermediate-level operational waste. The principal conditioning technique used is cementation, but the spent ion exchange resins from the operation of the PWRs are also either embedded in polystyrene (Beznau NPP) or bituminised (Gösgen NPP).

ZZL: The Central Interim Storage Facility in Würenlingen, owned and operated by Zwilag company. In addition to a storage hall for dry storage of spent fuel and vitrified HLW (see Section D.2.1), it features a storage building for ILW with a capacity of 4000 m³ of waste, and a storage hall for L/ILW with a capacity of 16 500 m³ of waste. Auxiliary facilities for the sorting and decontamination of materials and for the conditioning of waste are also available. An important conditioning facility is the plasma incinerator for

melting and incineration of LLW. The storage facility started active operation in June 2001. The sorting, decontamination and conditioning facilities have been available for active operation since December 2003. Test campaigns of the plasma incinerator with active waste started in 2004. In September 2009 a permit for the permanent operation of the plasma incinerator was granted by ENSI. Meanwhile, one or two incineration campaigns of this facility are carried out annually.
Until 2018, the building foreseen to storage L/ILW has only been used for the storage of conventional non-radioactive materials. The extension works for the «active» commissioning of the storage hall was completed by end of 2019. In June 2020 ENSI approved the active operation for the storage of low and intermediate level waste as licenced by the Federal Council in 1996.
ZWIBEZ: The interim storage facility at Beznau NPP. In addition to the hall for dry storage of spent fuel (see Section D.2.1), it consists of a storage hall for the storage of low-level operational waste from Beznau NPP with a capacity of 6000 m³ of waste. The storage hall for LLW was licensed in 1990 and started operation in 1994.
PSI: The Paul Scherrer Institute (PSI) operates the National Collection Centre for institutional radioactive waste (non-NPP-waste, e. g. from medicine, industry and research), where the waste is sorted and conditioned. PSI also operates the Federal Interim Storage Facility (BZL) for this waste, with a capacity of 2100 m³ of waste. An ongoing project aims at increasing the storage capacity significantly to provide for storage of institutional waste until the foreseen opening of the deep geological repository (see Section K).

D.2.4 Inventory of Radioactive Waste in Storage (Clause iv-a)

The inventories of the waste management facilities listed in Section D.2.3 are reported in Table D.2. This gives a comprehensive overview of the radioactive waste stored in Switzerland.

Table D.2: *Waste inventories stored at the radioactive waste management facilities as of December 2019.*

Site name	Waste class	Waste volume (m³)	Total activity Alpha (Bq)	Total activity Beta/Gamma (Bq)
Beznau NPP (incl. ZWIBEZ)	L/ILW, cond.[1] L/ILW, uncond.[2]	1199 28	$8.5 \cdot 10^{10}$ $1.1 \cdot 10^{9}$	$5.1 \cdot 10^{14}$ $5.8 \cdot 10^{11}$
Mühleberg NPP	L/ILW, cond. L/ILW, uncond.	797 62	$1.6 \cdot 10^{12}$ $1.6 \cdot 10^{8}$	$1.6 \cdot 10^{15}$ $7.4 \cdot 10^{11}$
Gösgen NPP	L/ILW, cond. L/ILW, uncond.	109 18	$7.5 \cdot 10^{9}$ $1.8 \cdot 10^{9}$	$1.2 \cdot 10^{14}$ $1.4 \cdot 10^{12}$
Leibstadt NPP	L/ILW, cond. L/ILW, uncond.	1401 5	$6.0 \cdot 10^{10}$ $3.8 \cdot 10^{7}$	$2.5 \cdot 10^{14}$ $2.0 \cdot 10^{10}$
ZZL	HLW, cond. ATA[3], cond. L/ILW, cond. L/ILW, uncond.	115 99 2253 391	$1.0 \cdot 10^{17}$ $2.8 \cdot 10^{14}$ $1.6 \cdot 10^{11}$ $2.2 \cdot 10^{11}$	$7.2 \cdot 10^{18}$ $3.7 \cdot 10^{16}$ $1.6 \cdot 10^{15}$ $8.8 \cdot 10^{12}$
PSI	ATA, cond. ATA, uncond. L/ILW, cond. L/ILW, uncond.	68 15 1555 549	$2.2 \cdot 10^{13}$ $1.2 \cdot 10^{13}$ $7.8 \cdot 10^{11}$ $3.5 \cdot 10^{10}$	$5.4 \cdot 10^{14}$ $1.6 \cdot 10^{14}$ $1.2 \cdot 10^{16}$ $8.7 \cdot 10^{13}$

[1] conditioned waste (cond.)
[2] unconditioned and partly conditioned waste (uncond.)
[3] Alpha-toxic waste (ATA)

D.2.5 Disposal of Radioactive Waste (Clause iv-b)

There are no radioactive waste disposal facilities in Switzerland. However, preparations are under way to identify suitable sites for deep geologic repositories for the Swiss radioactive waste (see Section B.2). From 1969 to 1982, 5341 tons (approximately 2300 m³) of L/ILW were dumped in the North Atlantic in the framework of campaigns organised by the OECD Nuclear Energy Agency. The radioactivity of material dumped amounted to 4420 TBq. 60 % of the waste came from medicine, industry and research and 40 % from the nuclear industry.

D.2.6 Radioactive Waste from Past Practices (Clause iv-c)

Radioactive waste from past practices is dealt with in the same manner as radioactive waste from medicine, industry or research and delivered to the National Collection Centre for all non-NPP radioactive waste at PSI. Collection and delivery are organised by the Federal Office of Public Health (FOPH). This concerns typically legacy objects discovered at conventional waste collection facilities (Radium painted instruments, lightning rods…) or from private owners, or else contaminated material from past practices. There are no other dedicated waste storage facilities for such material.

D.2.7 Nuclear Facilities Being Decommissioned (Clause v)

Decommissioning of small nuclear facilities

In Switzerland, there are currently four research reactors and a small waste treatment facility in different stages of decommissioning. Four of these five facilities are located at PSI, one at the University of Basel.

- Decommissioning of the research reactor DIORIT at PSI started in 1994 and is in its final phase. The biological shield of the reactor was completely dismantled by the end of 2013. In 2015, PSI declared an alteration of the decommissioning end state. The decision was taken to demolish the facility building instead of reusing it and to achieve the end state «brown field». In consequence, PSI needs a revised decommissioning order, the preparations for that reason are ongoing. The reactor base plate was dismantled and fragmented in 2016. Since the last National Report, contaminated pipes and ducts are being dismantled as well as some activated concrete structures.
- Decommissioning of the research reactor SAPHIR at PSI started in 2002 and is in its final phase. The reactor pool and the biological shield are completely dismantled and conditioned. Currently, the remaining concrete structures are measured with in-situ gamma spectrometry in order to prepare a general clearance procedure. The planned end state of the decommissioning of SAPHIR is the complete demolition of the building («brown field»).
- In April 2013, the PSI submitted a final decommissioning plan for its research reactor PROTEUS that finally ceased operation in April 2011. ENSI reviewed the decommissioning plan and assessed it in 2016. In 2017, the licensing authority DETEC gave the decommissioning order. By then, first dismantling activities started such as removal of no longer used pipes and instruments from the control room, dismantling of the upper platform and the staircase in the reactor hall. The planned end state of the decommissioning is only to remove the reactor and to reuse the former reactor building for non-nuclear purposes.
- The decommissioning of a small incinerator facility for low-level waste at the PSI is ongoing. DETEC gave the decommissioning order in July 2014. The dismantling activities are divided in 5 phases. In the first phase, various auxiliary equipment and the flue-gas stack were dismantled and a new off-gas-treatment plant was installed. In the second phase, the furnace itself was successfully dismantled. Currently, the dismantling of the air filter system is ongoing. The end state of decommissioning is the complete demolition of the building («brown field»).
- In February 2017, the University of Basel submitted the final decommissioning plan for its research reactor AGN-211-P that finally ceased operation in October 2013. The fuel elements were removed from the facility in July 2015. ENSI assessed the decommissioning plan in 2017. In February 2019, DETEC gave the decommissioning order. Since it is a simple and small facility, there is only one phase of decommissioning. All dismantling work was completed in 2019. The radioactive waste that arose from decommissioning was transferred to PSI for further treatment and conditioning. The planned end state of decommissioning is to reuse the rooms in which the reactor was installed.

Decommissioning of Mühleberg NPP

In late 2013, BKW Energy Ltd announced that their Mühleberg plant will cease power operation at the end of 2019. The single unit 373 MWe boiling water reactor started operation in 1972. It finally ceased power operation on 20 December 2019 and it is the first commercial Swiss NPP to be decommissioned. In December 2015, BKW submitted the application documents for the decommissioning of its NPP. The application comprises the main report detailing the decommissioning project's conceptual framework

and three subreports: accident analyses and emergency protection measures, the environmental impact report, and the security report.

The requirements for the final decommissioning plan[2] (in the Swiss legislation the «decommissioning project») are described in the Nuclear Energy Act, the Nuclear Energy Ordinance and in ENSI's Regulatory Guideline ENSI-G17. The Guideline ENSI-G17 is in accordance with the WENRA Safety Reference Levels and the respective IAEA Safety Standards on decommissioning.

After the final decommissioning plan had been reviewed and approved by the authorities (ENSI's advisory opinion was published in August 2017), the licensing authority DETEC granted the decommissioning order in June 2018. In the decommissioning order, the decommissioning procedure for Mühleberg NPP is described legally binding (see F.6).

According to the approved final decommissioning plan and based on DETEC's decommissioning order, the operator of Mühleberg NPP begun preparatory measures directly after final cessation of power operation. These measures include, e. g., transfer of spent fuel elements from the reactor to the spent fuel pool, installation of a redundant cooling system for the spent fuel pool independent of other operational plant systems, dismantling of large components in the turbine building and instead installation of waste management facilities.

[2] In the Swiss legislation the expression «decommissioning project» is being used (Art. 27 Nuclear Energy Act). But in the international understanding this expression is misleading. It is equivalent to the internationally agreed «final decommissioning plan».

Section E Legislative and Regulatory System

E.1 Implementing Measures (Article 18)

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

As described in Sections E.2 and E.3 below, Switzerland has taken the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under the Convention.

E.2 Legislative and Regulatory Framework (Article 19)

E.2.1 Overview (Paragraph 1)

Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of spent fuel and radioactive waste management.

The legislative and regulatory framework in Switzerland for the peaceful use of nuclear energy, the safety of nuclear facilities and radiological protection is based on a four-level system:

- 1st level: Federal Constitution of the Swiss Confederation
- 2nd level: Federal Acts
- 3rd level: Ordinances (issued by the Federal Council or a federal department)
- 4th level: Regulatory Guidelines

The safety of spent fuel and radioactive waste management is governed by the federal legislation on nuclear energy and on radiation protection. This legislation consists mainly of the following laws and ordinances:

- Nuclear Energy Act of 21 March 2003
- Radiological Protection Act of 22 March 1991
- Swiss Federal Nuclear Safety Inspectorate Act of 22 June 2007
- Nuclear Energy Ordinance of 10 December 2004
- Radiological Protection Ordinance of 26 April 2017
- Ordinance on Hazard Assumptions and the Assessment of the Protection against Accidents in Nuclear Installations of 17 June 2009
- Ordinance on the Decommissioning and Waste Management Funds for Nuclear Installations of 7 December 2007
- Ordinance on the Collection of Radioactive Waste of 26 April 2017
- Ordinance on the Swiss Federal Nuclear Safety Inspectorate ENSI of 12 November 2008

The Swiss Federal Nuclear Safety Inspectorate (ENSI) issues regulatory guidelines either in its capacity as a regulatory authority or based on an explicit mandate in an ordinance. Regulatory guidelines formalise the implementation of legal requirements and facilitate uniformity of implementation practices. They also specify the state of the art in science and technology. The Inspectorate may allow deviations from the regulatory guidelines in individual cases provided that the suggested solution ensures at least an equivalent level of nuclear safety or security.

The regulatory guidelines are divided into three series based on the classification of its over-sight activities:

- Series A: Regulatory guidelines relevant for the assessment of facilities
- Series B: Regulatory guidelines relevant for the surveillance of operations
- Series G: Regulatory guidelines relevant for both the assessment of facilities and the surveillance of operations

In its regulatory guidelines, ENSI aims to cover all explicit mandates from ordinances as well as all applicable IAEA requirements and WENRA Safety Reference Levels. The ENSI regulatory guideline system places particular emphasis on consistency and comprehensiveness. A complete list of the regulatory guidelines currently in force is given in Annex L.2.2.

The Inspectorate has established a Committee for the Regulatory Basis, which is responsible for issuing and revising regulatory guidelines. The latter is the case when it becomes apparent that some aspects of a guideline no longer reflect the state of the art. Moreover, the Committee for Regulatory Basis reviews the guidelines systematically on a regular basis, at the latest every ten years. However, most guidelines are reviewed earlier. Drafts are produced by working groups on the basis of a specification. The Committee reviews drafts for public consultations and publication. The results of the public consultations and the decisions taken by ENSI are documented. Finally, each regulatory guideline has to be approved by ENSI's Director General.
The Inspectorate participates in the following WENRA groups: «Reactor Harmonisation Working Group», «Working Group on Waste and Decommissioning» and «Inspection Working Group». In the area of waste and decommissioning, the incorporation of the Safety Reference Levels has been successfully completed. As demonstrated below, this legislation covers the requirements set forth in Paragraph 2. Thus, the obligation under Paragraph 1 of Article 19 of the Convention is met.

E.2.2 Radiation Safety (Paragraph 2 Clause i)

This legislative and regulatory framework shall provide for the establishment of applicable national safety requirements and regulations for radiation safety.

National requirements for radiation safety are established in the legislation on radiological protection (Radiological Protection Act and Radiological Protection Ordinance). This legislation aims at protecting human health and the environment against ionising radiation. It implements the internationally agreed principles of justification of a practice, optimisation of radiation exposure and dose limitation. Important requirements regarding spent fuel and radioactive waste management are as follows:

- The generation of radioactive waste must be minimised.
- Radioactive waste generated in Switzerland must in principle be disposed of domestically.
- Import and export of radioactive waste for disposal in Switzerland is allowed only under an international agreement.
- Material or waste is considered to be radioactive if at least one of the following criteria is fulfilled:
  - the activity exceeds the nuclide specific clearance level set in the Ordinance,
  - the surface contamination exceeds the nuclide specific value set in the Ordinance,
  - the dose rate at a distance of 10 cm from the surface exceeds 0.1 μSv per hour, after deduction of the background.
- The dose limit for occupational exposure is 20 mSv per year, after deduction of the background.
- The dose limit for individual members of the population is 1 mSv per year, after deduction of the (natural) background.
- A dose constraint lower than the above limit for individual members of the population must be set for each facility.
- The limits for immissions of radioactivity in the environment include
  - nuclide specific airborne concentrations,
  - nuclide specific concentrations in accessible waters,
  - a maximal dose of 1 mSv per year from direct exposure in working and living places.
- The discharges from facilities must be limited so that the immission limits and the dose constraint are met.
- Radioactive waste arising from medical, industrial and research facilities must be delivered to the National Collection Centre at the research centre of the Paul Scherrer Institute, which is a nuclear facility governed by the nuclear energy legislation.

These requirements are in line with the internationally agreed standards on radiation protection. More detailed criteria concerning radiation protection are set in ENSI's regulatory guidelines.
The Radiological Protection Ordinance as well as all other ordinances concerning radiation protection as the «Ordinance on the Use of Radioactive Materials», the «Ordinance on Dosimetry» and the «Ordinance on Education and Training and Authorized Practices in Radiation Protection» have been completely revised in order to adapt to the latest international recommendations. They entered into force on the 1st of January 2018.

E.2.3 Licensing System (Paragraph 2 Clause ii)

This legislative and regulatory framework shall provide for a system of licensing of spent fuel and radioactive waste management activities.

The Nuclear Energy Act establishes the need for a series of licences regarding nuclear materials, radioactive waste and nuclear facilities. According to the Nuclear Energy Act, a nuclear facility is any facility intended for the use of nuclear energy, the extraction, production, utilisation, processing or storage of nuclear materials, and the management of radioactive waste. Nuclear materials are substances that can be used for obtaining energy via nuclear fission processes.

Spent fuel and radioactive waste management activities are generally carried out in nuclear facilities. Radioactive waste management includes conditioning, interim storage and final disposal. The Nuclear Energy Act requires the following licences for nuclear facilities:

- **General licence:** This is mainly a political decision prior to the realisation of a nuclear facility. The main prerequisites for granting a general licence are
  - protection of human health and the environment,
  - no conflict with preservation of natural and cultural heritage and land use planning,
  - no conflict with international agreements and national security,
  - a conceptual plan for the decommissioning or closure of the facility,
  - evidence of the management of radioactive waste arising from the facility.

  The general licence defines the site, the purpose and the essential features of the planned facility, and the maximum permissible radiation dose to the public from the facility. For storage and disposal facilities, the main features include the nature of the fuel or waste to be stored or disposed, the capacity and the approximate layout of the surface and underground constructions.

  The general licence is granted by the Federal Council (federal government) and must be approved by Parliament. The approval is subject to a facultative referendum (see Section A.1).

  Nuclear installations with low hazard potential do not require a general licence. The criteria for the classification of nuclear installations with low hazard potential are defined in Article 22 of the Nuclear Energy Ordinance.
- **Construction licence:** The main prerequisites are again protection of human health and the environment and compliance with the obligations stated in the general licence. The construction licence defines the capacity of the storage or disposal facility, the main elements of the technical implementation and the basic requirements regarding emergency preparedness. The licensing authority is the Federal Department of Environment, Transport, Energy and Communication (DETEC).
- **Operation licence:** The main prerequisites for an operation licence are
  - compliance with the obligations of the general and construction licence,
  - protection of human health and the environment,
  - compliance with the nuclear safety and security requirements,
  - fulfilment of the requirements regarding staff, organisation, quality assurance and emergency preparedness.

The operation licence defines in particular the limits for the discharge of radioactive substances into the environment and the radiological monitoring of the surroundings. It is granted by DETEC. The operation licence and the construction licence can be granted simultaneously if a final judgment of the safe operation is possible at this time. All current operation licences for the Swiss nuclear facilities are not limited in time.

- **Decommissioning order:** This applies to all nuclear facilities. The order is based on the decommissioning project (synonymous to the final decommissioning plan) which has to be submitted by the owner of the facility upon termination of operation. It defines in particular the timetable and the steps of decontamination, dismantling and demolition, and the management of the radioactive waste arising. The authority giving the order is DETEC. After successful and complete decommissioning, DETEC declares that the former nuclear facility is no longer subject to the legislation on nuclear energy.
- **Closure order:** This applies only to deep geological repositories. The order is based on the project for closure which has to be submitted by the owner of the repository. It is given by the Federal Council

upon expiry of the monitoring period after termination of emplacement of waste packages. After closure the Federal Council may order further surface monitoring for a limited period of time, after which it will declare that the disposal facility is no longer subject to the nuclear energy legislation.

For a change of purpose of a nuclear facility or for a comprehensive upgrading of an NPP, an amendment to the general licence is required. For significant deviations from a construction or operation licence and decommissioning or closure order, an amendment to the licence or order is needed.

The licensing process is conducted by the Federal Office of Energy (FOE) on behalf of the DETEC and consists in general of the following main steps:

1. Submission of the application with a description of the project and a safety analysis report;
2. Deposition of the licence application documentation for public consultation; individuals, communities and organisations can raise objections against the project;
3. Review of the safety aspects of the project by ENSI. This review is commented on by the Swiss Federal Nuclear Safety Commission (NSC) and possibly by other organisations or experts;
4. Consultation of federal offices and cantonal governments;
5. Compilation by FOE of all the comments collected, and proposal to DETEC for a decision;
6. Decision by DETEC or the federal council, which usually contain conditions can be appealed to the federal courts.

Handling of nuclear materials and radioactive waste outside nuclear facilities also requires a licence. The obligation for a licence applies especially to the domestic transport, the import, export and transit of spent fuel and radioactive waste (non-exhaustive enumeration). The licensing authority for such licences is the FOE. Specific prerequisites must be met for the granting of a licence for the export of spent fuel for reprocessing purposes. They include in particular an international agreement with the country of destination, the existence in that country of an adequate facility corresponding to the international standards, and the fact that the country of destination has ratified the Joint Convention. Similar prerequisites are fixed for licences to import or export radioactive waste for management purposes (conditioning, storage or disposal).

Handling of radioactive material not subject to the Nuclear Energy Act requires a licence according to the radiation protection legislation. For activities in nuclear facilities, use of radioactive tracers for geological investigations in view of disposal, import, export and domestic transport of radioactive material from and to nuclear facilities, ENSI is the licensing authority. In all other cases, the Federal Office of Public Health (FOPH) is the licensing authority.

A speciality of the Swiss legislation on nuclear energy is that geological field investigations in view of the disposal of radioactive waste need a licence. The licence is granted by DETEC. The prerequisites for granting this licence include the aptitude for investigations to provide the necessary basis for subsequent safety assessments of the envisaged repository without affecting the suitability of the site. The licence defines in particular the main aspects of the investigations, including the approximate location and extent of drillings and underground structures.

E.2.4 Prohibition of Operation without a Licence (Paragraph 2 Clause iii)

This legislative and regulatory framework shall provide for a system of prohibition of the operation of a spent fuel or radioactive waste management facility without a licence.

According to the Nuclear Energy Act, a spent fuel or radioactive waste management facility is a nuclear facility. The Nuclear Energy Act requires a licence for the operation of such a facility. There are no exceptions to this requirement. Violations will be prosecuted and punished with prison or with a fine.

E.2.5 Institutional Control, Regulatory Inspection, Documentation and Reporting (Paragraph 2 Clause iv)

This legislative and regulatory framework shall provide for a system of appropriate institutional control, regulatory inspection and documentation and reporting.

Spent fuel and radioactive waste management may only take place in nuclear facilities. The Federal Council has appointed ENSI as the supervisory authority for nuclear safety, physical protection and

radiation protection in the nuclear facilities, and FOE as the supervisory authority for safeguards. As the main part of the regulatory body, ENSI coordinates these supervisory activities. ENSI also supervises the preparations for the disposal of radioactive waste and the transport of radioactive material from and to nuclear facilities. In addition to ENSI, the Swiss Federal Nuclear Safety Commission (NSC) advises the Federal Council and DETEC on nuclear safety matters.
In its function as a supervisor of the nuclear facilities, ENSI has established a comprehensive inspection system (see Section E.3).
The nuclear energy legislation requires comprehensive documentation on the construction, modification and operation of nuclear facilities. Detailed specifications on documentation and reporting are set forth in regulatory guidelines.
The NPP operators periodically report to the relevant supervisory authorities about the condition and operation of the facility, and notify them without delay of any incidents that have occurred. The authorities regularly inform the public on the condition of the nuclear facilities and on any matters pertaining to nuclear material and radioactive waste.

E.2.6 Enforcement (Paragraph 2 Clause v)

This legislative and regulatory framework shall provide for the enforcement of applicable regulations and of the terms of the licences.
ENSI is in charge of enforcing the legislation and the regulations applicable to nuclear facilities. It is empowered to take the necessary enforcement measures (see Section E.3 below). Different steps of construction and operation of nuclear facilities require ENSI permits.

E.2.7 Allocation of Responsibilities (Paragraph 2 Clause vi)

This legislative and regulatory framework shall provide for a clear allocation of responsibilities of the bodies involved in the different steps of spent fuel and of radioactive waste management.
According to the Nuclear Energy Act the producers of spent fuel and radioactive waste are responsible for its management including disposal. They have to bring the radioactive waste into a form suitable for transport, storage and disposal (conditioning), to store it pending disposal, and eventually to dispose it in a geological repository at their own cost. They also have to manage spent fuel.
The Swiss Confederation assumes responsibility for the collection, conditioning, storage and disposal of radioactive waste generated by the use of radioisotopes in medicine, industry and research. The Swiss Confederation has the right to take over the management of radioactive waste from NPPs in case the operators do not meet their duties; this would be at the expense of the concerned NPP operators.
As described under Section E.2.3, the authorities empowered to grant the different licences needed for spent fuel and radioactive waste management are clearly defined in the Nuclear Energy Act.
ENSI has the responsibility to supervise the nuclear facilities and to enforce the applicable legislation and regulations.

E.2.8 Regulating Radioactive Materials as Radioactive Waste (Paragraph 3)

When considering whether to regulate radioactive materials as radioactive waste, Contracting Parties shall take due account of the objectives of this Convention.
The Radiological Protection Act and the Nuclear Energy Act give the following definition of radioactive waste: «Radioactive waste is radioactive material or radioactively contaminated material that is not further used.» This is consistent with the internationally agreed definition. Since the ban on reprocessing (see Section B.1) spent fuel has to be managed as radioactive waste. This policy takes due account of the objectives of the Convention.

E.3 Regulatory Body (Article 20)

E.3.1 Establishment and Designation (Paragraph 1)

Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

The regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 19 is divided between several organisations:

- The **Federal Council** grants the general licence, which has to be approved by the Parliament and is subject to a facultative referendum. The Federal Council also issues the closure order for disposal facilities.
- The **Federal Department of the Environment, Transport, Energy and Communications** (DETEC) is the licensing authority for the construction and operation licences for nuclear facilities and for geological investigations in view of disposal. DETEC also issues the decommissioning order.
- The **Federal Office of Energy** (FOE) is the licensing authority for other licences according to the Nuclear Energy Act (e.g., transport, trade, import and export of nuclear fuel and radioactive waste). FOE also conducts the licensing process for nuclear facilities on behalf of the DETEC. It is also the competent authority for supervision of nuclear facilities with regard to safeguards and leads the site selection process.
- The **Swiss Federal Nuclear Safety Inspectorate** (ENSI) is the competent authority for supervising nuclear facilities with respect to radiation protection and nuclear safety at all stages of the life cycle. Since 2008, ENSI is also the competent authority with regard to physical protection. ENSI has three main functions: ENSI (a) specifies the detailed safety requirements in regulatory guidelines, (b) reviews licence applications, and (c) supervises the nuclear facilities, the preparations for the disposal of radioactive waste, and the transport of radioactive material from and to nuclear facilities. ENSI has also certain licensing competences according to the radiation protection legislation (see Section E.2.3). It is responsible for the assessment of safety in the site selection process.
- The **Federal Office of Public Health** (FOPH) is the main licensing authority for the handling of radioactive material which does not fall under the Nuclear Energy Act (see Section E.2.3). FOPH also supervises the handling of radioactive material in medical and research institutions and in situations where the protection of the general public is the primary concern.
- The **Swiss National Accident Insurance Fund** (Suva) supervises industrial practices and situations where the protection of workers is the primary concern.
- The **National Emergency Operations Centre** (NEOC) – part of the Federal Office for Civil Protection in the Federal Department of Defence, Civil Protection and Sports – is in charge of all emergency situations, including those arising from events at NPPs and relating to the protection of the public and the environment.

In addition to these organisations within the federal administration, the following advisory bodies on spent fuel and radioactive waste management have been established:

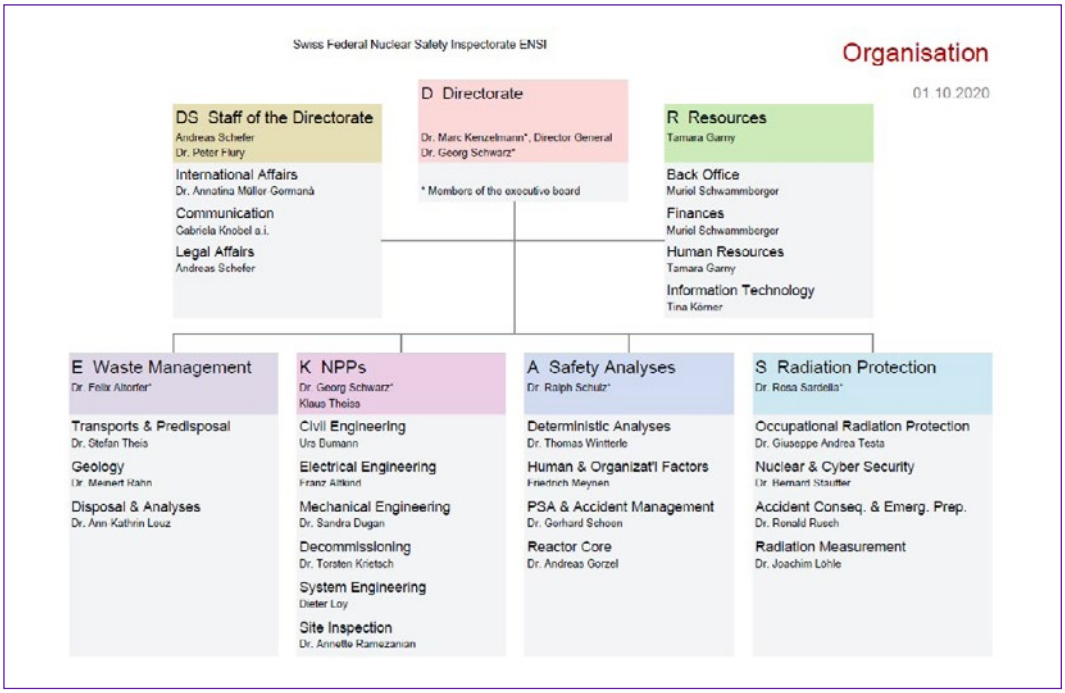
- The **Swiss Federal Nuclear Safety Commission** (NSC) advises the Federal Council, DETEC and ENSI on fundamental safety questions and takes part in legislation work in the area of nuclear safety. NSC can also comment on reviews carried out by ENSI.
- The **Interdepartmental Working Group on Radioactive Waste Management** (AGNEB) prepares technical and political documents for governmental decisions on radioactive waste management.
- The **Expert Group on Radioactive Waste Disposal** (EGT) advises ENSI on geological aspects of radioactive waste disposal.

ENSI is the Swiss regulatory authority in the narrow sense, *i. e.,* the principal supervisory authority. ENSI conducts its review of licence applications solely on the basis of nuclear safety criteria. It is a standalone organisation controlled by its own management board (ENSI board) and has its own budget (see Section E.3.2).

ENSI's primary task is to supervise and assess the nuclear safety and radiation protection of the nuclear facilities, including spent fuel and radioactive waste management. ENSI is also the competent authority with regard to physical protection. ENSI performs its supervisory functions by inspections, setting requirements, issuing enforcement orders, and granting permits within the terms of issued licences.

ENSI currently employs about 150 persons and is divided into six divisions (Figure 9). ENSI uses a processoriented management system which was last certified according to the ISO 9001:2015 standard in December 2019. Furthermore, ENSI has obtained the accreditation ISO/IEC 17025:2017 (general requirements for the competence of testing and calibration laboratories) in July 2015 and the accreditation ISO/IEC 17020:2012 (general requirements for the operation of various types of bodies performing inspection) in August 2015. Both accreditations will be prolonged in 2020. The management system is applied to all relevant activities and is subject to continuous improvement based on internal auditing, management reviews, evaluation of performance indicators and routine checks by the certification and accreditation agencies.

Figure 9:
ENSI Organisation as of October 2020 (Source: ENSI)



ENSI's annual budget is in the order of 59.6 million Swiss francs. All expenses of the safety authorities (with the exception of the legal and regulatory framework) are covered by fees from licence holders and Nagra.

Nuclear safety and radiation protection research, as far as promoted and endorsed by the regulatory body, is endowed with a budget of 1.9 million Swiss francs and is covered by public funds. An additional 4.1 million Swiss francs are financed by the operators of the NPPs and Nagra.

For specific tasks, ENSI contracts independent experts. For example, the surveillance of manufacturing, repair, replacement, modification and inservice inspections has been fully outsourced to the Swiss Association for Technical Inspections (SVTI). Further support in various areas is provided by the Paul Scherrer Institute (PSI, a research institute of the domain of the Swiss Federal Institutes of Technology, ETH Domain).

The implementation of the legislative and regulatory framework concerning spent fuel and radioactive waste management lies mostly with the Waste Management Division. The specialists in the Waste Management Division deal with matters concerning the transport of radioactive material, the conditioning, storage and disposal of spent fuel and radioactive waste. They evaluate the proposed methods for conditioning radioactive waste, issue the necessary approvals and permits and supervise the operation of the corresponding facilities. They have a leading role in ENSI's review on the safety of facilities for storage and disposal of spent fuel and radioactive waste. They supervise the construction and operation of such facilities. They follow and appraise the geological investigations in preparation of spent fuel and

radioactive waste disposal. In their role as the Swiss competent authority, they also issue the package and shipment approval certificates for the transport of radioactive material in Switzerland and supervise such transports to and from nuclear facilities.
In summary, Switzerland has established a regulatory organisation entrusted with the implementation of the legislative and regulatory framework related to spent fuel and radioactive waste management. This regulatory organisation is provided with the necessary authority, competence and financial and human resources to fulfil its assigned responsibilities.

E.3.2 Independence (Paragraph 2)

Each Contracting Party, in accordance with its legislative and regulatory framework, shall take the appropriate steps to ensure the effective independence of the regulatory functions from other functions where organisations are involved in both spent fuel or radioactive waste management and in their regulation.

The owners of spent fuel and radioactive waste in Switzerland are primarily the NPP operators. The Swiss Confederation has taken over the responsibility for the collection, conditioning, storage and disposal of radioactive waste from medicine, industry and research. In order to meet their responsibility regarding the disposal of spent fuel and radioactive waste, the NPP operators and the Swiss Confederation have established the National Cooperative for the Disposal of Radioactive Waste (Nagra). Nagra is responsible to prepare and implement solutions for the disposal of all kinds of radioactive waste, including spent fuel if declared as waste. The responsibility for conditioning, transportation and interim storage of NPP waste remains with the NPP operators.
Both the responsibility for the management of radioactive waste from medicine, industry and research and the regulatory task reside within the federal government. These two functions, however, belong to different departments (ministries), and the regulatory authorities are granted complete independence in their judgements.
The Nuclear Energy Act and the Swiss Federal Nuclear Safety Inspectorate Act clarify and expand the position, duties and responsibilities of the Inspectorate (ENSI) as the supervisory authority for nuclear safety and radiation protection in the field of nuclear energy. The Nuclear Energy Act states that the supervisory authorities are independent of technical directives and requests formal independence of the licensing authorities. ENSI is an organisation constituted under public law. ENSI itself is supervised by an independent body, the ENSI Board. The Board is elected by the Federal Council to whom it reports directly.
Due to its independent status, ENSI has no conflicts of interest. Acting in the politically sensitive field of nuclear energy, ENSI is kept under close scrutiny by the media, the public and non-governmental organisations (NGOs). Therefore, ENSI has a vital interest in maintaining its capacity to act by keeping independent from economic pressure, the nuclear industry and from political interference.
The section Communication of ENSI is responsible for the organisation of the information activities and for the realisation of the measure of communication. This section works closely with the management. Under the Nuclear Energy Act (Article 74), the Inspectorate «shall regularly inform the general public about the condition of nuclear facilities and any matters pertaining to nuclear goods and radioactive waste» and «shall inform the general public of any special occurrences». In addition to that, the Inspectorate is obliged to respond to questions from the Parliament on nuclear safety and the work of the regulatory body. As a federal authority, ENSI is subject to the Federal Act on Freedom of Information in the Administration. According to this law, all ENSI documents are public with a few exceptions, such as security-related information, personal data or trade secrets.
The information services of the Inspectorate go well beyond these legal requirements. It regularly provides direct information to the public. The Inspectorate's website www.ensi.ch is an important information tool covering all aspects of nuclear safety in Switzerland in the national languages of German and French as well as some aspects in Italian and English. It is accompanied by activities on social media – e. g. Twitter, YouTube, etc. ENSI is committed to objectivity and avoids any speculation or placation.
In addition to the annual reports (Regulatory Oversight Report, Research and Experience Report, Radiation Protection Report and Business Report), it publishes reports on current topics – e. g. earthquakes,

disposal of radioactive waste, etc. ENSI also publishes all the review reports generated by review meetings of conventions, review missions or topical peer reviews.

Other communication activities include responses to questions from NGOs and individuals as well as participation in public hearings, symposia and panel discussions on nuclear safety. ENSI regularly organises meetings with its stakeholders irrespective of their nuclear stance. Media activities include press conferences and press releases as well as interviews on issues of nuclear safety that are the subject of current media discussion.

In 2009, in connection with the search for sites for deep geological repositories, the competent authority leading the process (FOE) set up the Technical Forum on Safety, which is led by ENSI. The Technical Forum on Safety discusses and answers technical and scientific questions asked by the public, communities, siting regions, organisations, cantons and authorities in neighbouring states. The forum comprises experts from the body leading the process (FOE), from other bodies with supervisory or supportive roles (ENSI, Swiss Federal Office of Topography (swisstopo)), from commissions (NSC), from the National Cooperative for the Disposal of Radioactive Waste (Nagra), from the cantons, the neighbouring countries Germany and Austria, the Swiss Energy Foundation (SES), and up to two representatives from each of the proposed siting regions of the site selection process. In 2013 ENSI set up a similar Forum for questions concerning NPPs.

Section F Other General Safety Provisions

F.1 Responsibility of the Licence Holder (Article 21)

F.1.1 Licence Holder (Paragraph 1)

Each Contracting Party shall ensure that prime responsibility for the safety of spent fuel or radioactive waste management rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

Radioactive waste management includes conditioning, storage and disposal in a deep geological repository. All these activities are or will be carried out in nuclear facilities. The Nuclear Energy Act explicitly states in Article 22 that the licence holder is responsible for the safety of the facility and its operation. The specific obligations of the licence holder resulting from this fundamental responsibility are listed in the abovementioned article of the Nuclear Energy Act and elaborated in more detail in the Nuclear Energy Ordinance.

As described in Section E.2.7, the responsibility for the safe and permanent management of spent fuel and radioactive waste lies with the producers. The producers of spent fuel and radioactive waste are primarily the NPP operators. Spent fuel is stored at the NPPs and at the Central Interim Storage Facility ZZL. Conditioning and interim storage of operational waste is carried out at the NPPs and at ZZL. All these facilities are nuclear facilities which are operated according to the corresponding licences and supervised by the Swiss Federal Nuclear Safety Inspectorate (ENSI).

In order to ensure that the licence holders meet their responsibility, Switzerland has established a regulatory body entrusted with the implementation of the legislative and regulatory framework (see Section E.3). ENSI forms the main part of this regulatory body and has been given the necessary authority and competence to fulfil its enforcement functions. The supervision of the nuclear facilities carried out by ENSI makes sure that the licence holders fully meet their responsibility and obligations.

The Swiss Confederation takes over the responsibility for the collection, conditioning, storage and disposal of radioactive waste generated in medicine, industry and research. According to the Radiological Protection Ordinance, the research centre PSI operates the National Collection Centre and is in charge of conditioning and storage of this kind of waste. The National Collection Centre is a nuclear facility and thus subject to the Nuclear Energy Act. PSI holds the licences to operate the nuclear facilities necessary for these activities. The supervision exercised by ENSI ensures that PSI meets its responsibility regarding the safety of its radioactive waste management facilities.

All radioactive waste, including spent fuel is to undergo final disposal in geological repositories. No such repository is yet in operation. An eventual repository will be a nuclear facility and thus subject to the Nuclear Energy Act.

The licence holder will be responsible for the safe operation of such a repository. With its supervision, ENSI will ensure that the licence holder will also fully meet its responsibility and obligations.

F.1.2 Unlicensed Facilities, Activities and Materials (Paragraph 2)

If there is no such licence holder or other responsible party, the responsibility rests with the Contracting Party which has jurisdiction over the spent fuel or over the radioactive waste.

In the Nuclear Energy Act, the Swiss Confederation has reserved the right to take over the management of radioactive waste from NPPs in case the operators do not meet their duties. This would be at the expense of the concerned NPP operators, and the Swiss Confederation would establish a dedicated organisation independent of the licensing and supervisory authorities.

The Radiological Protection Ordinance defines the different kinds of non-nuclear radioactive waste that must be delivered to the National Collection Centre at PSI. The Federal Office of Public Health (FOPH) regulates the details concerning the treatment and collection of non-nuclear radioactive waste (see also the Ordinance on the Collection of Radioactive Waste). This includes cases where no licence holder or other responsible party exist.

F.2 Human and Financial Resources (Article 22)

F.2.1 Qualified Staff (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that qualified staff are available as needed for safety-related activities during the operating lifetime of a spent fuel and a radioactive waste management facility.

The Nuclear Energy Act requires qualified senior staff to manage and operate any nuclear facility and to fulfil all legal, regulatory and licence requirements. The Ordinance on the Requirements for the Personnel of Nuclear Installations specifies the necessary qualification and training of the staff of any nuclear installation. This is a prerequisite for granting an operation licence for nuclear facilities, including spent fuel and radioactive waste management facilities. The operation licence of the nuclear facility can be withdrawn in case these conditions are not or no longer met. Precise requirements on the organisation and operating staff of a nuclear facility are set out in the operation licence and in the technical specifications. Regulatory guidelines define specific regulatory requirements on the organisation (ENSI-G07), the operating staff (ENSI-B10), and on the radiation protection staff (ENSI-B13) of nuclear installations including spent fuel and radioactive waste management facilities.

The implementation of these legal requirements is ensured in practice by (1) review of the projects submitted to licence and (2) supervision of the operation of the nuclear facility.

F.2.2 Adequate Financial Resources (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of facilities for spent fuel and radioactive waste management during their operating lifetime and for decommissioning.

Current expenditure related to storage of spent fuel and radioactive waste, as well as to research and development, planning, geological investigations and, eventually, construction and operation of disposal facilities, are continuously paid for by the NPP operators until the end of commercial energy production. Two funds have been established by law in order to ensure the availability of sufficient financial resources after the final shutdown of an NPP for the decommissioning and the management of spent fuel and radioactive waste. The Ordinance on the Decommissioning and Waste Management Funds for Nuclear Facilities defines (1) the allocation of financial resources for the decommissioning and for the disposal of decommissioning waste, and (2) the allocation of financial resources to cover the costs for the final management of spent fuel and radioactive waste from NPP operation.

Both, the Decommissioning and the Waste Management Fund, were established to cover the management costs arising after final shutdown of the NPPs.

The two funds are independent legal entities administered by a Management Commission appointed by the Federal Council. The annual contributions to be paid to the funds by the NPP operators are based on cost estimates derived from specific decommissioning and disposal projects submitted by the operators. Technical issues are reviewed by the nuclear safety authorities, and the costs are estimated by independent cost experts. The projects, cost estimates and annual contributions are updated periodically. On the basis of the cost studies 2016, the total decommissioning costs amount to 3.78 billion Swiss francs and the waste management costs amount to 20.8 billion Swiss francs. By the end of 2018, the balance of the Decommissioning Fund was 2.4 billion Swiss francs, and that of the Waste Management Fund was 5.1 billion Swiss francs. As of the end of 2018, 5.9 billion Swiss francs had been spent (e.g. for research and preparatory tasks, reprocessing of spent fuel elements, construction of a central interim storage facility, acquisition of transport and storage containers, transportation). Another portion (amounting to 1.6 billion Swiss francs) will be required from 2019 until the time of shutdown of the NPPs decommissioning, and this amount has to be covered by the operators on an ongoing basis. In total, the Waste Management Fund has to secure 11.9 billion Swiss francs.

The next update of the cost estimates for decommissioning and waste management is requested for 2021.

F.2.3 Financial Provision for Institutional Controls (Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that financial provision is made which will enable the appropriate institutional controls and monitoring arrangements to be continued for the period deemed necessary following the closure of a disposal facility.

Regarding the closure of a disposal facility, the Nuclear Energy Act defines the following steps. Upon expiry of the period of underground monitoring following the emplacement of the waste packages, the Federal Council shall order the closure of the repository according to the corresponding project submitted by the owner of the repository. The closure of the repository will only be ordered if the permanent protection of human health and the environment is ensured. After the repository has been closed in accordance with the applicable regulations, the Federal Council may order further surface monitoring of the environment of the disposal facility for a limited period of time. Upon expiry of this additional monitoring period, the Federal Council will declare that the disposal facility is no longer subject to the nuclear energy legislation. At that time, the responsibility for the disposal facility will pass over to the Swiss Confederation. The Swiss Confederation may decide to continue monitoring of the site; this would be carried out within the framework of the general radiological surveillance of the environment.

The Waste Management Fund mentioned in Section F.2.2 covers the disposal costs up to and including the final closure of the repository and such monitoring after closure as may be ordered by the Federal Council. The continued monitoring, after the disposal facility has been released from nuclear regulatory control, will be carried out at the expense of the Swiss Confederation.

The legislation on radiological protection puts the Federal Office of Public Health (FOPH) in charge of monitoring the radioactivity in the environment. This duty includes the monitoring of the environment of past nuclear facilities cleared from regulatory control after decommissioning, and eventually will also include closed disposal facilities. As an example, the former experimental NPP at Lucens, which has been decommissioned and released from nuclear regulatory control, is subject to FOPH's environmental radiation monitoring programme.

F.3 Quality Assurance (Article 23)

Each Contracting Party shall take the necessary steps to ensure that appropriate quality assurance programmes concerning the safety of spent fuel and radioactive waste management are established and implemented.

The Nuclear Energy Act together with the Nuclear Energy Ordinance require the implementation of appropriate quality management (QM) systems for the construction and operation of nuclear facilities, including storage and disposal facilities for spent fuel and radioactive waste. The QM systems must be developed according to an internationally agreed standard (*e.g.,* ISO 9001) and be reviewed periodically by an independent body. The Regulatory Guideline ENSI-G07 «Organisation of Nuclear Installations» specifies the requirements for the organisation and the procedures according to the IAEA General Safety Requirements GSR Part 2 «Leadership and Management for Safety» and the corresponding guides. All Swiss nuclear facilities involved in spent fuel and radioactive waste management, including Nagra, have established and implemented certified QM systems based on the international industrial standard ISO 9001. Significant changes in the QM systems of the responsible organisation must be reported to ENSI. ENSI reviews and checks the completeness and the proper function of the QM systems of spent fuel and radioactive waste management facilities according to an international nuclear standard (*e.g.,* IAEA Safety Standards GSR Part 2, GS-G-3.1 and GS-G-3.3). By means of inspections and audits, ENSI ensures that the QM systems are effectively implemented.

F.4 Operational Radiation Protection (Article 24)

The Radiological Protection Act and the Radiological Protection Ordinance form the legal basis for the operational radiation protection in Switzerland. This legislation aims at protecting human health and the

environment against ionising radiation and is based on the recommendations of the International Commission on Radiological Protection (ICRP). It implements the internationally agreed principles of justification of a practice, optimisation of radiation exposure and dose limitation. More detailed requirements are defined in further Ordinances and in ENSI's regulatory guidelines, and specific conditions and obligations are contained in the operation licences granted to each nuclear facility operator.
The Radiological Protection Act was partly revised in October 2007. Based on the recommendations of the International Commission on Radiological Protection (ICRP) (e.g. Publication No. 103), the Radiological Protection Ordinance was totally revised and came into force in 2018. The Ordinances' contents are arranged according the recommended makeup into planned, emergency, and existing exposure situations. The goal of the latest revision of the Ordinance was to obtain compatibility with the new European Safety Directive, Version 24th from February 2010 (final) and the IAEA Basic Safety Standard, GSR Part 3 from July 2014. As a consequence of the revision other legal documents such as guidelines of the Swiss Federal Nuclear Safety Inspectorate will also have to undergo revisions (such as the Guideline ENSI-G12 «Nuclear Facility Internal Radiation Protection»). This guideline will replace partly the Guidelines HSK-R-07 «Guideline for Radiological Monitored Area of the Nuclear Installations and the Paul Scherrer Institute» as well as ENSI-G15 «Radiation Protection Objectives for Nuclear Installations» and specifies the Radiation Protection Ordinance for the application in nuclear facilities. It comprises all aspects regarding «source term reduction», «enclosure of radioactivity by barriers from the Radiological Controlled Area», «limiting and optimisation of external exposure» as well as «prevention of incorporation and contamination of personnel».

F.4.1 Radiation Exposure (Paragraph 1 Clause i)

Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility the radiation exposure of the workers and the public caused by the facility shall be kept as low as reasonably achievable, economic and social factors being taken into account.

The Swiss radiation protection legislation requires optimisation as a fundamental principle for limiting the radiation exposure of the personnel and the public. In order to satisfy this rule, the Regulatory Guideline ENSI-G15 requires that every licence holder of a nuclear facility (including storage and disposal facilities) has to establish a QM system for operational radiation protection. The QM system must include the optimisation process as an integrated part of the radiation protection planning. Above mentioned Guideline ENSI-G12 will comprise further detailed requirements about optimization and radiation protection planning.
It is the responsibility of the operator to define optimisation as part of the QM system for operational radiation protection. Most facilities have a system to control and implement optimisation. Depending on the level of estimated collective dose, a dose relevant job has to be controlled by a radiation protection officer or by an ALARA team consisting of engineers and radiation protection personnel. Every project leading to an estimated collective dose above 50 man-mSv has to be declared to ENSI at least one month in advance corresponding to the Regulatory Guideline ENSI-B03. ENSI evaluates the radiation protection planning report, discusses critical aspects of work flow, designated protection measures and monitoring with the operator, and inspects their implementation in the nuclear facility.

F.4.2 Radiation Doses (Paragraph 1 Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

The Radiological Protection Ordinance sets the dose limit for individual members of the population to 1 mSv per year and that for occupational exposure to 20 mSv per year (see Section E.2.2). This is in accordance with international standards. In order to ensure that these dose limits are not exceeded, refer-

ence values, limits, budgets and constraints for dose, contamination and activity have been defined in the Radiological Protection Ordinance, in the Regulatory Guidelines HSK-R-07, ENSI-G15, upcoming ENSI-G12 as well as in the licence conditions. Article 53 of the Radiological Protection Ordinance defines the dose limits and working conditions for young persons between 16 and 18 years and for pregnant and nursing women.
Models on atmospheric dispersion and exposure paths (as outlined in the Regulatory Guideline ENSI-G14 based on IAEA Safety Series No. 50-SG-S3), including transfer factors and dose conversion factors, are used to obtain the effective dose as a function of the discharge. The discharge limits are set by ENSI based on such calculations. The Regulatory Guideline ENSI-B02 requires that the activity discharged to the environment be reported by each nuclear facility in periodical reports.
The measuring instruments used in the facilities have to be calibrated periodically (ENSI-G13). ENSI takes various samples and carries out independent measurements in each nuclear facility for independent analyses several times a year.
To ensure the compliance with occupational dose limits, a system of dose budget and investigation levels is used as required in the Regulatory Guideline ENSI-G12. One set of dose budgets, so called *temporary dose contingents,* are defined in order to split the maximum permitted individual dose among different nuclear facilities where the person will work during the year. Employers must have a licence to send persons occupationally exposed to radiation to various facilities. It is the duty of the employer to inform the operators of the facilities about the dose budgets of his employees; the dose budget is the maximum dose an employee may accumulate during the period he works in the facility. Some facilities use additional daily or job specific dose constraints as investigation levels. In these cases, electronic personal dosimeters are used to monitor the actual dose.

F.4.3 Preventive Measures Taken (Paragraph 1 Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that during the operating lifetime of a spent fuel or radioactive waste management facility measures are taken to prevent unplanned and uncontrolled releases of radioactive materials into the environment.
The Radiological Protection Ordinance requires the licence holder to take appropriate measures to prevent unplanned and uncontrolled releases of radioactive materials into the environment. The corresponding technical and administrative requirements to be considered during planning, construction, operation and decommissioning are outlined in the «Ordinance on the Use of Radioactive Material» and in the Regulatory Guidelines HSK-R-07 (resp. upcoming ENSI-G12) and ENSI-B12 «Emergency Preparedness». All other facility specific details are laid down in the licences and permits.
The Radiological Protection Ordinance requires the declaration of rooms, buildings or areas as radiological controlled zones if the dose rate, surface contamination level or air contamination level may exceed certain limits listed in the Ordinance.

F.4.4 Radiation Exposure Due to Discharges (Paragraph 2 Clause i)

Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited to keep exposure to radiation as low as reasonably achievable, economic and social factors being taken into account.
In the licence application for the construction and operation of a nuclear facility (including storage and disposal facilities), the technical measures have to comply with the ALARA principle. For example, suitable barriers and air filters can be applied to reduce exposure to radiation caused by radioactive discharges. These measures are explicitly stated as conditions when granting the licence. Each nuclear facility has to periodically report the discharged radioactivity to ENSI.

F.4.5 Radiation Doses Due to Discharges (Paragraph 2 Clause ii)

Each Contracting Party shall take appropriate steps to ensure that discharges shall be limited so that no individual shall be exposed, in normal situations, to radiation doses which exceed national prescriptions for dose limitation which have due regard to internationally endorsed standards on radiation protection.

The annual dose limit for the public is ensured via a partition into source-related dose constraints of 0.3 mSv per year for each nuclear site (ENSI-G15). The dose from direct exposure must not exceed 0.1 mSv per year. Based on these dose constraints, maximum values for the total activity and activity concentrations discharged into the environment are derived from models for dispersion and transfer (ENSI-G14). Depending on whether the discharge occurs in a short period (shorter than a week) or continuously, it has to comply with the short or longterm discharge limits. These limits are verified by ENSI in the periodic safety review of the nuclear facility (ENSI-A03).

Material can be declared as non-radioactive if it is out of the scope of the Radiological Protection Ordinance. The clearance levels are explained in Section B.3 of this report. These criteria are derived from the de *minimis* value of 0.01 mSv per person and year. Guideline ENSI-B04 rules the procedure of clearance incl. the reporting to ENSI.

F.4.6 Corrective Measures (Paragraph 3)

Each Contracting Party shall take appropriate steps to ensure that during the operating lifetime of a regulated nuclear facility, in the event that an unplanned or uncontrolled release of radioactive materials into the environment occurs, appropriate corrective measures are implemented to control the release and mitigate its effects.

According to the Radiological Protection Ordinance, the licence holder is obliged to make the necessary operational preparations in order to be able to cope with failures. This includes regular training of the employees, instructions regarding the immediate measures to be taken in an emergency, and provision of sufficient technical assistance and well-trained personnel for dealing with failures at any time. This implies employing and training skilled personnel in the field of radiation protection. The dose limit for outside emergency personnel involved in rescuing human lives and protecting the population is 250 mSv during the first year after an event. The dose limit for personnel which would be deployed to cope with a radiological event is 50 mSv during the first year of the event.

In addition, the Radiological Protection Ordinance requires that the licence holder carries the responsibility for all risks. This means that in case of an unplanned or uncontrolled release of radioactive material into the environment, every possible effort has to be taken to mitigate its effects. This includes appropriate protective measures for the personnel, installation of failure safe locks as well as activity and dose monitoring inside the facility, on the premises and in the vicinity of the facility. The monitoring results are continuously updated on the ENSI website (http://www.ensi.ch «Topics» → «Measured Value about Swiss nuclear power plants»).

In case of a radiological incident within a nuclear facility or during transport of radioactive material, the licence holder has to notify ENSI and the National Emergency Operations Centre (NEOC) immediately (see Section F.5).

ENSI approves the training courses and the qualification of the radiation protection personnel. The nuclear facilities have to summarise the participation of their personnel in appropriate training courses in periodical reports.

F.5 Emergency Preparedness (Article 25)

F.5.1 Facility Emergency Plans (Paragraph 1)

Each Contracting Party shall ensure that before and during operation of a spent fuel or radioactive waste management facility there are appropriate on-site and, if necessary, off-site emergency plans. Such emergency plans should be tested at an appropriate frequency.

The Federal Civil Protection Crisis Management Board (BSTB) coordinates emergency planning and preparedness in Switzerland. The Concept for the Emergency Preparedness in Case of a Nuclear Power Plant Accident in Switzerland (2015) describes the requirements for emergency preparedness and is based on the following acts, ordinances, and regulatory guidelines:

- Nuclear Energy Act
- Nuclear Energy Ordinance
- Radiological Protection Act
- Radiological Protection Ordinance
- Ordinance on Emergency Preparedness in the Vicinity of Nuclear Installations
- Ordinance on the Federal Civil Protection Crisis Management Board
- Ordinance on Alerting, Alarming and the Secure Radio Network
- Ordinance on the National Emergency Operations Centre
- Ordinance on Iodine Prophylactics in the Case of a Nuclear Accident
- Ordinance on Maximum Levels for Contaminants
- Regulatory Guideline ENSI-B11: Emergency exercises
- Regulatory Guideline ENSI-B12: Emergency preparedness in nuclear installations
- Regulatory Guideline ENSI-G07: Organisation of nuclear installations
- Regulatory Guideline ENSI-A08: Analysis of source terms: Extent, methodology and boundary conditions

These requirements refer to NPPs and are used for other nuclear facilities by analogy. Prior to issuing the operating license for a new spent fuel or radioactive waste management facility, on-site emergency plans are required that must be approved by ENSI.

To prepare emergency measures for spent fuel and radioactive waste management facilities, specific scenarios are evaluated that form the basis for the emergency planning in the environment of such facilities. The emergency scenarios at such facilities include fires, life-threatening injuries to persons, excessive radiation to personnel, substantial release of radioactivity to the environment, spillage of oil and chemicals, fuel handling accidents in hot cells, accidents during transport of waste and spent fuel, severe earthquakes, airplane crash, and malevolent actions by third parties.

Off-site emergency plans are required if accidents involving increased radioactivity, which necessitates immediate action to mitigate or avert serious adverse consequences for human health and safety, living conditions and the environment, are possible. Accidents at spent fuel and radioactive waste management facilities located at NPPs are covered by the emergency organisation of the corresponding NPP. At PSI and ZZL only an airplane crash could lead to off-site doses requiring immediate action. For this scenario, the alerting and countermeasures are implemented for the population of the neighbouring communities.

On-Site Emergency Organisation

Each new spent fuel or radioactive waste management facility is in possession of facility-specific emergency preparedness documentation which includes the following information:

- Operating procedures for abnormal situations
- Emergency procedures
- Reporting procedure to ENSI, and in case of radiological events also to the National Emergency Operations Centre (NEOC)
- Reporting procedure to the police in case of rapidly evolving accidents (e.g. airplane crash)

The emergency organisation of the facility is inspected by ENSI during emergency exercises every year.

Off-Site Emergency Organisation and Protective Measures

The off-site emergency organisation is based on the resources within the swiss civil defence concept. These resources consist of a well-developed shelter infrastructure (Switzerland has sheltering capabilities for the whole population) and well-trained troops for fire and disaster mitigation. In case of a radiological emergency the Federal Civil Protection Crisis Management Board (BSTB) coordinates the use of civil and military resources. The Federal Office of Civil Protection, as a part of BSTB, takes the necessary measures until the Federal Civil Protection Crisis Management Board is ready to operate and upon immediate danger orders direct actions to protect the population and alerts the authorities of the Federation and the cantons.

The protective measures to be implemented for the population are based on the concept of measures as a function of dose. The concept describes which protective measures are to be adopted if an expected radiation dose is above a predefined intervention-level. In addition, the Ordinance on Maximum Levels for Contaminants contains limits for foodstuffs. The limits correspond to the maximum permitted levels or radioactive food contamination under EURATOM regulations.

Emergency Exercises

ENSI issues the operating license only if the on-site emergency organisation is operational and has been successfully tested by an emergency exercise. Furthermore, on-site emergency preparedness exercises are performed every year in accordance with the specifications in the Regulatory Guideline ENSI-B11. In addition, each one of the different emergency teams, e. g. fire brigade, has to carry out its own specific exercises. Neighbouring countries are invited to take part in full-scale emergency exercises carried out in nuclear power plants located in the vicinity of the border on a regular basis.

F.5.2 Territory Emergency Plans (Paragraph 2)

Each Contracting Party shall take the appropriate steps for the preparation and testing of emergency plans for its territory insofar as it is likely to be affected in the event of a radiological emergency at a spent fuel or radioactive waste management facility in the vicinity of its territory.

The Federal Civil Protection Crisis Management Board takes over in case of a radiological emergency from abroad. Automatic dose-rate monitoring systems have been installed in Switzerland. These systems continuously monitor the dose rate at a large number of locations.

F.6 Decommissioning (Article 26)

Each Contracting Party shall take the appropriate steps to ensure the safety of decommissioning of a nuclear facility.

The Nuclear Energy Act requires the operator of a nuclear facility to apply for a general licence as a first step. Applications for construction and operation licences can only be made once the general licence has been issued. The licensee must state the basic commitments with respect to decommissioning in the application documents for the general licence and present an initial decommissioning plan with the application documents for the construction licence. He has to regularly update the decommissioning plan during the operation period. At the end of the operational lifetime of the facility, he must submit a final decommissioning plan (in the Swiss legislation the «decommissioning project»). After this plan has been reviewed and approved by the authorities, a decommissioning order is issued by the licensing authority (DETEC). The legislation thus addresses aspects of decommissioning at the appropriate stages of facility development.

Earlier legislation required a decommissioning licence. Such licences were issued for the prototype reactor at Lucens, the research reactor AGN-201-P at the University of Geneva, and the research reactors DIORIT and SAPHIR at PSI. They retain their validity under the new legislation. The experience made so far demonstrates the sound basis provided by the former legislation.

In 2014, ENSI published a regulatory guideline that addresses all aspects of decommissioning and dismantling of nuclear installations in Switzerland (Regulatory Guideline ENSI-G17). This guideline respects WENRA's Safety Reference Levels in the field of decommissioning and the corresponding IAEA Safety Standards.

In June 2018, DETEC issued the decommissioning order for Mühleberg NPP. The order is based on ENSI's advisory opinion on the final decommissioning plan for Mühleberg NPP. In the decommissioning order the terms «final cessation of power operation» (which is different from final shut down), «establishing of post operational phase» in the reactor building and «preparatory measures» in the turbine building were legally well founded introduced and explained. In DETEC's decommissioning order is also laid down that there will be two separate licensing procedures: one for release of Mühleberg NPP from nuclear supervision and one for conventional demolition or reuse of the Mühleberg site.

The life cycle of an NPP can be divided into four stages: 1) planning (general licence), 2) construction (construction licence), 3) power operation (operating licence), 4) decommissioning (decommissioning order). Each stage is based on a separate licence or order, respectively, that ensures a complete sequence of legislation.

In the decommissioning order for Mühleberg NPP a distinction is made between cease of power operation and final shut down. Cease of power operation describes the moment when an NPP generates no more electricity. In the case of Mühleberg NPP, after cease of power operation, the spent fuel elements from the reactor core are transferred to the spent fuel pool. In the meantime, all measures to establish a safe technical postoperation are being implemented. To remove heat from the spent fuel pool some safety and operation systems from power operation are still necessary. Hence, the works being performed to establish the technical post-operational phase are conducted as part of operating licence and are not part of the decommissioning order. As soon as all works for establishment of the technical post-operational phase are completed, the facility is finally shut down.

F.6.1 Staff and Financial Resources (Clause i)

Such steps shall ensure that qualified staff and adequate financial resources are available.

Two funds have been established by law in order to ensure the availability of sufficient financial resources for the decommissioning of nuclear facilities and waste management (see Section F.2.2).

If the financial provisions prove insufficient during decommissioning, the owner of the facility concerned has to pay the difference within three years. In the case that the means of the fund are still not sufficient to cover the costs of decommissioning an NPP, the owners of the other NPPs are also liable for the amount in debt.

The costs of waste management are determined on the basis of the waste management programme, the current technical and scientific requirements and on the prices applicable when the calculation is being made. Costs estimates have to be updated every five years based on information from the owner of each nuclear installation. When a nuclear installation starts operation, the initial costs are estimated. They are recalculated when a nuclear installation is shut down or when a substantial change in costs is expected due to unforeseen circumstances.

The last updates (new cost studies) for decommissioning were prepared in 2016 by NIS Ingenieurgesellschaft mbH on behalf of swissnuclear, the organisation of Swiss nuclear operators. These studies took account of the latest knowledge available regarding the decommissioning of nuclear power plants. The decommissioning costs for Switzerland's five nuclear power plants and the Central Interim Storage Facility ZZL amount in total 3.8 billion Swiss francs. ENSI reviewed the technical aspects of the cost study. As part of the specifications for the Cost Study of 2016, the Administrative Commission defined binding cost structures for the first time to present the estimated costs for decommissioning and waste disposal. This term refers to cost structures for end-to-end use in all phases of cost planning and cost determination. Binding cost structures are meant to lay the foundation for planning costs transparently, comparing them meaningfully, and controlling them effectively as well as for enabling the fund resources to be drawn effectively.

The specifications for the Cost Study of 2016 also contained instructions on how to deal with inaccuracies and risks. To this end, a classification of cost levels was specified and taken into account in the determination and presentation of costs.
With adequate financial resources, the recruitment of qualified staff can be ensured. The Regulatory Guidelines ENSI-G07 and ENSI-G17 specify requirements that also apply to decommissioning. The decommissioning order can lay down specific obligations in this respect. The Nuclear Energy Act requires the operator to submit a detailed final decommissioning plan. The final decommissioning plan must address all aspects, including staff, organisation and quality management.
The decision to shut down the Mühleberg NPP in 2019 for example has not led to a fall in staff numbers at Mühleberg. The plant has developed a concept that ensures that the staff of Mühleberg NPP has a perspective for the work life after decommissioning.

F.6.2 Radiation Protection (Clause ii)

Such steps shall ensure that the provisions of Article 24 with respect to operational radiation protection, discharges and unplanned and uncontrolled releases are applied.
The Radiological Protection Act and the Radiological Protection Ordinance also apply to the decommissioning of nuclear facilities. This legislation covers all aspects of Article 26 Clause ii (see Section F.4). The decommissioning order lays down complementary obligations as appropriate.

F.6.3 Emergency Preparedness (Clause iii)

Such steps shall ensure that the provisions of Article 25 with respect to emergency preparedness are applied.
The legal requirements concerning emergency preparedness apply independently of whether a facility is in operation or is being decommissioned. These requirements cover all aspects of Article 26 Clause iii (see Section F.5). The decommissioning project must cover design accident evaluation and emergency preparedness planning for all stages of decommissioning.

F.6.4 Record Keeping (Clause iv)

Such steps shall ensure that records of information important to decommissioning are kept.
The Nuclear Energy Act requires the facility operators to keep and to update all technical records until decommissioning is completed. After completion of decommissioning, the operator has to hand over the documentation to the regulatory authorities.

Section G Safety of Spent Fuel Management

G.1 General Safety Requirements (Article 4)

Each Contracting Party shall take the appropriate steps to ensure that at all stages of spent fuel management, individuals, society and the environment are adequately protected against radiological hazards.

The protection of individuals, society and the environment against radiological hazards related to spent fuel management is subject to the Swiss legislation on radiation protection and on nuclear energy, as detailed in Section E.2. Compliance with the legal requirements regarding nuclear safety and radiation protection is verified and enforced by the Swiss Federal Nuclear Safety Inspectorate (ENSI). This is done by reviewing safety analysis reports during the licensing steps, supervising construction and operation particularly by inspections, and periodic safety reviews of the NPPs.

G.1.1 Criticality and Removal of Heat (Clause i)

In so doing, each Contracting Party shall take the appropriate steps to ensure that criticality and removal of residual heat generated during spent fuel management are adequately addressed.

Criticality and heat removal are addressed during the licensing process of a spent fuel management facility, during operation if changes in the operational procedures are planned, and in the periodic safety reviews of each NPP every 10 years. For storage facilities a systematic safety assessment report is requested every 10 years (see Section G.5.2). Criticality and Removal of Heat are analysed in the safety analysis report submitted with the licence application and reviewed by the regulatory body. Safety relevant changes to a spent fuel management facility, including equipment and procedures, require a licence from DETEC or a permit from ENSI. All Swiss spent fuel management facilities are in compliance with the requirements of Clause i.

G.1.2 Generation of Radioactive Waste (Clause ii)

In so doing, each Contracting Party shall take the appropriate steps to ensure that the generation of radioactive waste associated with spent fuel management is kept to the minimum practicable, consistent with the type of fuel cycle policy adopted.

Both, the Nuclear Energy Act and the Radiological Protection Act, require that any handling and management of radioactive materials must take place in such a way that the generation of radioactive waste is kept to the minimum practicable. The spent fuel management facilities mentioned under Section D.2.1 were built and are operated according to this principle. This will also be the case for future facilities.

G.1.3 Interdependencies (Clause iii)

In so doing, each Contracting Party shall take the appropriate steps to take into account interdependencies among the different steps in spent fuel management.

The remarks on Article 11, Clause iii apply likewise to Article 4, Clause iii (see Section H.1.3).

G.1.4 Protection of Individuals, Society and the Environment (Clause iv)

In so doing, each Contracting Party shall take the appropriate steps to provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation, which has due regard to internationally endorsed criteria and standards.

Protection of individuals, society and the environment from the effects of ionising radiation is a subject of the radiation protection legislation (see Section E.2.2), in which the ICRP system of radiation protection, consisting of justification, optimisation and dose limitation, is implemented. The applicable dose limits are compatible with the International Safety Standards (General Safety Requirements Part 3). In particular, a dose limit for members of the public of 1 mSv effective dose per year and a dose limit for workers of 20 mSv per year are implemented.
Compliance of spent fuel management facilities with the legislation is ensured during the licensing and operational phases. At each licensing step a safety analysis report demonstrating compliance has to be submitted and is reviewed by the regulatory body. During the operational phase, compliance is verified and enforced by regulatory supervision, mainly by inspections, systematic safety assessments and periodic safety reviews. The regulatory supervision includes monitoring of the radioactivity in the environment of the facility. Compliance with the environmental protection legislation is verified by the responsible authorities according to the environmental radiation monitoring program of the Federal Office of Public Health (FOPH).

G.1.5 Biological, Chemical and other Hazards (Clause v)

In so doing, each Contracting Party shall take the appropriate steps to take into account the biological, chemical and other hazards that may be associated with spent fuel management.
Biological, chemical and other hazards are subject to the environmental protection legislation, which aims at human health protection, especially with requirements concerning air and water quality. An environmental impact assessment is required for the general licence and for the construction licence.
This assessment is reviewed by the competent authorities before the licence is issued. Hazards other than radiation encountered by workers during the handling of spent fuel are covered by general legislation on safety in working places and enforced by supervision by the Swiss National Accident Insurance Fund (Suva).

G.1.6 Impacts on Future Generations (Clause vi)

In so doing, each Contracting Party shall take the appropriate steps to strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation.
Several legal requirements aim at avoiding impacts on future generations. The Nuclear Energy Act requires that all radioactivity hazards be removed from a nuclear facility upon termination of operation. The same Act also requires safe and permanent management and disposal of all radioactive waste (including spent fuel if). The specific design principles for deep geological repositories and the requirements for the safety case are detailed in the Regulatory Guideline ENSI-G03. Here, the principle is formulated that the risks to humans and the environment arising in the future from geological disposal of radioactive waste may not be greater than those permissible in Switzerland today (see Section H.1.6).
There are currently no disposal facilities for spent fuel, either in operation or under construction, in Switzerland. However, the requirements on long-term safety have been observed in the design and planning of disposal facilities, and compliance has been verified in the regulatory review of such projects.

G.1.7 Burdens on Future Generations (Clause vii)

In so doing, each Contracting Party shall take the appropriate steps to aim to avoid imposing undue burdens on future generations.
As explained in Section G.1.6 above, the legal requirements prevent imposing undue burdens on future generations. Regarding disposal, the Regulatory Guideline ENSI-G03 explicitly formulates, as one of the overall disposal objectives, that the responsibility for geological disposal lies with the generation enjoying the benefits of the energy produced, and no undue burdens may be placed on future generations (see Section H.1.7).

A geological repository has to be designed in such a way that after closure, no further measures are required to ensure long-term safety.

G.2 Existing Facilities (Article 5)

Each Contracting Party shall take the appropriate steps to review the safety of any spent fuel management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.

An overview of the existing spent fuel management facilities is given in Section D.2.1.

These facilities have been licensed as required by law. The Nuclear Energy Act and the Nuclear Energy Ordinance require the owners of all nuclear facilities to systematically and regularly assess the safety of these facilities under the supervision of ENSI. The spent fuel pools (SFP) are included in the periodic safety reviews of the NPPs, and their actual status is described when revised safety assessment documents are issued. In addition, operators of any nuclear facility in Switzerland (not only NPPs) have to perform systematic safety assessments (see Section G.5.2).

As a result of screening reassessments of the cooling provisions for the SFP in the Swiss NPPs, which were ordered by ENSI in the aftermath of Fukushima, improvement areas were identified. The Inspectorate thus ordered all licence holders to immediately implement two physically separated lines/connections for feeding the SFPs from outside the buildings as an accident management measure, and to backfit seismically robust SFP cooling systems in the first generation NPPs. In addition, the NPPs were requested to backfit redundant level and temperature measurements for the SFPs with readings available in the special emergency control rooms. The two separated hook-up points have been implemented in all plants. The project for backfitting the seismically robust SFP cooling systems has been completed in the Mühleberg NPP. In the NPP Beznau the backfitting project is still ongoing. The project is delayed due to problems in the procurement of the new heat exchangers, which should be installed in the SFP. As a consequence, NPP Beznau decided to abandon the original concept of a passive acting SFP-cooling. Instead, an active SFP-cooling circuit will be installed. The permits necessary for the conceptual changes and for the design of the new components have been granted by ENSI.

The planned improvements for the temperature and level measurements of the SFPs have been completed in all NPPs.

G.3 Siting of Proposed Facilities (Article 6)

G.3.1 Safety Impact Information (Paragraph 1)

Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed spent fuel management facility:

(i) to evaluate all relevant site-related factors likely to affect the safety of such a facility during its operating lifetime;

(ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment;

(iii) to make information on the safety of such a facility available to members of the public;

(iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

A spent fuel management facility is a nuclear facility according to the Swiss nuclear energy legislation. The site of a nuclear facility is fixed by the general licence which is a prerequisite for further licences and has to be approved by Parliament (see Section E.2.3). The safety analysis report to be submitted with the general licence application has to include an evaluation of the site-related factors likely to affect the

safety of the facility, as well as the likely safety impacts of the facility on individuals, society and the environment. Clauses i and ii are thus addressed.
The licensing procedure includes a public consultation. The documentation on the project, including the safety analysis report, the regulatory review report and the views and opinions of the cantons, is made available, and any person (also from foreign countries) can give input or raise objections. This fulfils the requirement of Clause iii.
The Nuclear Energy Act specifically requires that the siting canton as well as neighbouring cantons and countries shall be involved in the decision making regarding the general licence. Furthermore, bilateral agreements have been established with the neighbouring countries (France, Germany, Austria and Italy) with the aim of exchanging information on planned or operating nuclear facilities that are situated close to the common national borders. This fulfils the requirements of Clauses iv.
The site selection process leading to the application for a general licence is not explicitly defined in the legislation. According to Article 5 of the Nuclear Energy Ordinance, however, the federal authorities have developed a procedure for the siting of disposal facilities, which was approved by the federal government in 2008, see Section B.2. The stepwise procedure focuses primarily on safety related criteria, but socio-economic aspects are also taken into account. Cantons, siting regions and neighbouring countries are involved in the site selection process at an early stage as important stakeholders.

G.3.2 Effects on other Contracting Parties (Paragraph 2)

In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 4.
The remarks on Article 13, Paragraph 2 apply likewise to Article 6, Paragraph 2 (see Section H.3.2).

G.4 Design and Construction of Facilities (Article 7)

G.4.1 Limitation of Radiological Impacts (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that the design and construction of a spent fuel management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases.
The procedure for the construction licence for a nuclear facility, including spent fuel management facilities, requires the submission of a safety analysis report with the licence application. This safety analysis report, which is reviewed by the nuclear safety authority, has to contain the necessary information to verify that the possible radiological impacts on individuals, society and the environment are within the limits given in the regulation. The evaluation of the radiological impacts must encompass normal operation as well as possible accidental situations.

G.4.2 Decommissioning (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a spent fuel management facility are taken into account.
The Nuclear Energy Act requires for any nuclear facility a decommissioning concept at the general licence stage and a more detailed decommissioning plan at the construction licence stage. Under the previous legislation, a similar requirement was applied when granting the general licence to Zwilag for the Central Interim Storage Facility ZZL. Further details are given in Section F.6.

G.4.3 Technologies (Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that the technologies incorporated in the design and construction of a spent fuel management facility are supported by experience, testing or analysis.

During design, construction and operation, the Nuclear Energy Ordinance requires for any nuclear facility, that technologies, materials and organisational structures are employed that are supported by experience and proven to be of high quality. This requirement is therefore also considered in the regulatory review of licence applications and in the regulatory supervision during the construction phase. During planning, construction and operation, ENSI bases its assessments of nuclear facilities, including spent fuel management projects, on evaluations taking into account the recent developments in science and technology.

G.5 Assessment of Safety of Facilities (Article 8)

G.5.1 Safety Assessment (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that before construction of a spent fuel management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out.

A safety assessment report is part of the documentation required by the Swiss nuclear energy legislation for each licensing step of a nuclear facility, including spent fuel management facilities. An environmental impact assessment is required at the general licence and construction licence stages based on the Environmental Protection Act. ENSI carries out comprehensive reviews of the safety assessments, and the Federal Office for the Environment (FOEN) reviews the environmental impact assessment.

G.5.2 Update of Safety Assessment (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that before the operation of a spent fuel management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in clause (i).

The safety assessment has to be updated by the applicant and reviewed by ENSI at each step of the licensing procedure (general licence, construction licence and operation licence). Furthermore, the Nuclear Energy Act (Article 22, lit. e) requires periodic safety reviews during the lifetime of the NPPs, including their spent fuel management facilities. A frequency of ten years is set for these reviews by the Nuclear Energy Ordinance. The procedure and the requirements of the periodic safety reviews are outlined in the Regulatory Guideline ENSI-A03. The periodic safety reviews are examined by ENSI.

In addition, operators of any nuclear facility in Switzerland (not only NPPs) have to perform systematic safety assessments. The conditions and requirements for such assessments have been laid down in the Regulatory Guideline ENSI-G08. For storage facilities a systematic safety assessments report is requested with a frequency of 10 years.

G.6 Operation of Facilities (Article 9)

G.6.1 Operation Licence (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that the licence to operate a spent fuel management facility is based upon appropriate assessments as specified in Arti-

cle 8 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements.

The operation licence for a nuclear facility, including spent fuel management facilities, is granted based, inter alia, on a safety analysis report. ENSI supervises the construction of the facility and makes sure that the facility is built in accordance with the construction licence. The operation licence includes the obligation that active operation of the facility requires a corresponding permit from ENSI. This permit is issued after the commissioning programme has demonstrated that the facility fulfils all safety and other requirements.

G.6.2 Defining and Revising Operational Limits and Conditions (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that operational limits and conditions derived from tests, operational experience and the assessments, as specified in Article 8, are defined and revised as necessary.

ENSI supervises and inspects the commissioning and operation of each nuclear facility, including spent fuel management facilities. This includes the review and approval of operational conditions for the particular nuclear facility. According to the Nuclear Energy Ordinance, any changes to operational limits and conditions require a permit from ENSI that has the competence to revise operational limits and conditions as necessary for reasons of safety.

G.6.3 Accordance with Established Procedures (Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that operation, maintenance, monitoring, inspection and testing of a spent fuel management facility are conducted in accordance with established procedures.

The processes of operation, maintenance and monitoring of nuclear facilities, including spent fuel management facilities, are specified in the operation licence. The corresponding procedures as described in the facility operation documents are reviewed by ENSI. Their adequacy is a condition for issuing the permit to start operation. ENSI is entrusted with the supervision of nuclear facilities and carries out inspections according to an annual inspection plan. ENSI is empowered to enforce compliance with all requirements.

G.6.4 Engineering and Technical Support (Clause iv)

Each Contracting Party shall take the appropriate steps to ensure that engineering and technical support in all safety-related fields are available throughout the operating lifetime of a spent fuel management facility.

According to the Nuclear Energy Act, the fulfilment of requirements regarding the staff and the organisation is a prerequisite for the granting of the operation licence for a nuclear facility. The requirements concerning staff and organisation are outlined in the Nuclear Energy Ordinance and more specifically elaborated in the Regulatory Guidelines ENSI-G07, ENSI-B10 and ENSI-B13. They include the availability of engineering and technical support. ENSI inspects and supervises the qualification of the personnel of nuclear facilities including spent fuel management facilities. ENSI has the competence to intervene if a lack of technical or engineering support is determined to impact on the safety of the facility.

G.6.5 Reporting of Incidents (Clause v)

Each Contracting Party shall take the appropriate steps to ensure that incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body.

The requirements regarding the regular reporting (monthly, quarterly, and yearly) and the reporting of incidents are specified in the Nuclear Energy Ordinance and in the Regulatory Guidelines ENSI-B02 und ENSI-B03.

All safety-relevant incidents have to be reported without delay, first by telephone, and to be reconfirmed in writing within very short deadlines (a few hours at the most). Further reports, at least on the cause, effects, countermeasures and measures to prevent reoccurrence, must be submitted within a specified deadline after the written confirmation. An additional report is required after an appropriate period on the effectiveness of the measures against reoccurrence.

G.6.6 Collection and Analysis of Operating Experience (Clause vi)

Each Contracting Party shall take the appropriate steps to ensure that programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate.

The Nuclear Energy Act explicitly requires the operator of a nuclear facility, including spent fuel management facilities, to conduct systematic safety assessments and to observe and analyse operating experience gained in comparable facilities. The Nuclear Energy Ordinance further requires the operator to include the operating experience gained in the safety evaluations and to determine the relevance for his facility of the operating experience gained in comparable facilities. The conditions and requirements for such assessments have been laid down in the Regulatory Guideline ENSI-G08.

G.6.7 Decommissioning Plans (Clause vii)

Each Contracting Party shall take the appropriate steps to ensure that decommissioning plans for a spent fuel management facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.

The Nuclear Energy Act and the Nuclear Energy Ordinance require the updating of decommissioning plans for nuclear facilities on a regular basis (10-year cycle), considering all changes made to the facilities, as well as changes in the regulatory framework and technological development, as necessary. The Ordinance on the Decommissioning and Waste Management Funds requires a periodical update of the decommissioning cost estimate (5-year cycle). The operators of the NPPs have elaborated detailed decommissioning studies for their facilities that are based on the decommissioning plans. These studies were revised in 2016, the next update will take place in 2021.

G.7 Disposal of Spent Fuel (Article 10)

If, pursuant to its own legislative and regulatory framework, a Contracting Party has designated spent fuel for disposal, the disposal of such spent fuel shall be in accordance with the obligations of Chapter 3 relating to the disposal of radioactive waste.

According to the current legislation, radioactive waste is defined as radioactive material which is no longer used. Since the ban of reprocessing spent fuel has to be managed as radioactive waste and must be disposed of accordingly.

Section H Safety of Radioactive Waste Management

H.1 General Safety Requirements (Article 11)

Each Contracting Party shall take the appropriate steps to ensure that at all stages of radioactive waste management individuals, society and the environment are adequately protected against radiological and other hazards.

The protection of individuals, society and the environment against radiological and other hazards is subject to the Swiss legislation on radiation protection and on nuclear energy, as detailed in Section E.2, and to the legislation on environmental protection (mainly the Environmental Protection Act and associated ordinances).

Compliance with the legal requirements regarding nuclear safety and radiation protection is verified and enforced by regulatory bodies. These are mainly the Swiss Federal Nuclear Safety Inspectorate (ENSI) for nuclear facilities, including radioactive waste management facilities, and the Federal Office of Public Health (FOPH) for non-NPP practices. Compliance is verified by reviewing safety analysis reports during the licensing steps and by supervising construction and operation particularly through inspections.

Protection of the environment from hazards other than radioactivity is verified in the licensing process of practices by the Federal Office for the Environment (FOEN). During operation, protection of workers is assured by requirements and compliance checks of the Swiss National Accident Insurance Fund (Suva). Compliance with the legislation on protection of the general population and the environment from non-radiological hazards is verified by cantonal authorities.

H.1.1 Criticality and Removal of Heat (Clause i)

In so doing, each Contracting Party shall take the appropriate steps to ensure that criticality and removal of residual heat generated during radioactive waste management are adequately addressed.

The remarks on Article 4, Clause i apply likewise to Article 11, Clause i (see Section G.1.1).

H.1.2 Generation of Radioactive Waste (Clause ii)

In so doing, each Contracting Party shall take the appropriate steps to ensure that the generation of radioactive waste is kept to the minimum practicable.

Minimisation of radioactive waste is required by the Radiological Protection Act as well as the Nuclear Energy Act. The Nuclear Energy Ordinance further details the requirements for nuclear facilities. Compliance is subject to verification by the regulatory body during licensing review, issuance of permits, and regular inspections, and is recorded by appropriate safety indicators. Until now there has never been a reason for a regulatory enforcement action regarding minimisation of radioactive waste.

As the low permeable sedimentary formation Opalinus clay is the actual choice as host rock for deep geological repositories, it is essential to keep gas production as a result of decomposition and corrosion processes in the radioactive waste repositories at a sufficiently low level. High gas production rates and associated pressure build-up could possibly lead to rock damage, and consequently, the generation of pathways for radionuclides. As a result of a regulatory research project, some technical options were identified and assessed to minimise gas production from organic and metallic radioactive waste, respectively.

H.1.3 Interdependencies (Clause iii)

In so doing, each Contracting Party shall take the appropriate steps to take into account interdependencies among the different steps in radioactive waste management.

Radioactive waste management is subject to the requirement of optimisation formulated in the Radiological Protection Ordinance, thus interdependencies among the different steps must be (and in practice are) taken into account.

In addition, the nuclear energy legislation requires the producers of radioactive waste to prepare and submit a comprehensive waste management programme for all types of radioactive waste. The programme has to include

- origin, type and quantity of the radioactive wastes
- geological repositories required including their layout concept
- allocation of the waste types to the geological repositories
- realisation plan of the geological repositories
- duration and required capacity of interim storage
- financial plan for all the waste management activities until shutdown of the NPPs
- information concept.

The waste management programme has to be revised and submitted to the regulatory bodies every five years.

H.1.4 Protection of Individuals, Society and the Environment (Clause iv)

In so doing, each Contracting Party shall take the appropriate steps to provide for effective protection of individuals, society and the environment, by applying at the national level suitable protective methods as approved by the regulatory body, in the framework of its national legislation which has due regard to internationally endorsed criteria and standards.

The remarks on Article 4, Clause iv apply likewise to Article 11, Clause iv (see Section G.1.4).

H.1.5 Biological, Chemical and other Hazards (Clause v)

In so doing, each Contracting Party shall take the appropriate steps to take into account the biological, chemical and other hazards that may be associated with radioactive waste management.

The remarks on Article 4, Clause v apply likewise to Article 11, Clause v (see Section G.1.5).

H.1.6 Impacts on Future Generations (Clause vi)

In so doing, each Contracting Party shall take the appropriate steps to strive to avoid actions that impose reasonably predictable impacts on future generations greater than those permitted for the current generation.

Several legal requirements aim to avoid any impact from the application, production and handling of radioactive materials on future generations. The Radiological Protection Act and the Nuclear Energy Act require that all radiological hazards be removed from a nuclear site in the case that the operating licence is terminated.

The Nuclear Energy Act requires safe and permanent management and disposal of all radioactive waste in deep geological repositories. The specific design principles for deep geological repositories and the requirements for the safety case are detailed in the Regulatory Guideline ENSI-G03 which has been updated in 2020. Here, the principle is formulated that any possible future consequences from geological disposal of radioactive waste in Switzerland may not be greater than those permissible in Switzerland today. ENSI-G03 specifies the following protection criteria for the post closure phase:

- For any possible future evolution of a deep geological repository, the release of radionuclides may not lead to either an individual dose exceeding 0.1 mSv per year or to an exceedance of the risk constraint according to criterion (b) of paragraph 2.15 of the IAEA safety standard SSR-5.
- Within the time period set to demonstrate compliance with safety requirements (time period for assessment) the radiological consequences of an inadvertent human intrusion into the deep geological repository have to be assessed according to criteria (c) and (e) of paragraph 2.15 of the IAEA safety standard SSR-5.
- After the time period for assessment the radiological consequences on the surface shall not significantly exceed the mean radiation level in Switzerland.

There are currently no final disposal facilities for radioactive waste in operation or under construction in Switzerland. However, the requirements on the long-term safety are assessed based on the design and planning of disposal facilities, and compliance with these requirements is continuously verified in the regulatory review of such projects.

H.1.7 Burdens on Future Generations (Clause vii)

In so doing, each Contracting Party shall take the appropriate steps to aim to avoid imposing undue burdens on future generations.

As stated in Section H.1.6, the legal requirements prevent imposing undue burdens on future generations. Regarding disposal, the Regulatory Guideline ENSI-G03 explicitly formulates the main objective of geological disposal, as to ensure protection of the humans and the environment from ionizing radiation without imposing any undue burdens or responsibilities on future generations.

According to the basic design principles as imposed by Article 11 of the Nuclear Energy Ordinance, the repository must be designed in such a way that it can be closed within a few years. The Regulatory Guideline ENSI-G03 further states that after a repository has been closed, no further measures shall be necessary to ensure long-term safety. In the case of an unfavourable development in the boundary conditions that could threaten the safety of the repository or could put normal closure into question, technical and operational measures have to be adopted for temporary closure to allow the emplacement zones of a repository to be transformed rapidly into a passively safe state during the operational phase.

According to the Nuclear Energy Act, anyone who operates or decommissions a nuclear facility is obliged to safely manage all radioactive waste arising from that installation at his own cost. Two funds have been established by law to ensure the availability of adequate financial resources for the decommissioning of nuclear facilities and the management of spent fuel and radioactive waste (see Section F.2.2). The current decommissioning strategy for all Swiss nuclear installations is immediate dismantling.

Sites of past practices in Switzerland needing clean-up measures for reasons of radioactive contamination are being restored to safe conditions under the supervision of FOPH (see Section H.2.2).

H.2 Existing Facilities and Past Practices (Article 12)

H.2.1 Existing Facilities (Clause i)

Each Contracting Party shall in due course take the appropriate steps to review the safety of any radioactive waste management facility existing at the time the Convention enters into force for that Contracting Party and to ensure that, if necessary, all reasonably practicable improvements are made to upgrade the safety of such a facility.

An overview of the existing radioactive waste management facilities is given in Section D.2.3.

These facilities have been licensed as required by law. The Nuclear Energy Act and the Nuclear Energy Ordinance require the owners of all nuclear facilities to systematically and regularly assess the safety of these facilities under the supervision of ENSI. All Swiss NPPs have on-site waste treatment and conditioning as well as storage facilities for their own operational waste. These facilities are included in the periodic safety reviews of the NPPs, and their actual status is described when revised safety assessment documents are issued. In addition, operators of any nuclear facility (not only NPPs) in Switzerland have to perform systematic safety assessments. The conditions and requirements for such assessments have been laid down in the Regulatory Guideline ENSI-G08. For storage facilities a systematic safety assessments report is requested with a frequency of 10 years.

H.2.2 Past Facilities and Practices (Clause ii)

Each Contracting Party shall in due course take the appropriate steps to review the results of past practices in order to determine whether any intervention is needed for reasons of radiation protection bearing in mind that the reduction in detriment resulting from the reduction in dose should be sufficient to justify the harm and the costs, including the social costs, of the intervention.

One experimental power reactor has been dismantled in Switzerland. This facility, at Lucens in the canton of Vaud, was shut down in 1969 following an accident after a short period of operation, and was later decommissioned. The site was released from regulatory control in 1995 with the exception of six containers containing approximately 240 t unconditioned, solid radioactive waste. In 2003, these waste containers were transported to ZZL for storage and conditioning of the waste in view of later disposal. The complete former site at Lucens was released from regulatory control in 2004. The site is, however, subject to the environmental radiation monitoring programme of the Federal Office of Public Health (FOPH).

In 1989, the Federal Council decided that the Department of Nuclear Physics at the University of Geneva had completed the decommissioning of the research reactor AGN-201-P and released the site from the former atomic legislation. The fuel elements were transferred to PSI and later back to the USA. No radioactive waste resulted from the dismantling of this installation.

The Radiological Protection Ordinance assigns the obligation to collect legacy radioactive objects as radioactive waste and to investigate potential legacy sites to the FOPH. It sets a general reference level of 1 mSv per year for existing exposure situations whereas the FOPH can propose higher reference levels, up to 20 mSv per year, to the Federal Council, in individual cases.

In the last few decades, a number of collection campaigns were organised to collect radium waste still present in the watch industry, thus leading to an overall decrease in legacy objects in circulation. Enterprises which were still in operation in these years were thoroughly decontaminated.

However, recent discoveries of radium in old conventional landfills and in dwellings where radium paint had been used before the first ordinance on radiological protection in 1963 led the FOPH to set up a dedicated action plan. This «Radium Action Plan[3]» runs since 2015 and should be ended in 2022. It aims at identifying all radium legacy sites and remediate sites were the reference level of 1 mSv per year is exceeded. Based on historical research, all identified buildings and associated land (gardens) are diagnosed for radioactivity and, based on dose estimations, remediated if the reference level was exceeded. Potentially contaminated landfills for which an exceedance of the reference level can be excluded in their actual state are listed and kept under surveillance. Radioactive waste arising during remediation of contaminated sites are eliminated according to the Radiological Protection Ordinance. Weakly contaminated radioactive waste is disposed of in conventional landfills or incineration plants if specific conditions are met. All other radioactive waste is transferred to the National Collection Centre at PSI. Further information and collection campaigns for legacy objects are regularly organised and conventional waste collection or recycling facilities have the obligation to check incoming and outgoing waste for radioactivity.

H.3 Siting of Proposed Facilities (Article 13)

H.3.1 Safety, Impact and Information (Paragraph 1)

Each Contracting Party shall take the appropriate steps to ensure that procedures are established and implemented for a proposed radioactive waste management facility:

(i) to evaluate all relevant siterelated factors likely to affect the safety of such a facility during its operating lifetime as well as that of a disposal facility after closure;

[3] MURITH, C., BAECHLER, S., ESTIER, S., PALACIOS-GRUSON, M., «Remediation of Radium Legacies from the Swiss Watch Industry», Radiat Prot Dosimetry 173 (2017) 245–251.

(ii) to evaluate the likely safety impact of such a facility on individuals, society and the environment, taking into account possible evolution of the site conditions of disposal facilities after closure;

(iii) to make information on the safety of such a facility available to members of the public;

(iv) to consult Contracting Parties in the vicinity of such a facility, insofar as they are likely to be affected by that facility, and provide them, upon their request, with general data relating to the facility to enable them to evaluate the likely safety impact of the facility upon their territory.

A radioactive waste management facility is a nuclear facility according to the Swiss nuclear energy legislation. The remarks on Article 6, Paragraph 1, Clauses i to iv apply likewise to Article 13, Paragraph 1, Clauses i to iv (see Section G.3.1).

H.3.2 Effects on Other Contracting Parties (Paragraph 2)

In so doing, each Contracting Party shall take the appropriate steps to ensure that such facilities shall not have unacceptable effects on other Contracting Parties by being sited in accordance with the general safety requirements of Article 11.

For nuclear facilities in general, adequate protection beyond the national borders is effected in practice by the fact that the evaluation of impact is carried out irrespective of national borders. For disposal facilities, this requirement is explicitly stated by the Regulatory Guideline ENSI-G03. The possible consequences resulting from geological disposal of radioactive waste in Switzerland may not be higher in other countries than is permissible in Switzerland. Some nuclear facilities in Switzerland are located close to the German border. In the frame of a bilateral agreement with Germany, German regulatory authorities review licence applications for such nuclear facilities and assess the potential radiological effects according to the German regulations. Results are discussed by the German-Swiss Commission for the Safety of Nuclear Installations (DSK).

H.4 Design and Construction of Facilities (Article 14)

H.4.1 Limitation of Radiological Impacts (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that the design and construction of a radioactive waste management facility provide for suitable measures to limit possible radiological impacts on individuals, society and the environment, including those from discharges or uncontrolled releases.

The remarks on Article 7, Clause i apply likewise to Article 14 Clause i (see Section G.4.1).

H.4.2 Decommissioning (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that at the design stage, conceptual plans and, as necessary, technical provisions for the decommissioning of a radioactive waste management facility other than a disposal facility are taken into account.

The remarks on Article 7, Clause ii apply likewise to Article 14, Clause ii (see Section G.4.2).

H.4.3 Closure of Disposal Facility (Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that at the design stage, technical provisions for the closure of a disposal facility are prepared.

The Nuclear Energy Act requires a concept for the closure of the disposal facility at the stage of the general licence and a more detailed plan at the stage of the construction licence.

H.4.4 Technologies (Clause iv)

Each Contracting Party shall take the appropriate steps to ensure that the technologies incorporated in the design and construction of a radioactive waste management facility are supported by experience, testing or analysis.

Nuclear legislation stipulates that established or proven highquality processes, materials, technologies and organisational structures and processes must be used in order to guarantee nuclear safety in connection with the design, construction, commissioning and operation of nuclear installations.

The licence holder is obliged to monitor fieldrelated scientific developments, especially findings obtained from research activities, and must examine the extent to which conclusions may be drawn therefrom concerning safety and security. The licence holder must also monitor technological developments, including those relating to organisation and personnel, and must examine the extent to which lessons learned may be gained therefrom. The following are of particular relevance: recognised domestic and foreign technical standards; regulations of the country supplying the nuclear installation, as well as of other countries, relating to nuclear technology; recommendations of international bodies; state of the art in nuclear installations of a similar nature and in other relevant installations.

Furthermore, in accordance with the Nuclear Energy Ordinance, the safety-relevant properties of the host rock and the processes of interaction between the natural and engineered barriers have to be investigated in greater detail in test areas of a geological repository. Safety-relevant technologies for emplacing the backfill material (or its removal if retrieval is appropriate), for retrieving waste packages and for sealing of caverns and tunnels have to be tested and their operational reliability demonstrated.

H.5 Assessment of Safety of Facilities (Article 15)

H.5.1 Safety Assessment (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that before construction of a radioactive waste management facility, a systematic safety assessment and an environmental assessment appropriate to the hazard presented by the facility and covering its operating lifetime shall be carried out.

The remarks on Article 8, Clause i apply likewise to Article 15, Clause i (see Section G.5.1).

H.5.2 Post-Closure Safety Assessment (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that in addition, before construction of a disposal facility, a systematic safety assessment and an environmental assessment for the period following closure shall be carried out and the results evaluated against the criteria established by the regulatory body.

For a disposal facility, a safety assessment addressing the period after closure (longterm safety) is required at each licensing step. The safety assessment has to be revised regularly in the light of the actual situation of the facility and upon new findings in research and technology. It is reviewed by the competent supervisory authority ENSI based on the safety principles and protection criteria as stipulated in the Regulatory Guideline ENSI-G03.

The Environmental Protection Act requires the implementer of a facility subject to an environmental impact assessment to submit a report to the competent authority that enables assessment of the non-radiological hazards associated with the operational and post-operational period of this facility. For a deep geological repository a two-stage procedure is prescribed, where the first stage relates to the general licence application and the second stage to the application for the construction licence. Environmental impact issues are reviewed by the Federal Office for the Environment (FOEN).

H.5.3 Update of Safety Assessment (Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that before the operation of a radioactive waste management facility, updated and detailed versions of the safety assessment and of the environmental assessment shall be prepared when deemed necessary to complement the assessments referred to in paragraph (i).

The safety assessment of a radioactive waste management facility has to be updated by the applicant and reviewed by ENSI at each step of the licensing procedure (general licence, construction licence and operation licence) and also before and after closure of the disposal facility (Nuclear Energy Act and Regulatory Guideline ENSI-G03). Furthermore, the remarks on Article 8, Clause ii apply likewise to Article 15, Clause iii (see Section G.5.2).

H.6 Operation of Facilities (Article 16)

H.6.1 Operation Licence (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that the licence to operate a radioactive waste management facility is based upon appropriate assessments as specified in Article 15 and is conditional on the completion of a commissioning programme demonstrating that the facility, as constructed, is consistent with design and safety requirements.

The remarks on Article 9, Clause i apply likewise to Article 16 Clause i (see Section G.6.1). Furthermore, for the operation licence of a deep geological repository to be granted, the Nuclear Energy Act specifically requires that the findings gained during construction confirm the suitability of the site.

H.6.2 Defining and Revising Operational Limits and Conditions (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that operational limits and conditions, derived from tests, operational experience and the assessments as specified in Article 15 are defined and revised as necessary.

The remarks on Article 9, Clause ii apply likewise to Article 16, Clause ii (see Section G.6.2). Furthermore, for storage and disposal facilities, the Nuclear Energy Ordinance stipulates that a storage permit issued by ENSI is required for each type of waste package (defined in ISRAM, see Section D.1).

H.6.3 Accordance with Established Procedures (Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that operation, maintenance, monitoring, inspection and testing of a radioactive waste management facility are conducted in accordance with established procedures. For a disposal facility the results thus obtained shall be used to verify and to review the validity of assumptions made and to update the assessments as specified in Article 15 for the period after closure.

The remarks on Article 9, Clause iii apply likewise to Article 16, Clause iii (see Section G.6.3). Furthermore, the safety assessment of a radioactive waste management facility has to be updated by the applicant and reviewed by ENSI at each step of the licensing procedure (general licence, construction licence and operation licence) and also before and after closure of the disposal facility (Regulatory Guideline ENSI-G03).

H.6.4 Engineering and Technical Support (Clause iv)

Each Contracting Party shall take the appropriate steps to ensure that engineering and technical support in all safety-related fields are available throughout the operating lifetime of a radioactive waste management facility.

The remarks on Article 9, Clause iv apply likewise to Article 16, Clause iv (see Section G.6.4).

H.6.5 Characterization and Segregation of Radioactive Waste (Clause v)

Each Contracting Party shall take the appropriate steps to ensure that procedures for characterization and segregation of radioactive waste are applied.

According to the Nuclear Energy Ordinance, the conditioning of radioactive waste requires an approval from ENSI. The approval depends, inter alia, on the measures taken to ensure that the properties of the waste and its characterisation are optimal in view of the waste management steps following conditioning. The former point includes that attention is paid to segregation whenever this is beneficial.

H.6.6 Reporting of Incidents (Clause vi)

Each Contracting Party shall take the appropriate steps to ensure that incidents significant to safety are reported in a timely manner by the holder of the licence to the regulatory body.

The remarks on Article 9, Clause v apply likewise to Article 16, Clause vi (see Section G.6.5).

H.6.7 Collection and Analysis of Operating Experience (Clause vii)

Each Contracting Party shall take the appropriate steps to ensure that programmes to collect and analyse relevant operating experience are established and that the results are acted upon, where appropriate.

The remarks on Article 9, Clause vi apply likewise to Article 16, Clause vii (see Section G.6.6).

H.6.8 Decommissioning Plans (Clause viii)

Each Contracting Party shall take the appropriate steps to ensure that decommissioning plans for a radioactive waste management facility other than a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility, and are reviewed by the regulatory body.

The remarks on Article 9, Clause vii apply likewise to Article 16, Clause viii (see Section G.6.7).

H.6.9 Closure of Disposal Facility (Clause ix)

Each Contracting Party shall take the appropriate steps to ensure that plans for the closure of a disposal facility are prepared and updated, as necessary, using information obtained during the operating lifetime of that facility and are reviewed by the regulatory body.

Article 13 of the Nuclear Energy Act requires a plan for the monitoring period and a plan for the closure of the disposal facility as a prerequisite for granting the general licence. Monitoring relies on data acquisition within the pilot section, a small but representative part of the main disposal facility (the requirements on which are outlined in Art. 66 of the Nuclear Energy Ordinance and the Regulatory Guideline ENSI-G03), and on experiments carried out within the test zones, the on-site rock laboratory (Nuclear Energy Ordinance, Article 65). The data acquired by the monitoring will form the basis for the future decision on closure of the repository.

For the construction licence a project for the monitoring period and a plan for the closure of the disposal facility are required.

As a general obligation, the licence holder is bound to regularly update the project for the monitoring period and the plan for the closure of the disposal facility, taking account of changes made to the facility, changes in the regulations and technological development (Nuclear Energy Act).

H.7 Institutional Measures after Closure (Article 17)

H.7.1 Keeping Records (Clause i)

Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility records of the location, design and inventory of that facility required by the regulatory body are preserved.

The Nuclear Energy Act requires the Federal Council (federal government) to take the necessary steps to ensure that information on a closed disposal facility, including location, design and inventory is preserved. The required duration of the preservation is not specified. The Nuclear Energy Act prescribes long-term marking of the disposal facility.

The Nuclear Energy Ordinance requires the host canton of a deep geological repository to enter information on the protection area defined for the disposal facility in its land register (see Section H.7.2).

According to the requirements of Article 71 of the Nuclear Energy Ordinance and the Regulatory Guideline ENSI-G03, respectively, the documentation related to the closure of the disposal facility has to contain at least the following information:

- A description of the closed facility and its location;
- The location and extent of the underground installations;
- The inventory of the emplaced radioactive waste, separated according to their type and amount for each emplacement chamber;
- Details of the emplacement and the detailed position of each disposal container as well as on the conditioning of the contained waste packages;
- The layout of the technical safety barriers, including and the sealing of the tunnels;
- Details on interim storage of waste packages in case these might be relevant for possible retrieval of the waste or long-term safety;
- A summary of the results from the monitoring period;
- The basis for and the results of the final safety assessment.

The owner of the disposal facility is obliged to hand over the documentation to the competent Federal Department (DETEC) after closure of the facility or after termination of the additional monitoring period. At least three copies of the documentation have to be provided in order to allow for archiving at different locations. The long-term durability of the documentation has to be demonstrated and the required maintenance measures explained (ENSI-G03).

H.7.2 Institutional Controls (Clause ii)

Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility active or passive institutional controls such as monitoring or access restrictions are carried out, if required.

The Nuclear Energy Act requires the safe and permanent disposal of radioactive waste to be realised in such a way that the long-term safety does not rely on active surveillance and maintenance. However, further monitoring after closure of a disposal facility may be stipulated. The Nuclear Energy Act requires establishing a protection area around a disposal facility. The protection zone is the underground area where intrusions may impair the long-term safety of the disposal facility. It includes all parts of the repository, the host rock area relevant for the hydraulic isolation of the repository, and the host rock area providing a significant contribution to the retention of released radionuclides. The protection area is defined provisionally in the general licence and definitively in the operation licence and is integrated into the land register of the host canton. Future activities such as drillings, underground constructions or blastings, which may affect the protection area of a disposal facility, are subject to authorisation by the competent federal department (DETEC). Such authorisations may only be granted provided the long-term safety of the disposal facility will not be impaired by the planned activities.

As there are no disposal facilities to be closed in Switzerland in the near future, further details of the institutional controls after closure have not yet been decided. The Nuclear Energy Act allocates the corresponding decisions to the federal government.

H.7.3 Intervention Measures (Clause iii)

Each Contracting Party shall take the appropriate steps to ensure that after closure of a disposal facility if, during any period of active institutional control, an unplanned release of radioactive materials into the environment is detected, intervention measures are implemented, if necessary.

Switzerland has implemented a national monitoring programme of the radioactivity in the environment. This monitoring is performed by FOPH. The environment of a closed disposal facility will be subject to the environmental radiation monitoring programme. The intervention measures to be taken in the case of increased environmental radiation are established by the radiation protection legislation and by the Ordinance on the Emergency Organisation in Case of Increased Radioactivity. The responsibility for such potential intervention measures after closure lies with the Swiss Confederation.

Section I Transboundary Movement (Article 27)

I.1 General Requirements (Paragraph 1)

Each Contracting Party involved in transboundary movement shall take the appropriate steps to ensure that such movement is undertaken in a manner consistent with the provisions of this Convention and relevant binding international instruments.

I.1.1 Authorisation by State of Destination (Clause i)

In so doing, a Contracting Party which is a State of origin shall take the appropriate steps to ensure that transboundary movement is authorised and takes place only with the prior notification and consent of the State of destination.

The import and export of radioactive material are subject to an authorisation issued under the Nuclear Energy Act and the Nuclear Energy Ordinance (for nuclear material and radioactive waste) or the Radiological Protection Act and the Radiological Protection Ordinance (for other radioactive materials). As a general rule, Swiss nuclear waste is to be managed inside Switzerland. Exceptionally, a licence can be granted under restrictive conditions as listed in the Nuclear Energy Act and the Nuclear Energy Ordinance, including the agreement of the state of destination and the obligation for the waste owner to take back the exported waste if necessary. As sea dumping of radioactive waste ceased in the early 1980s, no radioactive waste has been exported from Switzerland for disposal purposes since.

Export of spent fuel for reprocessing has finally been prohibited since 2018. However, the last shipment of Swiss spent fuel elements to foreign reprocessing sites already took place in June 2006. All resulting reprocessing waste had been repatriated by end of 2016. Hence there will be no future need of transboundary movement of spent fuel and according waste packages except – if licensed – for small amounts as an exception for research purposes.

Export of radioactive waste for conditioning, storage or disposal, or for research purposes, is possible but subject to authorisation. Such licenses will be issued if the following general conditions are met:

a. the protection of humans and the environment is assured, and nuclear safety and security are guaranteed;
b. there are no conflicting reasons associated with non-proliferation for nuclear arms, in particular international control measures that are not binding under international law but are supported by Switzerland;
c. no sanctions have been imposed under the Embargo Act of 22 March 2002;
d. the required insurance cover exists in accordance with the Nuclear Energy Liability Act of 18 March 1983;
e. there are no conflicting commitments under international law, and Switzerland's national security is not affected;
f. the persons responsible for the installation concerned possess the necessary expertise.

Additional specific export conditions for the purpose of conditioning Swiss waste:

a. the country of destination has consented to the import of radioactive waste for conditioning purposes in an agreement under international law;
b. the country of destination has a suitable waste management installation that corresponds to the latest international standards of science and technology;
c. all countries concerned have given their consent to the transit of the radioactive waste in question;
d. the exporter has entered into a binding agreement with the importer of the radioactive waste that has been approved by the Federal Council or its designated authority and which stipulates that the exporter shall take back any radioactive waste that may result from conditioning or – if applicable – any radioactive waste that may not have been conditioned.

Additional specific export conditions for the exceptional purpose of storage and/or disposal of Swiss waste:

- in addition to letters a-c (above)

- the exporter has entered into a binding agreement with the importer of the radioactive waste that has been approved by the authority designated by the Federal Council, and which stipulates that the exporter shall take back the consignment if necessary.

Additional specific import conditions for the exceptional purpose of managing non-Swiss radioactive waste in Switzerland:

a. Switzerland has consented to the import of radioactive waste for management purposes in an agreement under international law;
b. Switzerland has a suitable waste management installation that corresponds to the latest international standards of science and technology;
c. all countries concerned have given their consent to the transit of the radioactive waste in question;
d. the importer and the exporter of the radioactive waste consignment have signed a legally binding agreement that has been approved by the country of origin and stipulates that the exporter shall accept the consignment if it has to be returned for any reason.

Small quantities of nuclear material (up to 15 g) are exempted from the provisions of the Nuclear Energy Act, but such transports are subject to authorisation under the Radiation Protection Act.

According to the Nuclear Energy Act, air transport within the Swiss airspace of nuclear materials containing plutonium is prohibited.

I.1.2 Movements through States of Transit (Clause ii)

In so doing, transboundary movement through States of transit shall be subject to those international obligations which are relevant to the particular modes of transport utilised.

Switzerland is a party to the European Agreement on the International Carriage of Dangerous Goods by Road (ADR) and by Rail (RID). Air transport is covered by the ICAO Dangerous Goods Regulations and transport on the river Rhine by the ADN (Accord européen relatif au transport international des marchandises dangereuses par voies de navigation intérieures). The transit of radioactive material is subject to an authorisation issued under the Nuclear Energy Act and the Nuclear Energy Ordinance (for nuclear material and radioactive waste) or the Radiological Protection Act and the Radiological Protection Ordinance (for other radioactive materials) like import and export. Licences for transit are not issued unless the international obligations relevant to the modes of transport used are fulfilled. There were no transits of radioactive waste or spent fuel through Switzerland in recent years.

I.1.3 Requirements for State of Destination (Clause iii)

In so doing, a Contracting Party which is a State of destination shall consent to a transboundary movement only if it has the administrative and technical capacity, as well as the regulatory structure, needed to manage the spent fuel or the radioactive waste in a manner consistent with this Convention.

The Radiological Protection Act prohibits the import of radioactive waste not originally arising from Switzerland for disposal purposes unless under an international agreement.

The import of radioactive waste originating from other countries can be exceptionally allowed if

a. Switzerland has consented to the import of radioactive waste for disposal purposes in an agreement under international law;
b. Switzerland has a suitable nuclear facility that fulfils the latest international standards in science and technology necessary to handle such waste;
c. all countries concerned give their consent to the transit of radioactive waste;
d. the importer and the exporter of the radioactive waste consignment have signed a legally binding agreement that has been approved by the country of origin and stipulates that the exporter shall accept the consignment if it has to be returned.

Switzerland has the administrative and technical capacity, as well as the appropriate regulatory structure, so that it would be in a position to manage imported spent fuel or radioactive waste in a manner consistent with the Convention.

In recent years Switzerland has occasionally issued authorisations to import radioactive waste originating from maintenance or decontamination of equipment from swiss nuclear power plants in Installations outside Switzerland. These authorisations where issued under the Nuclear Energy Act, and the resulting secondary waste is regarded as Swiss waste as it originated from maintenance of Swiss equipment.

I.1.4 Meeting the Requirements for State of Destination (Clause iv)

In so doing, a Contracting Party which is a State of origin shall authorise a transboundary movement only if it can satisfy itself in accordance with the consent of the State of destination that the requirements of Clause iii are met prior to transboundary movement.

According to the Nuclear Energy Act, a licence is required for the export of radioactive waste. The conditions are explained in detail therein (see I.1.1). They ensure that the requirements of Article 27 Paragraph 1 Clause iv of the Convention are fulfilled.

I.1.5 Re-entry in Case of Non-Conformity (Clause v)

In so doing, a Contracting Party which is a State of origin shall take the appropriate steps to permit re-entry into its territory, if a transboundary movement is not or cannot be completed in conformity with this Article, unless an alternative safe arrangement can be made.

The Nuclear Energy Act explicitly requires a binding agreement between the exporter and the importer concerning the re-entry into Switzerland, if necessary, of radioactive waste to be exported for conditioning or disposal as a condition for issuing the export licence. Wherever necessary the competent Swiss regulatory body is prepared to confirm this preparedness as, e. g., in cases where the EU Directive 2006/117/Euratom is applied.

I.2 Shipment South of Latitude 60 (Paragraph 2)

A Contracting Party shall not licence the shipment of its spent fuel or radioactive waste to a destination south of latitude 60 degrees South for storage or disposal.

In November 1990, Switzerland acceded to the Antarctic Treaty. According to Articles 5 and 6 of the treaty, the disposal of radioactive waste is prohibited in the area south of 60° South latitude.

Section J Disused Sealed Sources (Article 28)

J.1 Possession, Remanufacturing and Disposal (Paragraph 1)

Each Contracting Party shall, in the framework of its national law, take the appropriate steps to ensure that the possession, remanufacturing or disposal of disused sealed sources takes place in a safe manner.

Switzerland has expressed its commitment to the Code of Conduct on the Safety and Security of Radioactive Sources and its two Supplementary Guidance on the Import and Export of Radioactive Sources and on the Management of Disused Radioactive Sources. It regularly reports to other parties and the IAEA regarding its compliance with the Code. Handling of radiation sources requires a licence according to the Radiological Protection Act. The Federal Office of Public Health (FOPH) maintains databases enclosing information on all radioactive sources on its territory. The secure management of disused sources is enforced in the frame of the licence regime. There are several end of life options for disused sources in Switzerland. Return to supplier for reuse or recycling is the preferred option for high activity sources. Several private actors take care of specific elimination pathways and delivery as radioactive waste to the National Collection Centre for radioactive waste at PSI assures the proper management of all other waste. The costs of waste elimination are borne by the owner.

There are several provisions regarding the recovery and the restoration of appropriate control over potential orphan sources. Private companies, such as scrap metal dealers, foundries, waste incineration plants and landfills, for which the probability of detecting orphan sources is enhanced, must dispose of a measuring concept and are trained to deal with such cases. The regulatory authorities (FOPH and Suva) organise their delivery to the National Collection Centre at PSI. The state takes over expenses if no waste owner can be found.

J.2 Re-entry into Territory (Paragraph 2)

A Contracting Party shall allow for re-entry into its territory of disused sealed sources if, in the framework of its national law, it has accepted that they be returned to a manufacturer qualified to receive and possess the disused sealed sources.

There are no industrial manufacturers of sealed radioactive sources in Switzerland. Therefore, no authorisation for re-entry into Swiss territory of disused sealed sources has been applied for. Very few sealed sources in the research sector can be produced by highly specialised research centres. Switzerland would allow re-entry into its territory of such disused sealed sources. The prerequisites for such an import are set forth in the Radiological Protection Ordinance.

Section K General Efforts to Improve Safety

As outlined in the present report, the safety of spent fuel management and the safety of radioactive waste management in Switzerland are in compliance with the obligations of the Convention. There is thus no imminent need for measures to improve safety in Switzerland. However, Switzerland strives for continuing improvement of safety. In this regard, the following activities may be mentioned.

Regulatory Guidelines

Several regulatory guidelines in the field of waste management have been recently updated or are in process of revision. There are the Guidelines ENSI-B17, ENSI-G05, ENSI-G23 and ENSI-G03.

The Guideline ENSI-B17 «Operation of Interim Storage Facilities for Radioactive Waste» specifies the operation of interim storage facilities for radioactive waste. With respect to spent fuel elements assemblies, it specifies the operational aspects of dry storage in Dual Purpose Casks (DPC). In addition to the interim storage of conditioned radioactive waste, this guideline also specifies the temporary storage of decommissioned disused largescale radioactive components as well as unconditioned or partially conditioned radioactive materials. The Guideline ENSI-B17 shall be applicable for both existing and new interim storage facilities, regardless of whether the respective storage facility has its own operating license or is covered by a license held by another nuclear installation. It interred into force in February 2020.

The Guideline ENSI-G05 «Transport and Storage Casks for Interim Storage» applies to the design, manufacture and use of Dual-Purpose Casks (DPC) for the dry storage of spent fuel elements assemblies and vitrified high level waste (HLW) in interim storage facilities. This actual revision of guideline is in force since 2008. In February 2020 ENSI published the new guideline ENSI-B17 which includes all requirements of the use of DPC. Therefore, it is necessary to update the Guideline ENSI-G05. The new version of the Guideline ENSI-G05 will list all requirements to the design and the manufacturing of DPCs. The new version of the Guideline ENSI-G05 will be published in 2021.

The new Guideline ENSI-G23 «Design Principles for other Nuclear Installation» specifies the design principles for nuclear facilities other than NPP and deep geological repositories. So far only the design requirements for interim storage facilities were specified in the former ENSI-G04 Guideline, which has been replaced by the Guideline ENSI-B17. As the Guideline ENSI-B17 covers only the operation of interim storage a new guideline for the corresponding design requirements has been necessary. Furthermore, it has become apparent during supervision that the requirements for the design of the other nuclear facilities (not only for interim storage facilities) must be clarified in detail and specifically defined, as the existing corresponding requirements for NPPs are not always or only partly transferable to them. The Guideline ENSI-G23 will be published in 2022.

The Guideline ENSI-G03 «Specific design principles for deep geological repositories and requirements for the safety case» specifies the applicable protection objective and protection criteria and the requirements for the design, operation and long-term safety applying to a deep geological repository. The guideline in force since 2009 is currently updated in view of the up-coming general license application for geological repositories in Switzerland (see section B.2). In addition, the IAEA Safety Standard SSR-5 «Disposal of Radioactive Waste» (2011) and the WENRA Safety Reference Levels of the Report «Radioactive Waste Disposal Facilities Safety Reference» (22 December 2014) have been considered for this update. The new version of the Guideline ENSI-G03 «Deep geological repositories» is supposed to come into force by the end of 2020.

New interim storage facility at PSI

In order to extend the storage capacity of non-nuclear radioactive waste (e.g., from medicine, industry and research) the Paul Scherrer Institute (PSI) plans to build a new interim storage facility beside the existing Federal Interim Storage Facility (BZL). In June 2014, PSI submitted the application for the construction and operation licence. After the description of the project and the safety analysis report have been reviewed and approved by the authorities (ENSI's advisory opinion was published in July 2017), the licensing authority (DETEC) granted the construction license in September 2018.

The new interim storage facility has been applied for as a nuclear installation with low hazard potential. For this reason, the capacity of the facility continues to be limited by the maximum permissible amount of radioactivity, regardless of the volume of waste and the number of containers.

Activities with respect to transport dual purpose casks after long-term storage

Addressing long-term storage of spent fuel, ENSI has finished a two-year regulatory project in 2015/2016. As a result, actions were identified in the fields of package components, spent fuel properties and procedures in the surface facility of the deep geological repository as well as general aspects such as licensing or knowledge management.

Implementing these actions, ENSI has adapted its licensing process: Instead of only validating foreign transport package design approvals, ENSI issues own approvals to get the complete access to the design justifications relevant to ageing. In addition, approvals for dual purpose cask (DPC) designs for interim storage facilities include a periodical review requirement any ten years to address ageing effects. Getting the full control of the package design approval review process for both, transport and storage, assure ENSI to establish a rather comprehensive ageing surveillance program for DPC and to evaluate significant results with respect to the safety justifications for transport and storage. The regulatory framework has been competed with the amendment of the guideline ENSI-B17 related to the operation of storage facilities, now including ageing surveillance requirements. To support the operators implementing a comprehensive ageing management and providing corresponding safety justifications of DPC, ENSI has published an ageing guide for dry interim storage, which is now available in three languages (English, German and French) ((http://www.ensi.ch «Documents» → «Other documents» → «Ageing Guide for Dry Interim Storage»). The guide defines the process of the periodical design review and the necessary justifications to demonstrate continuous compliance with the underlying transport and storage approvals. The required justifications cover ageing effects of cask components and cladding material as well as the decay of the radioactive content and organisational changes.

The operators have introduced a collaborative process for safety justifications with respect to ageing including gap analysis and evaluations considering existing approvals. Additionally, they have provided a roadmap for the periodical review of the already stored DPCs. Another focus has been put on technical issues such as developing ageing surveillance techniques as well as comprehensive documentation review and ageing specific justification methods.

International review missions

In 2018, ENSI hosted an International Physical Protection Advisory Service (IPPAS) Mission. Amongst other things, the IPPAS mission recommended that ENSI expands its regulatory cyber security requirements for nuclear installations. Further recommendations relate, amongst other things, to the development of a process for determining the unacceptable radiological consequences of an act of sabotage, the interfaces between nuclear security and safeguards, plus the use of the Design Basis Threat for the definition of realistic sabotage scenarios.

Switzerland also took part, on a voluntary basis, in the Topical Peer Review Process which started in 2017 according to the EU Nuclear Safety Directive 2014/87/EURATOM. The first Topical Peer Review focused on the overall ageing management programs implemented in the NPPs as well as on insights gained from specific ageing supervision programs.

In April 2015, an International Regulatory Review Service (IRRS) follow-up mission was conducted in Switzerland. The mission concluded that the four recommendations and 16 suggestions for which ENSI was primarily responsible have been implemented but that the Swiss government should give ENSI, as the technical nuclear safety authority, the ability to issue legally binding technical safety requirements and licence conditions on nuclear safety, nuclear security and radiation safety. The IRRS mission report was published on the ENSI website. Also, an OSART follow-up mission to the Mühleberg NPP was completed in June 2014. Switzerland participated in the European Stress Test and its follow-up activities. Furthermore, in December 2013, Switzerland tabled a proposal to amend Article 18 of the Convention on Nuclear Safety and contributed actively to the development of the Vienna Declaration on Nuclear Safety which resulted from the ensuing Diplomatic Conference.

ENSI is currently preparing for the next IRRS mission, which will take place in October 2021 in Switzerland.
Every Swiss NPP is a WANO member. Since 2005, all Swiss NPPs have been involved in the WANO peer review process. The cycle for WANO peer reviews and WANO follow-up missions is about six years, i. e. the NPPs are involved in either a WANO peer review or a WANO follow-up mission every two to three years.
All Swiss NPPs underwent OSART missions, including follow-up missions. No further OSART missions are planned in Switzerland for the time being. This is also because the Swiss NPPs are regularly involved in the WANO peer review process (see above).

Openness and transparency

National Reports of Switzerland on the Joint Convention also serve as an information source for other purposes. They provide comprehensive information on the safety of spent fuel management and on the safety of radioactive waste management in a clearly arranged manner. All Swiss Reports on the Joint Convention and the results of the review are publically available on ENSI's website (http://www.ensi.ch «Documents» → «Conventions»):

Safety Culture

The Swiss Federal Nuclear Safety Inspectorate (ENSI) is convinced that the establishment of a good safety culture needs room and time to develop. Cultural values inside an organisation are influenced by its people with their values, world views and behaviours (see a more detailed description of the ENSI position towards Safety Culture in the Oversight of Safety Culture in Nuclear Installations (http://www.ensi.ch «Documents» → «Strategy Documents» → «Oversight of Safety Culture in Nuclear Installations»).
Operating plants with a general licence are under the supervision of ENSI. Safety culture is subject to the regular supervision. The «specialist discussions promoting a dialogue on safety culture» is a well-established instrument for reflecting this topic. These dialogues represent a particular type of interaction with the supervised parties, different from «classical» oversight activities, aimed at promoting self-reflection and exchange on values and world views, the deeper elements of an organisation's (safety) culture.
Although the project of deep geological disposal of radioactive waste in Switzerland is still years from the submission of a request for a general licence or having a site being operated, ENSI contacted the National Cooperative for the Disposal of Radioactive Waste (Nagra) and started at this early stage a dialogue to get an insight into its understanding and implementation of its values of safety culture.
It is to mention, that the legislative framework does not support a formal approach from the national authority before the submission of a request for a general licence for building and operating a deep geological disposal of radioactive waste. Nevertheless, ENSI took the initiative to set up a dialogue and Nagra welcomed this voluntarily. After the first couple of meetings, Nagra judged the exchange valuable for their reflection on safety culture and agreed to continue this dialogue in the future on a regular base.

Section L Annexes

L.1 List of Abbreviations

ADR	European Agreement concerning the International Carriage of Dangerous Goods by Road
ADN	Accord européen relatif au transport international des marchandises dangereuses par voies de navigation intérieures
AGNEB	Interdepartmental Working Group on Radioactive Waste Management
ALARA	As low as reasonably achievable
ATA	Alpha-toxic waste
BWR	Boiling water reactor
BSTB	The Federal Civil Protection Crisis Management Board
BZL	Federal Interim Storage Facility at PSI for all non-nuclear radioactive waste originating from medicine, industry and research
DETEC	Federal Department of the Environment, Transport, Energy and Communications
DPC	Dual purpose cask
DSK	German-Swiss Commission for the Safety of Nuclear Installations
EGT	Expert Group on Radioactive Waste Disposal
ENSI	Swiss Federal Nuclear Safety Inspectorate (Eidgenössisches Nuklearsicherheitsinspektorat), Swiss regulatory body as from 1 January 2009
ETH	Swiss Federal Institute of Technology
FOE	Federal Office of Energy
FOEN	Federal Office for the Environment
FOPH	Federal Office of Public Health
HLW	High-level waste
HSK	Swiss Federal Nuclear Safety Inspectorate (Hauptabteilung für die Sicherheit der Kernanlagen), Swiss regulatory body until 31 December 2008
IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organisation
ICRP	International Commission on Radiation Protection
ILW	Intermediate-level waste
ISRAM	Information System for Radioactive Materials
L/ILW	Low- and intermediate-level waste
LLW	Low-level waste
Nagra	National Cooperative for the Disposal of Radioactive Waste
NEOC	National Emergency Operations Centre
NPP	Nuclear power plant
NSC	Swiss Federal Nuclear Safety Commission
OECD	Organisation of Economic Co-operation and Development
PSI	Paul Scherrer Institute at Villigen and Würenlingen
PWR	Pressurised water reactor
QM	Quality management
RID	Regulations concerning the International Carriage of Dangerous Goods by Rail
SFP	Spent fuel pools
Suva	Swiss National Accident Insurance Fund
SVTI	Swiss Association for Technical Inspections
WENRA	Western European Nuclear Regulators' Association
ZWIBEZ	Interim storage facility at Beznau NPP
Zwilag	Company that owns and operates ZZL
ZZL	Central Interim Storage Facility at Würenlingen

L.2 References to National Laws and Regulations

L.2.1 Legislation (Acts and Ordinances)

Acts

The main legal provisions for authorisations and regulation, supervision and inspection are based on the following legislation:

- Nuclear Energy Act of 21 March 2003, RS 732.1.
- Swiss Federal Nuclear Safety Inspectorate Act of 22 June 2007, RS 732.2.

- Federal Act of 7 October 1983 on the Protection of the Environment, RS 814.01.
- Federal Act of 24 January 1991 on the Protection of Waters, RS 814.20.
- Radiological Protection Act of 22 March 1991, RS 814.50.

Ordinances

There are a number of federal ordinances (lower level of legislation) of relevance to nuclear energy legislation. The most important are as follows:

- Ordinance on Alerting the Authorities and the Public of 18 August 2010, RS 520.12.
- Ordinance on the Federal Civil Protection Crisis Management Board of 2 March 2018, RS 520.17.
- Ordinance on the National Emergency Operations Centre of 17 October 2007, RS 520.18.
- Nuclear Energy Ordinance of 10 December 2004, RS 732.11.
- Ordinance on Hazard Assumptions and the Assessment of the Protection against Accidents in Nuclear Installations of 17 June 2009, RS 732.112.2.
- Ordinance on the Methodology and the General Conditions for Checking the Criteria for the Provisional Shutdown of Nuclear Power Plants of 16 April 2008, RS 732.114.5.
- Ordinance on the Requirements for the Personnel of Nuclear Installations of 9 June 2006, RS 732.143.1.
- Ordinance on the Federal Nuclear Safety Commission of 12 November 2008, RS 732.16.
- Ordinance on the Decommissioning and Waste Management Funds for Nuclear Installations of 7 December 2007, RS 732.17.
- Ordinance on the Swiss Federal Nuclear Safety Inspectorate ENSI of 12 November 2008, SR 732.21.
- Ordinance on Emergency Preparedness in the Vicinity of Nuclear Installations of 14 November 2018, RS 732.33.
- Radiological Protection Ordinance of 26 April 2017, RS 814.501.
- Ordinance on Iodine Prophylactics in the Case of a Nuclear Accident of 22 January 2014, RS 814.52.
- Ordinance on the Use of Radioactive Materials of 26 April 2017, RS 814.554.
- Ordinance on the Collection of Radioactive Waste of 26 April 2017, RS 814.557.

L.2.2 List of the Inspectorate's (ENSI) regulatory guidelines

Status: September 2020

Languages:

- All regulatory guidelines are originally written in German. Some guidelines have been translated into French (f) and English (e) for information purposes only. In the event of any discrepancies, the German version prevails.

Note:

- Non-classified regulatory guidelines are available on the ENSI website («Documents» → «Guidelines»).
- Guidelines of the series A cover the assessment of facilities, guidelines of the series B cover the surveillance of operations, and guidelines of the series G are guidelines with general requirements, which cover both the assessment of facilities and surveillance operation. With the exception of the Guideline HSK-R-46, guidelines of the series R were issued before the Nuclear Energy Act and the Nuclear Energy Ordinance entered into force in February 2005.
- Regulatory guidelines in the field of physical protection and computer security are not listed.

Guideline	Title of guideline	Date of current issue
ENSI-G01	Safety Classification for Existing Nuclear Power Plants	2011/1
ENSI-G02	Design principles for Operational Nuclear Power Plants	2019/8
ENSI-G03/e	Specific Design Principles for Deep Geological Repositories and Requirements for the Safety Case	2009/4
ENSI-G05	Transport and Storage Casks for Interim Storage	2008/4
ENSI-G07/e/f	The Organisation of Nuclear Installations	2013/7
ENSI-G08	Systematic Safety Assessments for the Operation of Nuclear Installations	2015/6
ENSI-G09/e	Operational Documentation	2019/8
ENSI-G11	Safety Classified Vessels and Pipework: Engineering, Manufacture and Installation	2013/6
ENSI-G13	Measuring Instruments for Ionising Radiation	2018/11
ENSI-G14/f	Calculation of Radiation Exposure in the Vicinity due to Emission of Radioactive Substances from Nuclear Installations	2009/12
ENSI-G15/f	Radiation Protection Objectives for Nuclear Installations	2010/11
ENSI-G17/e/f	Decommissioning of Nuclear Installations	2014/4
ENSI-G20/e	Reactor Core, Fuel Assemblies and Control Rods: Design and operation	2015/2
ENSI-A01/e	Technical Safety Analysis for Existing Nuclear Installations: Scope, Methodology and Boundary Conditions	2018/9
ENSI-A03/e	Periodic Safety Review of Nuclear Power Plants	2014/10
ENSI-A04	Application Documents for Modifications to Nuclear Installations Requiring a Permit	2016/4
ENSI-A05/e	Probabilistic Safety Analysis (PSA): Quality and Scope	2019/3
ENSI-A06/e	Probabilistic Safety Analysis (PSA): Applications	2015/11
ENSI-A08/f	Analysis of Source Terms: Extent, Methodology and Boundary Conditions	2010/2
ENSI-B01	Ageing Management	2011/8
ENSI-B02	Periodic Reporting by the Nuclear Installations	2015/6
ENSI-B03	Reports by the Nuclear Installations	2016/11
ENSI-B04	Release of Controlled and Surveillance Areas, and of Materials from the Requirement for Authorisation and Supervision	2018/11
ENSI-B05	Requirements for the Conditioning of Radioactive Waste	2018/12
ENSI-B06	Safety Classified Vessels and Pipework: Maintenance	2013/6
ENSI-B07	Vessels and Piping Classified as Important to Safety: Qualification of non-destructive Testing	2008/9
ENSI-B09	Determining and Recording the Doses of Persons Exposed to Radiation	2018/7
ENSI-B10/e	Basic Training, Recurrent Training and Continuing Education of Personnel in Nuclear Installations	2010/10
ENSI-B11/f	Emergency Exercises	2015/12
ENSI-B12/f	Emergency Protection in Nuclear Installations	2019/8
ENSI-B13/f	Training and Continuing Education of the Radiation Protection Personnel	2010/11
ENSI-B14	Maintenance of Electrical and Instrumentation and Control Equipment Classified as Important to Safety	2010/12
ENSI-B17	Operation of interim storage facilities for radioactive waste	2020/1
HSK-R-07	Guideline for the Radiological Monitored Area of the Nuclear Installations and the Paul Scherrer Institute	1995/6
HSK-R-08	Structural Safety for Nuclear Power Plants, Swiss Federal Supervising Procedures for Construction Work	1993/1
HSK-R-46	Requirements for the Application of Computer-based Instrumentation and Control Important to Safety in Nuclear Power Plants	2005/4
HSK-R-50	Requirements Important to Safety for Fire Protection in Nuclear Installations	2003/3
HSK-R-102	Design Criteria for the Protection of Safety Equipment in Nuclear Power Stations against the Consequences of Airplane Crash	1986/12

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