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Inspection fédérale de la sécurité nucléaire IFSN
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Swiss Federal Nuclear Safety Inspectorate ENSI

Implementation of the obligations of the

Convention on Nuclear Safety

CNS

6th National Report of Switzerland in Accordance with Article 5 of the Convention

August 2013

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in Accordance with its Article 5

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Foreword

Switzerland signed the Convention on Nuclear Safety (CNS) on 31 October 1995. It ratified the Convention on 12 September 1996, which came into force on 11 December 1996. In accordance with Article 5 of the Convention, Switzerland has prepared and submitted the country reports for the regular Review Meetings of Contracting Parties organised in 1999, 2002, 2005, 2008, 2011 and for the Extraordinary Meeting in 2012. These meetings at the IAEA headquarters in Vienna were attended by a Swiss delegation.

This 6th report by the Swiss Federal Nuclear Safety Inspectorate (ENSI or the Inspectorate) provides an update on compliance with CNS obligations. In addition, the report gives consideration to issues that aroused particular interest at the 5th Review Meeting and at the 2012 Extraordinary Meeting dedicated to the consequences of the accident at Fukushima Daiichi.

The report starts with general political information on Switzerland, a brief history of nuclear power and an overview of Swiss nuclear facilities. The section "Summary and Conclusions" provides an overview of the contents of the report and its conclusions on the degree of compliance with the obligations of the Convention. This is followed by a comprehensive overview of the status of nuclear safety in Switzerland (as of March 2013). The numbering in the report follows that of the CNS Articles 6 – 19. The comments for each section indicate clearly how Switzerland complies with the key obligations of the Convention.

The technical issues related to the Fukushima accident, arising from the Extraordinary Meeting in 2012, are incorporated under the appropriate articles. A subsection of the Summary & Conclusion gives an overview on how these issues were dealt with, providing direct references to the specific articles of the National Report where more details can be found. Annex 1 describes how the IAEA Action Plan on Nuclear Safety is implemented by Switzerland. Annex 4 contains a list of abbreviations used in the text, and Annex 5 provides a list of ENSI's guidelines currently in force.

Introduction

Country and State

Switzerland is located in the middle of Europe and is surrounded by France to the west, Germany to the north, Austria and Liechtenstein to the east and Italy to the south. With a total surface area of 41,285 km^2 – more than half of which are mountainous – and a population of 8.0 million, Switzerland is a small, densely populated country. The Rhine, Rhone and Inn rivers originate in the Swiss Alps. Switzerland has four official languages: German, French, Italian and Rhaeto-Romanic, the latter being spoken only by some 0.5% of the Swiss population. About 20% of current residents are foreign nationals.

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. At each level, a significant number of political rights are guaranteed to the people. All other legislative power remains with the cantons, which retain therefore a high degree of autonomy. Municipalities and communities also enjoy considerable rights of self-government.

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 vote 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. 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.

In 2011, Gross Domestic Product in Switzerland per capita was approximately CHF 74,000 (EUR 60,000). The most important economic sectors are banking, tourism, machinery manufacture, chemical and pharmaceutical industry, foodstuffs, watches and medical technology. Its major export partners are Germany, USA, China, Italy, France, the United Kingdom and Japan.

Total energy consumption in Switzerland was about 852'000 TJ in 2011. Electricity consumption accounts for about 25% of energy consumption. The main sources of electricity in Switzerland are hydroelectric (2011: 54%) and nuclear power (41%).

Background of nuclear power in Switzerland

Until the late 1960s, Switzerland generated electricity exclusively from hydro power and did not resort to fossil fuels as the latter was not available as a natural resource in Switzerland. By the mid-1950s, there was interest in the use of the relatively new nuclear energy technology in order to cover the increasing demand for power. In accord with the general policy on electricity production, it was left to the private sector to promote and use nuclear energy. However, it was recognised that any nuclear programme would require a legislative framework to ensure safety and radiation protection. It was also recognised that such legislation should be exclusively at the federal level. As a result, 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, Switzerland enacted a new Nuclear Energy Act and its related ordinance 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 NPPs must be subject to a facultative national referendum. In addition, the Federal Government was given full legal responsibility for geological waste repositories.

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 operating units, which were commissioned between 1969 and 1984. Two projects were cancelled.

Licensing procedures for three new units on existing sites were on-going in Switzerland before the events at Fukushima occurred. ENSI was involved in the procedures and had issued the three safety evaluation reports related to siting, which focused on the hazard reassessments on a site-specific basis. Shortly after the Fukushima accident, the Federal Council suspended these procedures. 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, although the existing plants should continue to operate as long as they can do so safely.

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.

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 CNS. 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 also formally independent of the Swiss Federal Office of Energy.

This was achieved on 1 January 2009 when ENSI became an 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.

Nuclear power plants

Switzerland has four Nuclear Power Plants (NPPs) (one double-unit NPP) – Beznau I and II, Mühleberg, Gösgen and Leibstadt. They are located at four different sites and have four different reactor and containment designs, which were delivered by three different reactor suppliers (Westinghouse, General Electric and Kraftwerk Union). Local suppliers contributed to civil engineering, buildings and mechanical and electro-technical equipment. The NPPs are operated by the following companies:

Beznau I&II	Axpo Power AG
Mühleberg	BKW AG
Gösgen	Kernkraftwerk Gösgen-Däniken AG
Leibstadt	Kernkraftwerk Leibstadt AG

The main technical characteristics of the Swiss NPPs are summarised in Table 1.

Table 1: Main technical characteristics of the Swiss NPPs (as of March 2013)

	First generation NPPs			**Second generation NPPs**	
	Beznau I	Beznau II	Mühleberg	Gösgen	Leibstadt
Licensed thermal power Pth [MWth]	1130	1130	1097	3002	3600
Nominal net electrical power Pel [MWel]	365	365	373	985	1220
Reactor type	PWR	PWR	BWR	PWR	BWR
Containment type	Large dry, free standing steel inside concrete building	Large dry, free standing steel inside concrete building	Pressure suppression, Mk I inside concrete building	Large dry, free standing steel inside concrete building	Pressure suppression, Mk III inside concrete building
Normal heat sink	River Aare	River Aare	River Aare	Wet cooling tower (River Aare)	Wet cooling tower (River Rhine)
Number of reactor coolant pumps	2	2	2	3	2
Number of turbine sets	2	2	2	1	1
Number of fuel assemblies	121	121	240	177	648
Fuel	UO2 (+MOX until outage 2013)	UO2	UO2	UO2	UO2
Number of control assemblies	25	25	57	48	149
Reactor supplier	W	W	GE	KWU	GE
Turbine supplier	BBC	BBC	BBC	KWU	BBC
Site Licence	1964	1967	1965	1972	1969
Construction licence	1964	1967	1967	1973	1975
First operating licence	1969	1971	1971	1978	1984
Commercial operation	1969	1971	1972	1979	1984
Backfitted bunkered automatic ECCS and residual heat removal system since:	1993	1992	1989	Included in the original design	Included in the original design
Filtered containment venting system since:	1993	1992	1992	1993	1993

Abbreviations

Mk I, Mk III	GE Containment Types Mark I and Mark III
PWR	Pressurised Water Reactor
BWR	Boiling Water Reactor
W	Westinghouse Electric Corporation
GE	General Electric Technical Services Corporation
KWU	Siemens Kraftwerk Union AG (now Areva NP)
BBC	Brown Boveri & Cie, AG (now Alstom)
UO2	Uranium oxide
MOX	Mixed oxide
ECCS	Emergency core cooling system

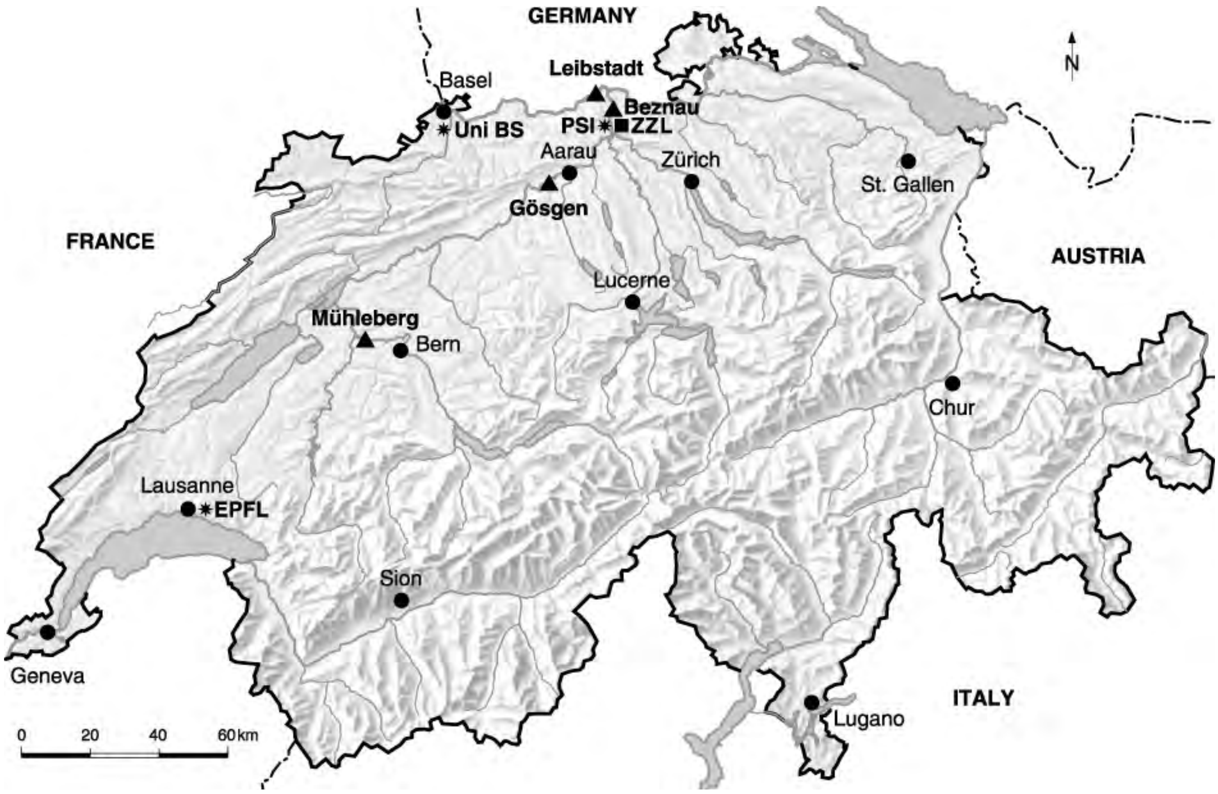


Figure 1: Geographic location of Swiss nuclear facilities. Triangles mark the NPP sites. Asterisks mark experimental and research installations. Squares mark facilities for nuclear waste management. The dots are major cities.

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 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.

Facilities for nuclear education, research and development

Most nuclear research in Switzerland is performed at the Paul Scherrer Institute (PSI). Research at PSI is conducted in collaboration with other national and international research institutes and the industry. It covers the following areas: elementary particle physics, biological sciences including radiation protection, solid state research and material science, nuclear energy research, non-nuclear energy research and environmental research related to energy production, medical research and medical treatment (oncology).

Several nuclear installations are located at the PSI site, of which the Hot Laboratory is the most important in terms of nuclear safety. The research reactors DIORIT and SAPHIR are in an advanced state of decommissioning, the research reactor PROTEUS has been finally shut down; the application documents for its decommissioning are in preparation. Finally, there are two small research reactors (P < 2 kWth) used mainly for teaching purposes at the University of Basel and the Swiss Federal Institute of Technology in Lausanne.

Processing and interim storage of nuclear waste

Swiss legislation requires immediate conditioning of radioactive waste from nuclear installations except for technical optimisation in periodic conditioning campaigns. Consequently, each NPP is equipped with facilities for waste conditioning and interim storage. On-site facilities for storage of spent fuel are located at the Beznau site (dry storage, also for waste) and at the Gösgen NPP (wet storage, spent fuel elements only). Both facilities started operation in spring 2008.

In addition to the on-site facilities, a centralized storage and conditioning facility (Zentrales Zwischenlager ZZL), owned by ZWILAG, is located adjacent to the PSI campus. This facility provides interim storage capacity for spent fuel, intermediate and low-level radioactive waste. Any return waste from the reprocessing of Swiss spent fuel in La Hague and Sellafield is stored here. The facility also contains installations for the conditioning of specific waste categories and the incineration or melting of low-level waste. The Central Interim Storage Facility started active operation in June 2001.

PSI operates the national collection centre for all institutional radioactive waste: waste from medicine, military applications, industry and research. This waste can be treated either at PSI installations or at the ZWILAG, followed by interim storage at the Federal Interim Storage Facility, which is also located on the premises of PSI.

Current status of the process to select sites for geological repositories

In accordance with the Nuclear Energy Act, in 2008 Switzerland started a process to select sites for the disposal of radioactive waste in deep geological formations. This process is coordinated by the Swiss Federal Office of Energy and accords with current legislation on spatial planning. Safety has the highest priority in the site-selection process, but the process also considers socio-economic issues. The site selection procedure was subject to broad public consultation in 2007, not only in Switzerland but in neighbouring countries as well, before the Federal Council (federal government) approved the site selection concept.

Site selection is based on a staged approach, currently expected to end by 2022. Stage 1, finished in 2011, led to the identification of three suitable regions for the siting of the high-level waste (HLW) repository and six suitable regions for the siting a low- and intermediate-level waste (L/ILW) repository. Selection was based on safety criteria defined by the regulatory authority. Stage 2, which started in 2011, will lead to the identification of at least two potential repository sites for each category within the previously identified siting regions. For this selection, each of the site regions will be compared to the others on the basis of a proposed site for a surface facility, a choice of access facilities (shafts and/or ramps) and a proposed underground site region, which then will be evaluated by a provisional safety assessment. Socio-economic factors, e.g. during the choice for a suitable surface facility site, are taken into account at this stage. Stage 3 will focus on a detailed investigation of sites still under consideration, including drilling activities and a detailed safety analysis for each selected site. A definitive site will be chosen at the end of this stage.

Each stage concludes with a broad public consultation process in both Switzerland and neighbouring countries. Statements submitted to this public consultation process are summarized and answered in a specific consultation report. The site-selection process will end with approval by the Federal Council of the selected sites (HLW and L/ILW, respectively). This will be followed by the general licensing procedure specified in the nuclear energy legislation. The Federal Council will grant the general licence, which will require approval by the Swiss Parliament. Parliamentary approval is also subject to a facultative national referendum. Currently, it is expected that the repository for L/ILW will become operational in 2035, whereas the repository for HLW will become operational after 2045.

Summary and Conclusions

In the aftermath of the Fukushima Daiichi accident, the Swiss government has decided to phase out nuclear energy; existing plants will continue to operate as long as they are safe. As a result, the Swiss activities for the current reporting period can be summarised in the following points:

Safe Operation of existing plants:

- In Switzerland, on-going activities regarding safety assessment of the different stages in the lifetime of nuclear installations consist of periodic assessments and assessments of long-term operation for existing Swiss NPPs. Assessments of long-term operation (LTO) have been performed for two Swiss NPPs which have been in commercial operation for over 40 years. A detailed examination demonstrated that the conditions for the taking out of service of an NPP are not and will not be reached by these two plants (Beznau NPP and Mühleberg NPP) within the next 10 years. Nevertheless, it is mandatory to continue with the scheduled ageing management, maintenance and backfitting activities.

Post Fukushima Actions:

- ENSI analysed the accident in Fukushima Daiichi and produced four relevant reports between August and December 2011 (ENSI Report on Fukushima I: Chronology; ENSI Report on Fukushima II: Human and Organisational Factors; ENSI Report on Fukushima III: Lessons Learned; ENSI Report on Fukushima IV: Radiological Effects).
- ENSI issued orders for reassessments on the design of the Swiss NPPs against earthquakes, external flooding and a combination thereof.
- Orders for the conduct of investigations on the coolant supply for the safety systems and the spent fuel pool cooling of Swiss NPPs were issued.
- ENSI drafted a National Action Plan, called "Action Plan Fukushima", in which all measures and backfittings related to the Lessons Learned from the Fukushima Daiichi accident are described and by which these are being implemented and monitored in Switzerland.
- An external emergency storage facility for the Swiss NPPs, containing various operational resources for emergencies, was established.
- Various activities related to the review of emergency preparedness measures in case of extreme events in Switzerland are currently under way.

Organisational and regulatory framework:

- To reflect changed requirements, ENSI's organisational structure has been adapted.
- Relevant guidelines of the Inspectorate were revised.

International peer reviews and cooperation:

- In November 2011, an IRRS Mission was conducted in Switzerland. The results of the mission are currently being implemented. It is planned to have an IRRS Follow-Up Mission in 2015.
- In October 2012, an OSART Mission to the Mühleberg NPP was completed.
- Switzerland participated in the European Stress Test and its Follow-Up activities.
- Switzerland took part in the 2nd Extraordinary Meeting of the CNS and tabled various proposals to amend the Convention.

Summary of the detailed answers to Articles 6 – 19 of the Convention

Article 6 – Existing nuclear installations

The general safety level of Swiss NPPs is high. The first generation of NPPs in Switzerland (Beznau units I and II and Mühleberg) – which started operation in the late 1960s and early 1970s – has been the subject of progressive backfitting following major developments in NPP safety technology as well as in response to the Fukushima accident. First-generation NPPs have been the subject of regular safety reviews. Licences for their continued operation were granted on the basis of these reviews. In December 2012, the Inspectorate published its review report on the long-term operation of the Mühleberg NPP. The Mühleberg NPP intends to carry out the backfits ordered on the basis of Fukushima and those required for the purposes of long-term operation within the overall DIWANAS project. The second generation of NPPs (Gösgen and Leibstadt) incorporated various safety and operating improvements in their initial design, but all Swiss NPPs have conducted substantial backfits since commissioning.

All Periodic Safety Reviews PSRs conducted in Switzerland were reviewed in depth by the Inspectorate. The final review reports of the Inspectorate are available on the Inspectorate's website (www.ensi.ch).

After the Fukushima accident, additional safety reviews were performed. All Swiss NPPs were required to back-fit two additional external feed options to resupply spent fuel pools with coolant. An external storage facility at Reitnau has been in place since June 2011, containing various operational resources for emergencies that can readily be called up. Mobile accident management equipment stored on-site has been significantly upgraded. In conclusion, all Swiss NPPs have undergone the safety review process required under the Convention and have incorporated the improvements identified in the respective safety review reports. The Swiss policy of continuous improvement to NPPs based on the current state of the art of science and technology ensures a high level of safety.

Article 7 – Legislative and regulatory framework

The legislation and regulatory framework for nuclear installations is well established in Switzerland. It provides the formal basis for the supervision and the continuous improvement of nuclear installations. The main legal provisions for authorisations and regulation, supervision and inspection are regulated in the Nuclear Energy Act, the Nuclear Energy Ordinance, the Radiological Protection Act and the Radiological Protection Ordinance. The Nuclear Energy Act and its ordinance came into force in 2005. Safety requirements and regulations are detailed in more than 40 regulatory guidelines of the Inspectorate, covering all aspects of the lifetime of an NPP, i.e. operation and decommissioning, nuclear waste, transport and disposal, as well as radiation protection and emergency preparedness. The Nuclear Energy Act also provides for inspections and safety assessments performed by the Inspectorate, and for the enforcement of applicable regulations and the terms of the licence. The Nuclear Energy Act and the Nuclear Energy Ordinance are well established. Due to the Swiss Government's decision to phase out nuclear, the Nuclear Energy Act is currently under revision, to enshrine the phase out into law. New guidelines issued by the Inspectorate have also been introduced. By involving the stakeholders in the procedure of issuing guidelines (especially hearings) and publishing guideline drafts for public comments, the regulatory process is transparent. Furthermore, each new regulatory guideline includes the related international WENRA and IAEA requirements.

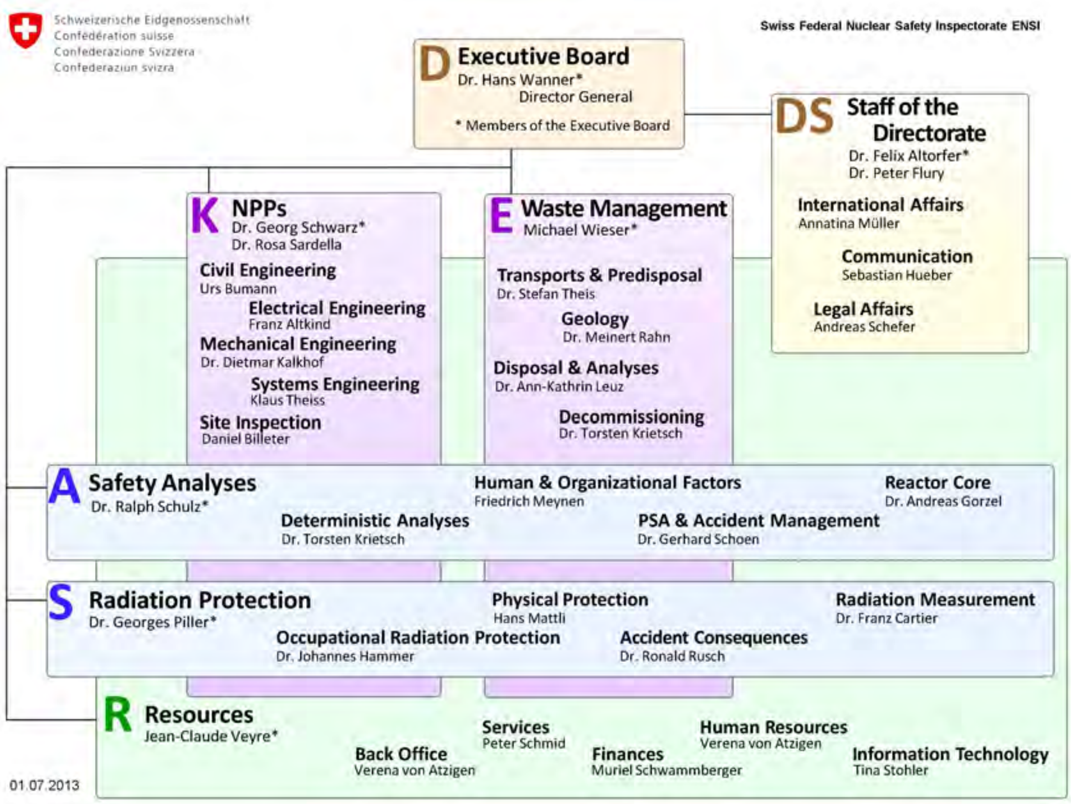
Article 8 – Regulatory body

The Federal Council (federal government) grants general licences. The Department of Environment, Transport, Energy and Communication grants construction licences and operating licences for nuclear facilities. The Swiss Federal Nuclear Safety Inspectorate ENSI is the supervisory authority for nuclear safety including radiological protection and nuclear security.

The responsibilities and tasks of the Inspectorate have increased in the last 25 years and so the workforce has gradually increased to about 145, including more than 100 specialists in reactor safety, radiation protection, waste management, etc. In addition, its structure has been adapted to reflect changed requirements. After the accident in Fukushima, ENSI created a Division called "Staff of the Directorate". In this Division, three sections are responsible for communication, law and international affairs to support the executive management of ENSI in its daily activities.

The Inspectorate is fully independent of organisations concerned with the promotion or utilisation of nuclear energy and the licensing of NPPs. It was made independent of the Federal Office of Energy on 1 January 2009 and is controlled by its own strategic board (ENSI board) and has its own budget.

The Inspectorate uses a processoriented management system, which was first awarded ISO 9001 certification in December 2001. In November 2007, it was also awarded ISO 14001 certification (environmental management). The accreditation of the inspection activities according to ISO/IEC 17020:2012 is on-going and clearly scheduled. The management system applies to all relevant activities and is subject to continuous improvement based on management reviews, international expert missions (the last IRRS Mission to the Inspectorate took place in November 2011), evaluation of performance indicators, internal audits and routine checks by the certification agency. As a result, the management system of the Inspectorate



ENSI's organisational chart, as of July 2013.
Source: ENSI

is well established and provides effective support for both management and daily operations. The entire system was considered as a Good Practice in the IRRS mission of 2011.

A two-week IRRS mission visited Switzerland in November 2011. The final report of this mission is publicly available and contains 19 "Good Practices", 12 recommendations and 18 suggestions. By the end of 2012, the Inspectorate drafted an action plan that described the chosen for the suggested improvements in view of the IRRS follow-up mission which is likely to take place in 2015.

Article 9 – Responsibility of the licence holder

In Switzerland, the responsibilities of the licence holder for the safe operation of an NPP are expressly stated in the Nuclear Energy Act. Article 22 of the Swiss Nuclear Energy Act sets out the general obligations on part of the licence holder. It expressly states that the licence holder is responsible for the safety of the installation and its operation. It further details the most important duties of licence holders. Each NPP has accepted the conditions laid down for operation and a corresponding statement is included in the preamble of the operating manual for each NPP. The Inspectorate conducts inspections and technical discussions with the utilities to ensure that operators assume full responsibility for the safety of their installations. Since 2009 and 2012, the licence holders participate in technical fora chaired by the Inspectorate. In these fora, questions from the public are discussed with regards to technical safety aspects of NPPs and geological repositories.

Article 10 – Priority to safety

Safety has always been afforded the highest priority by all organisations actively involved in operating and deconstructing nuclear installations in Switzerland. To give the highest priority to safety is, by law, a general obligation of each licence holder. All licensees have implemented this obligation in their management system and it is also demonstrated by the commitment of these organisations to external comparison, peer review, and improvement. All Swiss NPPs underwent OSART missions, including the follow-up missions. The last OSART mission took place in October 2012. Since 2005, all Swiss NPPs have taken part in the WANO Peer Review Process involving a WANO Peer Review and a WANO Follow-up Mission in a regular cycle of about six years. The Inspectorate also demonstrated a commitment to peer review and improvement by hosting an IRRS mission in 2011.

Article 11 – Financial and human resources

NPP operators in Switzerland have sufficient financial resources to maintain a high level of safety throughout the lifetime of an NPP. Should an NPP no longer fulfil the regulatory safety requirements, its licence would be revoked and it would not be able to continue operating. Decommissioning and waste disposal is funded by dedicated funds.

As required by the Swiss Nuclear Energy Act, corresponding ordinances and regulatory guidelines, the installations have sufficient qualified staff capable of managing and controlling nuclear installations. In the reporting period, staffing levels were substantially increased at all Swiss NPPs.

NPP personnel receive regular education and training. Retraining is provided so that personnel keep abreast of advances in science and technology and plant modifications. All Swiss NPPs operate plant-specific fullscope replica simulators.

Article 12 – Human factors

The obligation of the licensee to establish a suitable organisation (i.e. organisational structures and processes) is firmly embedded in the Swiss legislative framework. The Nuclear Energy Ordinance sets out requirements concerning the organisation that are specified in detail in guideline “Organisation of Nuclear Power Installations”. Attention is also given to the concept of safety culture. The beforementioned guideline stipulates that the licensee has to anchor measures in its management system to observe, to assess, and to strengthen its safety culture.

The Nuclear Energy Ordinance lays down a series of NPP design principles, including a human factor principle: “Workstations and processes for the operation and maintenance of the installation must be designed so that they take account of human capabilities and their limits”. The Inspectorate pays particular attention to this principle in its oversight of plant modernisation projects.

All NPPs conduct thorough investigations of human and organisational factors whenever they are identified as the root cause or a contributing factor in events with a relevance to safety.

Article 13 – Quality assurance

All Swiss NPPs have an integrated management system and are certified under ISO 9001 (Quality Management), OHSAS 18001 (Occupational Health and Safety) and ISO 14001 (Environmental Management) norms. All NPPs have incorporated appropriate self-assessment processes in their management systems. The management systems are audited periodically by the certification institute and the certificates are renewed on a regular basis.

The Inspectorate regularly performs inspections to assess the effectiveness of quality assurance measures incorporated in the management system.

Article 14 – Assessment and verification of safety

In Switzerland, the review and assessment procedure includes an evaluation of the safety analysis report (SAR), safety-relevant systems, deterministic accident analyses, probabilistic safety analysis (PSA), reports on ageing surveillance programmes together with other safety-related documents if requested by the Inspectorate. As part of the integrated oversight approach (see below), an annual systematic assessment of nuclear safety is conducted for each NPP based on event analyses, inspection results, operator licensing reviews, safety-indicator data and information in the periodic licensee reports. The assessment of the periodic safety review (PSR) by an NPP is documented in a Periodic Safety Review evaluation report. PSRs are required every 10 years, at the latest. Plant documentation must be regularly updated, including the SAR and PSA. The licence document includes important conditions and operating requirements. The Nuclear Energy Ordinance contains a requirement for a PSA and for PSRs.

An Ageing Surveillance Programme is in place for all Swiss NPPs. This programme serves to collect information on the structures, systems and components of relevance for the monitoring of ageing and understanding ageing mechanisms in order to maintain safety margins and the safety functions of structures, systems and components throughout the life of a plant. It is a prerequisite for long-term operation.

The following additional points help to ensure that the physical state of an NPP complies with its licence:

- Modifications important to safety require a permit by the Inspectorate.
- A plant review must be carried out after each refuelling outage.
- The Inspectorate has an efficient inspection programme in place in order to verify compliance with licensing requirements.

The Inspectorate adopts an integrated oversight approach. To obtain a realistic picture of the safety of each installation, the Inspectorate operates a systematic safety assessment system. Safety relevant information is structured in such a way that there is a distinction between the individual safety provisions as defined in plant documents and their real state and behaviour, together with a distinction in terms of technical and human-organisational aspects. Every piece of data is assigned to fundamental safety functions and to levels of defence in depth and barriers.

The data for each NPP is summarised in a table. Inspection findings, operator licensing reviews, event analysis results, safety-indicator data and information in the periodic licensee reports are evaluated annually as part of the integrated oversight process.

Immediately after the reactor accidents at the Fukushima Dai-ichi NPP, ENSI initiated measures to review the safety of Switzerland's nuclear power plants. These measures were contained in four formal orders issued by ENSI. The first three formal orders (dated 18 March, 1 April and 5 May 2011) called for immediate measures and supplementary analyses. The immediate measures comprised the construction of a joint external emergency storage facility for the Swiss nuclear power plants, including the necessary plant-specific hook-up points for Accident Management (AM) equipment, and backfits to provide external injection into the spent fuel pools. The additional reassessments focused on the design of the Swiss nuclear power plants against earthquakes, external flooding and a combination thereof. Screening investigations were also requested regarding the coolant supply for the safety and auxiliary systems and the spent fuel pools.

In parallel with these investigations by the licensees, ENSI itself conducted topical inspections during 2011, entailing reviews of the cooling systems already in place for spent fuel pools, protection against external flooding and systems for filtered containment venting. These topical inspections were continued during 2012.

The results of ENSI's reviews confirmed that the Swiss NPPs display high levels of protection against the impacts of earthquakes, flooding and combinations thereof, and that appropriate precautions have been put in place to cope with a loss of power supply and of the ultimate heat sink. The safety case has been demonstrated for all the analysed accidents on the basis of the hazard assumptions that are currently applicable. This means that compliance with the basic statutory requirements for fulfilling the fundamental safety functions (reactivity control, cooling of the fuel elements and confinement of radioactive substances) is guaranteed. In order to continue improving safety, however, ENSI has stipulated a series of additional requirements for substantial backfits, e.g. a requirement for a flood-proof and earthquake-resistant diversified ultimate heat sink. ENSI is supervising the work carried out by the nuclear power plants to meet these requirements in the course of its ongoing supervisory activities, either by drawing up reviews, issuing permits or carrying out on-site inspections and checks.

In its fourth formal order issued on 1 June 2011, ENSI requested the licensees to take part in the EU stress tests. The results of the peer review at European level confirm ENSI's conclusions regarding the safety of Swiss NPPs. ENSI is currently implementing the two recommendations made by the peer review team for Switzerland, which relate to scenarios beyond the design basis. In addition, ENSI is participating in the follow-up work on the EU stress tests in order to track implementation of the recommended measures in Europe, and it is actively collaborating on the optimisation of the WENRA Safety Reference Levels.

Article 15 – Radiation protection

Based on the recommendations of the International Commission on Radiological Protection (ICRP), both the Radiological Protection Act and the Radiological Protection Ordinance were revised and came into force in 1994. The Inspectorate has subsequently issued revised versions of most of its relevant guidelines.

Currently, the Radiation Protection Ordinance is under revision to obtain inter alia compatibility with the new European Safety Directive, Version 24th February 2010 (final).

The supervisory and control methods currently applied by the Inspectorate are in compliance with the Convention's requirement to keep radioactive doses to the

Performing radiation control
Source: ENSI

public and the environment as low as reasonably achievable and also to keep the generation of radioactive waste associated with the use of nuclear power at the lowest possible level.

Calculated doses on the base of annual emissions for a virtual most exposed group of the population, including the exposure due to deposition from former years, have always been well below 0.2 mSv per year. Since 1994, values due to annual releases have been below 0.01 mSv per year for all Swiss NPPs.

Since 1994 (with two exceptions: an incident in 2009 exceeding the dose limit in two cases and an incident in 2010 exceeding the dose limit in one case), no individual dose above 20 mSv per year was accumulated by any plant personal or contractors during their work in the Swiss NPPs. Since 1987, all annual collective doses have remained well below 4 man-Sv per unit and all have been kept below 2 man-Sv since 1995. The low annual individual and collective doses prove the effectiveness of the measures based on the most recent recommendations of the ICRP (e.g. guidelines, job planning and supervision).

The Inspectorate reviews the radiation planning process of the NPPs as a part of its supervisory duties. Additionally, the Inspectorate reviews all periodical reports of the power plants related to radiation protection measures.

Article 16 – Emergency preparedness

Since the fifth Swiss report, several ordinances relating to emergency preparedness have been revised: the Emergency Preparedness Ordinance, the Ordinance on the Organisation of Operations in Connection with NBC and Natural Events, the Ordinance on Alerting the Authorities and the Public, and the Ordinance on the National Emergency Operations Centre. The lessons learned from the accident of Fukushima have led to the initiation of numerous activities in Switzerland with the aim of improving preparedness and response capabilities both on and off site. On the basis of a report by ENSI, the Federal Council decided on 4 May 2011 to set up an official working group to review emergency preparedness measures in case of extreme events in Switzerland (IDA NOMEX). The report of IDA NOMEX was adopted by the Federal Council on 7 July 2012. It describes 56 organisational and legislative measures deemed to be necessary as a result of the review conducted. ENSI is responsible for implementing measures related to assistance for persons with severe radiation exposure, the availability of measurement and forecasting systems for NPPs in extreme events, the reference scenarios for emergency preparedness, and the review of the emergency planning zones around NPP sites. The follow-up and completion of these activities will extend over several years.

Based on its action plan "Fukushima 2012", ENSI performed inspections of the emergency operations facilities in all NPPs. The approaches and methods for the source term estimation were also examined.

Each Swiss nuclear installation has on-site and off-site emergency organisations and plans. The emergency planning zones around NPPs are defined. Emergency protective measures, e.g. sheltering and the availability of iodine tablets, have also been established.

There is an automatic dose rate monitoring and emergency response data system (ANPA/MADUK) in and around all NPPs in Switzerland. The data is transmitted electronically to the Inspectorate, the National Emergency Operations Centre and the Ministry of the Environment of Baden-Württemberg (Germany). The ANPA/MADUK system also provides the Inspectorate with online access to measurement data for approximately 25 important plant parameters. The Inspectorate has also set up an automated system for radiological prognosis.

Exercises are conducted regularly to test emergency preparedness and plans. A recent revision of a guideline dealing with exercises allows the Inspectorate to require staff emergency exercises lasting up to 24 hours in order to check the adequacy of Severe Accident Management procedures and organisational measures especially for long-duration events. This requirement has been implemented due to a suggestion from the mission of the Integrated Regulatory Review Service, which took place in November 2011. Appropriate channels exist for alerting the public, the National Emergency Operations Centre and neighbouring countries. Bilateral agreements between Switzerland and neighbouring countries covering alerts in the event of an emergency are in place. The preparedness of Switzerland and its response at the international level is regularly verified by its participation in international exercises conducted by the IAEA or ECURIE.

Severe accident management guidance (SAMGs) of Swiss NPPs are available for all plant states. They are generally symptom-based and thus suitable to cover a comprehensive set of scenarios. The use of mobile or accident management equipment to cope with a Station Blackout (SBO) recently received special attention, including topical inspections by ENSI. Effects of damage to infrastructure and communication systems are addressed by IDA NOMEX. The work on the measures suggested by IDA NOMEX will continue.

Article 17 – Siting

The licensing procedure includes the steps required to evaluate the relevant NPP site-related safety factors. Under the Nuclear Energy Act and the Nuclear Energy Ordinance, a general licence for a nuclear installation can only be granted if the site is suitable. The decision on whether to grant a general licence is subject to a facultative national referendum. When evaluating the suitability of a potential NPP site, a comprehensive investigation of the external hazards has to be carried out as a basis for an appropriate plant design. All site-related factors must be included in a Safety Analysis Report (SAR). Furthermore, the general licence application must include an environmental impact report, a decommissioning concept and other safety-related documents. Applicants for a construction licence must submit an updated SAR, a deterministic safety analysis (which can be part of the updated SAR) and a probabilistic safety analysis (PSA) as described in the section on Article 14. The Inspectorate reviews these documents and publishes the results in a safety evaluation report. Those living in the areas surrounding the site of a proposed NPP (including areas in neighbouring countries) are invited to participate in the comprehensive public consultation conducted as part of the licensing procedure. Switzerland has signed agreements on the exchange of information with its neighbours Austria, France, Germany and Italy and is signing party of the ESPOO convention. Site-related factors are re-evaluated periodically as part of a Periodic Safety Review. Currently, no new builds are planned as the Swiss Government decided on a nuclear phase out in Switzerland in May 2011.

The applicability and effectiveness of the Inspectorate's re-evaluation process has been demonstrated by the probabilistic re-assessment of seismic hazards at Swiss NPP sites (PEGASOS). This project was carried out by Swiss licensees in response to a requirement in the Inspectorate's PSA review process. In 2008, Swiss licensees launched a follow-up project – PEGASOS Refinement Project (PRP) – in order to take advantage of recent findings in earth sciences and new geological and geophysical investigations at existing NPP sites. PRP aims at reducing the uncertainty range of the former PEGASOS results. PRP is expected to produce its final results in the course of 2013.

Because of the insights coming from the Fukushima accident, ENSI asked the licensees to reanalyze adequate protection against external flooding for their NPPs taking into account the upgraded site-specific flooding hazard. The results identified some necessary backfits (e.g. improving the water intake's protection against blockage on one site). After implementation of the measures ENSI concluded that all the Swiss plants have sufficient margins over their design base.

Finally, as regards extreme weather conditions, ENSI defined in greater detail the requirements for the probabilistic hazard analyses and safety case. At the end of 2012, in compliance with an ENSI request to this effect, the plants submitted a document illustrating how they intend to build their safety case. The probabilistic hazard analyses and safety case for extreme weather conditions, including statements of safety margins, are expected to be submitted to ENSI by the end of 2013.

The construction of NPP Beznau in 1969.
Source: Schweizer Journal

Article 18 – Design and construction

The Swiss NPPs were designed, constructed and backfitted in accordance with the concept of defence in depth. To enhance robustness against extreme external events, all Swiss NPPs have a special independent, bunkered system for shutdown and residual heat removal. The various levels of defence that exist ensure that safety criteria and dose limits for the public are met during normal operation of the NPP and for all design-basis accidents. In addition, there are appropriate measures to prevent or mitigate the release of radioactive materials into the environment in the case of beyond design-basis accidents. Design, materials and components are subject to rigorous control and scrutiny and regular testing in order to verify their fitness for service. Safety assessments for the long-term operation of first-generation NPPs have been performed as part of the periodic safety reviews. Backfitting is carried out when necessary. All Swiss NPPs possess a filtered containment venting system to mitigate radiological effects on the environment in the most severe accident scenarios.

After Fukushima, the protection of the Swiss NPPs and their spent fuel pools (SFP) against external events has been reassessed by the licence holders. Furthermore, the Inspectorate 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 Inspectorate conducted several inspections to assess the situation in the Swiss NPPs regarding issues that resulted from the accident management actions performed at Fukushima.

Furthermore, as specified in Article 5 of the Ordinance on Hazard Assumptions and the Evaluation of Protection against Accidents in Nuclear Plants (SR 732.112.2), the safety of an NPP has to be demonstrated for natural hazards with an exceedance frequency 10^{-4} per annum. The seismic hazard was reassessed by a SSHAC Level 4 study (as defined in NUREG/CR-6372) in 2004. This study is designated as the PEGASOS project. In order to reduce the uncertainty of the PEGASOS results (mainly with additional data), the PEGASOS Refinement Project (PRP) was initiated. Based on intermediate results of PRP, ENSI requested the licensees to demonstrate seismic safety. The corresponding safety cases were submitted and reviewed by ENSI in 2012. It could be demonstrated that all Swiss NPPs fulfil the requirements. The external flooding analyses were redone in 2011 for flood levels with an exceedance frequency of 10^{-4} per annum. It could be shown that all Swiss NPPs fulfil the requirements. All Swiss NPPs have conducted substantial seismic backfits since commissioning.

To sum up, the Swiss NPPs were designed and constructed on the basis of the IAEA concept of defence in depth. The basic principles regarding redundancy, diversity, physical and functional separation, and automation were integrated in the Nuclear Energy Act, in the Nuclear Energy Ordinance, and in the guidelines issued by the Inspectorate, ensuring that those principles are implemented in the plants as far as reasonable.

As a result, further backfitting measures to be taken depend on the assessments and analysis which have still to be performed as a consequence of the Fukushima events. These backfittings are described and their implementation monitored in ENSI's yearly up dated Action Plan Fukushima. Further improvements will also be made by implementing the requirements from the Inspectorate regarding long-term operation. The safety requirements for equipment used in beyond design basis conditions will be implemented in a new guideline in which updated design rules for the existing NPPs will be laid down.

Article 19 – Operation

The requirements for the safe operation of Swiss NPPs are specified in the operating licence granted to each NPP. The operation licence includes commissioning approval. The commissioning programme, which requires the approval of the Inspectorate, comprises pre-operational and start-up tests as well as procedures for testing any equipment important for safety. The most important operational procedures are the Technical Specifications, which include the limiting conditions for operation and similarly require the approval of the Inspectorate. The operational procedures for an NPP also cover the maintenance, testing and surveillance of equipment. Engineering and technical support in all fields of relevance to safety is available to all NPP staff.

The Nuclear Energy Act, the Nuclear Energy Ordinance and regulatory guidelines include requirements on the notification of events and incidents. Under the Ordinance, each NPP must use dedicated emergency operation procedures (EOPs) for operational anomalies and emergency conditions. The ultimate objective of EOPs is to bring the plant into a safe operational state. The legislation also requires an extension to EOPs in the form of severe accident management guidance (SAMG). This is designed to prevent or at least minimise any impact on the environment. In all Swiss NPPs, SAMG is implemented covering all relevant operational states. All the plants have met the requirement to examine and take account of the behaviour of the instrumentation under severe accident conditions in the course of the introduction of SAMG. All NPPs have Accident Management (AM) procedures on a variety of measures to deal with scenarios beyond the design basis of the plant.

All Swiss NPPs are equipped with special bunkered safety systems designed against extreme external events. ENSI has requested a new safety case to demonstrate that the Swiss NPPs have adequate protection against the 10,000-year earthquake and the combination of this earthquake and a 10,000-year flooding. The necessary analyses were submitted by the licence holders and examined by ENSI. Several open points were identified that require further examination. The existing strategies to cope with Station Blackout (SBO) scenarios have been extended. As a result, additional equipment has been installed or stored on the plant sites and the existing accident management procedures will be adapted accordingly. A flood-proof and earthquake-resistant external storage facility is in place at Reitnau since June 2011 in order to strengthen the provision for accident mitigation.

The Swiss NPPs have developed their own on-site technical support covering the surveillance test programme, reactor engineering and fuel management, operational experience feedback, plant modifications and safety-related computer applications.

The Nuclear Energy Act, the Nuclear Energy Ordinance and the Inspectorate's guidelines contain requirements on the notification of events and incidents. An important process in Swiss NPPs is the process dealing with non-conformance control and remedial action. It is guided by procedures that form part of the management system. Any non-conformance is reported and discussed at the daily morning meeting held by each NPP and follow up action (e.g. work authorisations) is initiated where necessary. Furthermore, each NPP has a process for dealing with external operating experience, which screens and evaluates information on external events. The Inspectorate has its own process for assessing events in nuclear installations in other countries.

Each Swiss NPP is required to carry out a Periodic Safety Review (PSR) every 10 years, at the latest. As part of the PSR, each plant is required to assess in summary form its own operating experience and any important foreign event of relevance to the plant. This review is also assessed by the Inspectorate and its safety evaluation report is publicly available.

In addition to its general inspection activities, the Inspectorate gains further insight into the operations of an NPP through a system of comprehensive operator reporting. Both the Inspectorate and the operators collect operating experience from domestic and foreign NPPs. In some cases, an analysis of a particular operating experience has resulted in important safety-related backfitting or modifications to Swiss NPPs.

The Nuclear Energy Act includes the principle that the originator of radioactive waste is responsible for its safe and permanent management. Thanks to high fuel quality and plant cleanliness, the generation of radioactive waste at NPPs is kept to the minimum possible. The resultant waste is collected and separated. As a general rule, radioactive waste is conditioned as soon as practicable, mostly on site at an NPP or the Paul Scherrer Institute (PSI), but also in part externally at the Central Interim Storage Facility. All procedures for the conditioning of radioactive waste require the approval of the Inspectorate. Each NPP stores spent fuel discharged from reactors on site for a few years.

The Nuclear Energy Act prohibits the reprocessing of spent nuclear fuel for a period of ten years starting on 1 July 2006. At present, spent fuel is also stored in transport and storage casks at the Central Interim Storage Facility. The return of waste from foreign reprocessing facilities to the Central Interim Storage Facility started in 2002 and is on schedule. Since July 2006, any spent fuel from the NPPs Mühleberg

Entrance Meeting of IAEA's OSART Mission visiting the NPP Mühleberg, October 2012.
Source: BKW Energie AG

and Leibstadt is transported to the Central Interim Storage Facility and stored in dry transport and storage casks. The Beznau NPP operates its own dry storage facility on site, whereas the Gösgen NPP started on-site operation of a separate wet storage facility for spent fuel in May 2008.

All Swiss NPPs underwent Operational Safety Review Team (OSART) missions, including the follow-up missions, and all of them have implemented the recommendations received in the OSART reports. All Swiss OSART reports are available to the public. In October 2012, the Mühleberg NPP subjected itself to an OSART mission. All Swiss NPPs also underwent more than one World Association of Nuclear Operators (WANO) mission at their own initiative, the last one being a Follow-Up Mission at the Beznau NPP.

Answers to the requirements of the Guidelines regarding the National Reports under the CNS – INFCIRC/572

Requirement:	Activity executed by Switzerland:	Further information:
Suggestions or Challenges summarized in the Rapporteur's Report. *The following challenges were identified for Switzerland during the 5th Review meeting of the CNS:* 1. The events at Fukushima will pose challenges in projects to build 3 new reactors and will also pose challenges to the upgrading of existing plants.	1. In 2011, after the events in Fukushima Daiichi, the Swiss government decided to phase out nuclear energy. As a result, no new nuclear power plants will be built. As concerns backfitting of existing plants there is a legal requirement in Switzerland for constant upgrading following the state-of-the-art in science and backfitting technology. Since their construction the Swiss NPPs have undergone several backfits to comply with that requirement. In the wake of Fukushima additional improvements were demanded by ENSI which resulted in backfitting measures at the plants. As examples the currently on-going backfitting projects can be mentioned: additional level and temperature measurements for the spent fuel pools at all the plants; an additional cooling system for the spent fuel pools at the first generation plants; additional diverse ultimate heat sink at the Mühleberg NPP.	See Introduction and Articles 6, 18 and 19
2. In the next reporting period, 3 of Switzerland's NPPs will have been operating for more than 40 years. As a result, the regulatory oversight of these plants will need to focus more on the specific issues arising from long-term operation.	2. The Nuclear Energy Act specifies that nuclear installations must be back-fitted, where necessary with the state of art technology. Assessments of long-term operation (LTO) have been performed for two Swiss NPPs which have been in commercial operation for over 40 years. A detailed examination demonstrated that the conditions for the taking out of service of an NPP are not and will not be reached by these two plants within the next 10 years. Nevertheless, it is mandatory to continue with the scheduled ageing management, maintenance and backfitting activities.	See Article 14
Description of significant changes to Switzerland's national nuclear energy and regulatory programs and measures taken to comply with the Convention's obligations	As a result of the events in Fukushima Daiichi, Switzerland decided to phase out nuclear energy. Therefore, no nuclear new builds are planned and the Inspectorate has had to adapt its organisational structure. Due to this situation, the Nuclear Energy Act is currently being revised, to enshrine the nuclear phase out into law. New regulatory guidelines issued by the Inspectorate have been introduced. By involving the stakeholders and the broad public in the procedure of issuing guidelines (especially hearings), the regulatory process is transparent. Furthermore, each new regulatory guideline includes the related international WENRA and IAEA requirements.	See Introduction, Articles 7 and 8

Requirement:	Activity executed by Switzerland:	Further information:
Results of international review missions including the IAEA missions conducted in Switzerland during the review period, progress made by Switzerland in implementing any findings, and plans for follow-up	An IRRS mission visited Switzerland in November 2011. The final report contains 19 "Good Practices", 12 recommendations and 18 suggestions. By the end of March 2012, the Inspectorate drafted an action plan for the suggested improvements in view of the IRRS follow-up mission which is likely to take place in 2015. An OSART Mission took place at the Mühleberg NPP in October 2012. The findings were recorded in the mission report (NSNI/OSART/012/170). The report was derestricted in January 2013. A follow up mission will be conducted by the IAEA to review the implementation of the proposed improvements.	See Articles 8 and 19
Operating experience, lessons learned and corrective actions taken in response to accidents and events having significance for the safety of nuclear installations	After the Fukushima Daiichi accident, an interdisciplinary team of experts (the "Japan Analysis Team") reconstructed the events of the accident and subjected them to in-depth analysis. The results were presented to the public in four reports. All measures, additional safety analyses and backfittings related to the accident are described and monitored by the Swiss "Action Plan Fukushima", which is updated yearly. With regards to the flaw indications discovered at Unit 3 of the Doel NPP in Belgium, Switzerland performed additional non-destructive testing to reassess the quality of the forging base material of the reactor pressure vessels of the Mühleberg NPP. No indications of manufacturing defects have been detected. The vessel of the Leibstadt plant, while featuring piping by the same supplier as in Belgium, was made using rolled steel, not forged steel, from Japanese and French suppliers.	See Articles 14, 18 and 19
Lessons learned from emergency drills and exercises	Each Swiss NPP conducts an emergency exercise every year. The outcomes of an exercise may lead to new measures to improve the functioning of the emergency organisation. Such measures are being implemented into the training programmes of the members of the emergency organisation. According to the Inspectorate's Guideline B11, the yearly emergency exercise of each plant takes place in the presence of several representatives of the Inspectorate. A recent revision of this guideline allows the Inspectorate to require staff emergency exercises lasting up to 24 hours in order to check the adequacy of Severe Accident Management procedures and organisational measures especially for long-duration events. This requirement has been implemented due to a suggestion from the mission of the Integrated Regulatory Review Service, which took place in November 2011.	See Article 16

Requirement:	Activity executed by Switzerland:	Further information:
Actions taken to improve transparency and communication with the public	ENSI is subject to the Federal Act on Freedom of Information in the Administration. According to this law, all ENSI documents are public with defined exceptions. ENSI regularly informs the public about its activities. For instance, it organises regular meetings with stakeholders. In the past, ENSI made important decisions based on its own expertise and on the expertise of external experts. Since 2009 and 2012, the Inspectorate chairs two Technical Fora. In these Fora, questions from the public are discussed with regards to technical safety aspects of Swiss NPPs (Technical Forum on NPPs) and geological repositories (Technical Forum on Safety). Since 2011, ENSI has expanded its information activities. Furthermore, ENSI appreciates the operators' communication activities related to experience exchange at an international level (e.g. WANO, OSART). All Swiss NPPs underwent OSART missions including a follow-up mission. All Swiss OSART reports are available to the public. All Swiss country reports for the Convention on Nuclear Safety (CNS) and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management are published on ENSI's website.	See Article 8

Actions taken in Switzerland in the light of the Fukushima Daiichi accident

Introduction

As a direct consequence of the Fukushima Daiichi accident in Japan, the Inspectorate issued three formal orders in which the licensees of the Swiss NPPs were required to implement immediate measures and to conduct additional reassessments. The immediate measures comprised the establishment of an external emergency storage facility for the Swiss NPPs, including the necessary plant-specific hook-up points for Accident Management (AM) equipment, and backfits to provide external injection into the spent fuel pools. The additional reassessments, which were to be carried out immediately, focused on the design of the Swiss NPPs against earthquakes, external flooding and a combination thereof. Investigations on the coolant supply for the safety systems and the spent fuel pool cooling on the basis of first insights gained from the accident in Japan were also requested.

In addition to the aforementioned orders, and on the basis of the internationally accessible information, ENSI carried out an analysis of the events at Fukushima and published the results in four reports (http://www.ensi.ch/en/dossiers-3/fukushima-2/). These reports provide detailed descriptions of the causes, consequences and radiological impacts of the accident at Fukushima. They analyse the contributory human and organisational factors, and specify lessons that can be derived from this information together with 37 specific issues for further investigation (see Annex 2). In a fourth formal order on 1 June 2011, ENSI instructed the Swiss operators to take part in the EU stress tests.

The open points identified in the EU stress tests (see Annex 3), together with the issues identified in the analysis of the events at Fukushima (see Annex 2), are being processed according to their importance and urgency in a Swiss national action plan, called "Action Plan Fukushima". This "Action Plan Fukushima" is detailed on a yearly basis and describes ENSI's oversight activities related to Fukushima. ENSI has set the goal of investigating the identified issues and implementing the derived measures by 2015.

Actions taken in Switzerland in the light of the Fukushima Daiichi accident
Source: ENSI

The activities for 2011 are described in this introduction. In 2012 the activities focused on eleven key issues. For 2013 nine key issues were retained for detailed investigations. In the following sub-sections, a brief overview will be given about the measures implemented as a consequence of the Fukushima Daiichi accident.

Containment integrity

Seismic robustness of the containment venting systems at Gösgen and Leibstadt NPPs:

2013: Following the cursory review completed at the end of 2012, the detailed review of the submitted documentation by ENSI will continue into the second quarter of 2013.

Seismic robustness of the isolation for the containment and the primary circuit:

2013: The cursory review was completed for the plants in question at the start of 2013. The cursory review produced certain further requirements regarding the submission of additional documents. These documents will be submitted in the first quarter of 2013 and will be taken into account by ENSI in its statement to be issued in the second quarter of 2013.

Requirements for containment integrity:

2013: The main report of the peer review team in connection with the EU stress test (April 2012) includes a recommendation at European level that the containment, as the final barrier before the release of radioactive substances, plays a key role in severe accidents. Switzerland's NPPs already have equipment and measures in place which largely guarantee attainment of the "Confinement of radioactive substances" fundamental safety function; their rating in the review by international experts was therefore good. ENSI is actively involved in the technical working group of WENRA (a sub-group of the Reactor Harmonization Working Group), which is currently focusing on containment integrity in case of severe accidents. In particular, the group will review the existing WENRA requirements and will adapt them where necessary. ENSI will then examine whether the requirements for the revised Safety Reference Levels are met in Switzerland.

For further information on this subject see articles 14, 15, 17, 18 and 19.

Containment venting and hydrogen management system

2012: Provisions against the hazard caused by hydrogen were taken into account in the design of Swiss NPPs at an early stage. Various aspects of these provisions were reviewed again in the light of events at Fukushima.

Relevant work during 2012 focused on investigations of protective measures against the hydrogen hazard in the spent fuel pools, the seismic resistance of the containment venting systems and the follow-up activities arising from the inspections regarding containment venting. The status of the relevant work is presented in brief below.

The licensees have submitted their investigations regarding protection against hydrogen hazards in the area of the spent fuel pools. Based on its review of the submitted documentation, ENSI has imposed specific additional requirements for each plant to ensure monitoring of the spent fuel pools, upgrading of the spent fuel pool cooling systems and extension of the relevant on-site emergency preparedness measures. These measures additionally reduce the risk of a severe accident in the area of the spent fuel pools.

In addition, the Gösgen and Leibstadt NPPs have submitted their studies regarding the seismic resistance of the containment venting systems together with proposals of improvements, if needed.

2013: ENSI's review of the studies submitted by the NPPs of Gösgen and Beznau in 2012 (regarding the improvement of displays in the emergency control room and the updated post-LOCA study) is scheduled for 2013.

In connection with the EU stress test, various aspects of the hydrogen hazard in case of severe accidents in the reactor should be reconsidered. Extensive studies have already been carried out in connection with the probabilistic safety analysis, so important basic material is already available. Based on the review in connection with the EU stress tests and the NSC's report, various analyses are to be carried out by the Swiss NPPs.

For further information on this subject see articles 6, 14, and 18.

Earthquakes

2012: By the end of March 2012, in accordance with the specified deadline, the Swiss NPPs supplied ENSI with proof of their ability to overcome a 10,000-year earthquake and a combination of earthquake and flooding, as required by the formal order dated 1 April 2011. ENSI's formal order dated 5 May 2011 also required design reassessments of the spent fuel pools, their buildings and cooling systems, and proof of compliance with the permitted dose limits for these accidents. In ENSI's statements on the seismic safety case that was submitted, additional requirements were identified; these relate in general to individual components in the nuclear plants for which more detailed analyses are required or whose seismic behaviour can be improved by minor structural adaptations. All the additional requirements were incorporated into individual follow-on measures in the course of normal supervisory activities, and processing of them will continue on this basis.

2013: In compliance with formal orders from ENSI regarding protection against the 10,000-year earthquake, the Swiss NPPs submitted new safety cases for the safe shutdown earthquake (SSE) in 2012. For this purpose, use was made of the seismic hazard assumptions (PRP Intermediate Hazard) current at the time in question based on the new earthquake catalogue issued by the Swiss Seismological Service (SED) and the site specific data acquired during the Pegasos Refinement Project (PRP). The calculation was based on current results from attenuation modelling. Completion of the PRP project is planned in the second quarter of 2013. ENSI will then review the results and define new hazard assumptions. By the fourth quarter of 2013, the methodology and the timeline for seismic safety case to be provided by the Swiss NPPs will be redefined in detail. Following this, the safety case submitted by the licensees of NPPs must be revised or a new one must be furnished. In the course of analyses for the EU stress test, ENSI became aware of a circumstance that proved advantageous during the severe earthquakes which occurred in Japan: in the Japanese NPPs, automatic scrams were triggered upstream by means of the seismic instrumentation. Triggering of this sort has not yet been implemented in the Swiss NPPs. In 2013, ENSI will set up a working group to examine whether automatic scrams should take place upstream, by means of the seismic instrumentation, in Swiss NPPs.

For further information on this subject see articles 6, 14, 17, 18 and 19.

Emergency management at national level

2012: On 4 July 2012, the Swiss Federal Council took note of the report by IDA NOMEX (the Interdepartmental Working Group to Review Emergency Preparedness Measures in case of Extreme Events in Switzerland) and instructed various Federal agencies to draft organisational and legislative measures. In this context, ENSI collaborated with representatives of the Federal Office for Public Health (FOPH), the Swiss Accident Insurance Fund (SUVA) and the Group of Swiss NPP Operators (GSKL) in 2012 to compile a report in which the prevailing situation regarding support and treatment for persons exposed to severe radiation and the agreements with the plants, and specific alternative solutions were proposed.

The current status of measurement and forecasting systems was assessed in collaboration with Federal agencies and the power plant operators. The requirements for these systems were redefined on the basis of this analysis and the lessons learned from Fukushima.

In November and December 2012, moreover, ENSI carried out inspections of the emergency control center (ECC) and substituted ECC at NPP sites. The inspection reports are being drawn up. Human and organisational aspects of emergency management by NPP licensees are also addressed here.

2013: ENSI coordinates its activities with other Federal agencies and cantons on the basis of measures adopted by the Federal Council arising from the final report of IDA NOMEX (the Interdepartmental Working Group to Review Emergency Preparedness Measures in case of Extreme Events in Switzerland) issued in July 2012. ENSI will also devote attention to the implementation of international recommendations and the problem of liquid radioactive discharges as a consequence of reactor accidents. ENSI's work for 2013 is as follows:

The reviews of existing reference scenarios for emergency preparedness/protection will be completed, in collaboration with representatives of the cantons, Federal agencies and NPPs. The results will be incorporated into the review of emergency preparedness zones, which will then be carried out by the same working group. In case of incidents at NPPs, deployments of external emergency preparedness organisations and notifications to neighbouring countries are linked to specified levels on the International Nuclear Event Scale (INES). The IRRS issued a recommendation to Switzerland that the classification of emergencies and the ensuing deployment of emergency preparedness organisations should be geared to a special IAEA classification system created for emergencies; ENSI will therefore carry out a study regarding the implementation of the IAEA emergency classification system in the NPPs and at ENSI itself in 2013. As a result of the Fukushima accident, significant quantities of radioactively contaminated water were discharged into the sea in addition to the airborne releases of radioactive substances. ENSI will require the licensees to examine those cases in which large quantities of radioactively contaminated water can be expected in their plant, the routes by which these quantities of water can reach the surrounding area, and the methods that can be used to retain and/or minimise them. In 2012, ENSI drafted a report on the situation in Switzerland in case of a discharge of large quantities of radioactivity into the rivers Aare and Rhine; the Federal agencies and cantons concerned are carrying out the consultation process regarding this report until the end of February 2013. The need for action to optimise protective measures for the population in such cases will be determined after completion of the consultation process in 2013, in liaison with the cantons and Federal agencies.

For further information on this subject see article 16.

EU Stress Test Follow-Up

2013: The European Nuclear Safety Regulators' Group (ENSREG) approved an action plan for follow-up measures to the EU stress test in 2012. Its objective is to request the participating countries to draw up their own national action plans for the implementation of the measures resulting from the EU stress test. Switzerland participates actively in this process. ENSI has drawn up a status report for the implemented and planned measures (as at the end of 2012) and will continue to take part in the follow-up actions.

For further information on this subject see articles 7, 8, 14, 17-19.

Experience Feedback

2012: To examine the issue of experience feedback, topical inspections were carried out in all the Swiss NPPs during the fourth quarter of 2012, focusing on the processes for the assessment of external occurrences. These inspections showed that suitable specified guidance documents are in place at the plants so that the external occurrences of relevance to each plant can be assessed in greater detail. The interfaces to the relevant processes for the implementation of derived measures have also been defined throughout. The review of documentation on experience feedback and any improvement measures that may be required are followed up in the Action Plan 2013.

2013: The plants must finalise those documented requirements for the analysis of external occurrences and for the derivation of measures which were only available in draft form when ENSI carried out its inspections of key points in 2012. These documents must be submitted to ENSI by the deadlines in the second half of 2013. ENSI will then assess the submitted documents.

Switzerland assesses operational experience from foreign NPPs. On the one hand, statutory requirements oblige the licensees to evaluate occurrences abroad for the purpose of gaining knowledge for their own plants. On the other hand, ENSI keeps track of the key issues at international level (in bilateral committees and international working groups of the NEA (Nuclear Energy Agency) and the IAEA). ENSI is also a member of the "European Clearinghouse on NPP Operational Experience Feedback", a body of experts which focuses on knowledge gained from operational experience on the basis of event analyses, assessments and reporting. ENSI plans to subject its own process for the assessment of foreign operating experience to a review in order to identify potential for improvement and, as an option, to initiate closer collaboration with the Clearinghouse.

For further information on this subject see article 19.

Extreme weather conditions

2012: In its letter to the licensees dated 4 July 2012, ENSI specified the requirements for the probabilistic hazard analyses and the safety case needed to demonstrate adequate protection of the plant against extreme weather conditions. The concept for proving adequate protection against extreme weather conditions was submitted by the licensees by the end of 2012 in accordance with the deadline. Due to the large number of analyses, the licensees were granted one more year for completing the assessment than was envisaged in the Action Plan 2012.

2013: ENSI defined the requirements for the probabilistic hazard analyses and safety cases needed to demonstrate adequate protection of plants against extreme weather conditions in greater detail during 2012. At the end of 2012, in compliance with an ENSI requirement to this effect, the Swiss plants submitted a concept to prove adequate protection; this is currently under review. The probabilistic hazard analyses and safety case for extreme weather conditions, including statements of safety margins, are expected to be submitted to ENSI by the end of 2013.

For further information on this subject see article 17.

Flooding

2012: In its formal order dated 1 April 2011, ENSI required all the Swiss NPPs to submit their safety case demonstrating adequate protection against the 10,000-year flood. The relevant proof was submitted to ENSI. In its statements, ENSI concluded that all the plants can be brought into a safe condition even if the external power supply fails at the same time. The applicable dose limits are respected by all the plants. In connection with the analyses of seismically induced flooding, ENSI identified new requests in 2012, although they do not cast doubt on the overall result of that review. In order to complete its analyses regarding seismically induced flooding, the Gösgen NPP (KKG) must consider the effects of a failure of the dam installations located upstream in the relevant area surrounding the KKG. The Mühleberg NPP (KKM) must complete the seismic safety calculations for dam installations in the power station's zone of influence in accordance with the requests contained in the review reports of the Swiss Federal Office of Energy (SFOE). KKM submitted the requested documents by the deadline. The relevant statement by the authorities is expected in the first quarter of 2013.

For further information on this subject see articles 14, 17, 18 and 19.

Aerial view of the Mühleberg NPP
Source: BKW Energie AG

Increase in safety margins

2013: Following the events at Fukushima, investigations were conducted and demonstrations was provided during 2011 and 2012 in connection with external natural events and sequences entailing the failure of essential safety systems which create increased autonomy requirements for the NPPs; these activities confirmed that the Swiss NPPs display a high level of protection against the impact of the incidents that were analysed. The requirements for safety precautions stipulated by law to comply with the basic protection objectives (control of reactivity, cooling of fuel elements and containment of radioactive substances) are met. Moreover, the available safety margins are mainly attributable to the robust design of the special emergency systems at the plants, which are specially protected against external events.

In the Swiss country report on the EU stress test (December 2011), the concept of "safe shut-down paths" was used to supply deterministic proof for the first time; safe shutdown paths enable the plants to be brought into safe shutdown after incidents. Swiss NPPs have three safe shut-down paths.

As a consequence of the accident at Fukushima, ENSI ordered specific back-fitting measures to cope (in particular) with severe accidents at the Swiss NPPs; some of these measures have already been implemented, while others are still in the planning phase. In addition, the Swiss NPPs have implemented further improvements such as the procurement of additional mobile power supply units for the specific purpose of improving autonomy in case of severe accidents.

Increasing safety margins in case of accidents beyond the design basis is a key issue for analysis work in 2013.

Based on the results of probabilistic and deterministic analyses, the objective is to identify areas where backfits could contribute the most towards a further reduction of the hazard, taking account of the principle of adequacy. The Swiss licensees will be asked to define potential improvements in these areas. A systematic overview will be used to show that, as a result of the measures developed, all appropriate precautions have been implemented to bring about a further reduction of the hazard by means of permanently installed systems or prepared measures that are available at short notice.

As the third safe shutdown path is strengthened, ENSI will also review extended requirements (e.g. design requirements or testing intervals) for accident management equipment under conditions resulting from extreme external events. These include, for example, the emergency power supply for the instruments required for Severe Accident Management.

For further information on this subject see article 14.

International supervision and cooperation

Internationally harmonised assessment scales:

2012: The primary purpose of cooperation among international authorities to ensure the safety of nuclear technology is to continue the development and harmonisation of safety requirements so that those countries which utilise nuclear energy will have a set of regulatory instruments at their disposal. These include the Safety Standards of the International Atomic Energy Agency (IAEA) and the Safety Reference Levels of the Western European Nuclear Regulators' Association (WENRA). At the end of 2011, ENSI's Director General was elected as Chairman of WENRA. ENSI is using this circumstance to make further progress with the development of harmonised Safety Reference Levels for all areas of nuclear energy, and to advance their implementation in European countries that use nuclear energy. ENSI's formal order dated 1 June 2011 required the licensees of Swiss NPPs to take part in the EU stress test. There were carried out in Switzerland in the same way as in the EU countries with NPPs. ENSI also took part in the peer review process which was completed by April 2012, whereby international teams assessed the country reports in overall terms and on a topic-by-topic basis according to standard criteria. The results from the EU stress test should also be incorporated into follow-up activities.

Switzerland takes part in the IAEA's Safety Standards Groups on an on-going basis. Switzerland also participated the Ministerial Conference on Nuclear Safety at Fukushima in December 2012. As elements of the IAEA Action Plan, these events aim to help strengthen the international nuclear safety regime.

For further information on this subject see articles 7 and 8.

International reviews and transparency:

2012: A two-week IRRS mission with a team of 24 experts from 14 countries visited Switzerland in November 2011. The final report by the review mission contains 19 "Good Practices", 12 recommendations and 18 suggestions. By the end of 2012, ENSI drafted an action plan for the suggested improvements in view of the IRRS follow-up mission which is likely to take place in 2015.

An OSART (Operational Safety Review Team) mission visited the KKM in October 2012. The OSART team drew up 21 recommendations and proposals regarding further improvements to operational safety at the plant. 10 Good Practices were also identified. ENSI observed the mission but did not participate in it directly. The IAEA published the final report in January 2013. An OSART follow-up mission to assess the measures implemented by KKM is likely to take place in 2014.

For further information on this subject see articles 8 and 19.

Convention on Nuclear Safety

2012: An extraordinary conference on the Convention on Nuclear Safety (CNS) took place in August 2012. Switzerland submitted its country report for this event in May 2012, in compliance with the specified deadline; this was published on ENSI's website (see http://www.ensi.ch/de/2012/05/11/swiss-national-report-to-the-second-cns-extraordinary-meeting/). In advance of the extraordinary conference, eleven countries (including Switzerland) submitted suggested changes to the CNS Guidance Documents and they went on to develop joint proposals for changes at two Consultancy Meetings in June and July 2012. The Conference accepted at least the basic content of most of the proposals, including the changes desired by Switzerland. These changes brought about practical improvements to the content of the reports and their discussion during the conferences, but do not make any substantial or binding changes to the international safety regime.

Russia and Switzerland also submitted motions to amend the Convention itself. In particular, Switzerland wanted to introduce binding status for international peer reviews, the implementation of safety reviews and improvements to transparency. Unfortunately, the proposals submitted to the Convention were unable to attract a consensus in this form. Instead, the parties to the Convention agreed to set up a working group (the "Effectiveness and Transparency Working Group"). By the next regular Review Meeting in 2014, this group will endeavour to draft broad-based proposals to improve the CNS and its processes.

Lengthy loss of power supply (Station Blackout, SBO)

2012: ENSI conducted team inspections in all plants during the fourth quarter of 2012 in order to review the precautionary measures to cope with a prolonged loss of AC power supply (Station Blackout, SBO).

The purpose of these inspections was to review the strategies in place at the plants for coping with an SBO incident beyond the design basis, the Accident Management (AM) resources available to terminate the accident, the hook-up points for emergency supply of cooling water and electricity, and the emergency procedures relating to an SBO.

The inspections demonstrated that the plants have effectively continued to develop their existing strategies, and that adequate AM resources are available to prevent core damage after an SBO. The results of the inspections will also be assessed in detail during the first quarter of 2013. Depending on the results of the assessment, ENSI will decide whether further actions are required in addition to the measures regarding SAM equipment already stipulated for the Action Plan 2013.

For further information on this subject see articles 16, 18 and 19.

Loss of the ultimate heat sink

2012: In order to meet the requirements arising from ENSI's formal order dated 5 May 2011, the KKM submitted an application for "permit of concept" by the stipulated deadline of 30 June 2012. This application covers three back-fitting projects which should be combined to deliver an overall solution (the DIWANAS project).Among other activities, the DIWANAS project includes the construction of an alternate (diverse) ultimate heat sink to the river Aare.

ENSI has carried out a cursory review of the submitted application documents. The cursory review yielded some further requirements regarding additional documents to be submitted. These documents were submitted by KKM in mid-December 2012, in compliance with the specified deadline, and were taken into consideration by ENSI when it issued the "permit of concept" at the end of January 2013. As regards scheduled dates for the implementation of measures included in the DIWANAS project, ENSI requested (in its statement on the long-term operation of the KKM) that the backfits covered by the DIWANAS project must be implemented by the end of the 2017 annual refuelling and maintenance outage, and a binding implementation plan for this purpose must be submitted by 30 June 2013.

For further information on this subject see article 14.

Reitnau external storage facility

2012: The central storage facility for Severe Accident Management equipment at Reitnau (canton of Aargau), which was the subject of a request by ENSI to all licensees of Swiss NPPs in March 2011, was commissioned on 1 June 2011. After assessing the submitted documentation by the licensee of the facility and on the basis of an ENSI inspection report dated 31 May 2011, ENSI was able to determine from its initial assessment that the Reitnau external storage facility is deemed to be a viable facility for the purposes of storing equipment and auxiliary supplies in order to extend the emergency preparedness of the Swiss NPPs in case of severe accidents.

The assessment of the Reitnau external storage facility to date was summarised by ENSI in a report published in the first quarter of 2013.

For further information on this subject see article 16 (mainly), 6, 14 and 18.

Safety Culture

2012: The accident at Fukushima entails potential implications at multiple levels for the safety culture of Swiss NPPs. On the one hand, the findings from the analysis of the accident should be considered to determine whether they can be applied to the safety culture of Swiss NPPs. On the other hand, the political consequences of the accident in Switzerland, i.e. the decision to withdraw from nuclear energy, should be considered to determine their potential impact on the safety culture. This self-examination and the implementation of any specific measures is the responsibility of the licensees of the Swiss NPPs. In 2012, ENSI assured itself that the licensees are actually fulfilling this responsibility, during the "specialist discussions on safety culture", as they are known. These are open, constructive and discursive discussions on a chosen topic with the primary aim of encouraging the licensees to consider their own safety culture. Specialist discussions of this sort were conducted at all the NPPs between July and December 2012. The overall assessment of the specialist discussions and reports on them will follow in the first quarter of 2013.

As the accident at Fukushima has shown, the safety culture of a licensee organisation is heavily influenced by the safety culture of the responsible supervisory authority (i.e. the supervisory culture), among other factors. By launching an internal project that will run for several years, ENSI has initiated a self-examination process to consider its supervisory culture. This project should help ENSI to learn the right lessons from the Fukushima accident for its own supervisory activities. New guiding principles for ENSI should also be drafted against this background.

For further information on this subject see articles 12 (mainly) 6, 8, 9, 10 and 14.

Severe Accident Management

2013: Severe Accident Management (SAM) includes the implementation of measures following core damage accidents to cool the damaged reactor core and to limit or reduce the release of radioactive substances into the surrounding area. As the reactor accident at Fukushima showed, these activities have to be carried out for lengthy periods under unfavourable radiological conditions, thereby creating the requirement to provide an infrastructure that is suitable for long-term operation under accident conditions. In connection with infrastructure, in 2012 ENSI requested the plants to submit a report on the long-term operability of the emergency control centre (ECC) and substituted ECC to ENSI by the end of the first quarter of 2013. The plants submitted these reports by the specified deadline and they are currently under review. On the basis of these reports, ENSI will carry out follow-up inspections of the emergency accommodations for lengthy deployments this year, and will order additional measures as required. The procedures of the activation of the Reitnau external storage facility and the provision of SAM equipment and its transportation from the external storage facility to the plant will also be tested during the course of 2013. These tests will be carried out as part of an unannounced alarm exercise and an emergency exercise in one plant.

For further information on this subject see articles 16 (mainly), 6, 14 and 18.

Major activities in Switzerland related to the identified issues in the Summary Report of the 2nd Extraordinary Meeting of the CNS

Identified issue:	**Activity executed by Switzerland, i.e. reference to Articles in present report:**
For existing NPPs, the results of reassessments of external events, of periodic safety assessments and of any peer reviews, and any follow-up actions taken or planned, including upgrading measures.	See Articles 14, 17, 18 and 19
For existing NPPs, any actions taken or planned to cope with natural hazards more severe than those considered in the design basis.	See Article 17
For new NPPs, improved safety features and additional improvements, if any, to address external hazards and to prevent accidents and, should an accident occur, to mitigate its effects and avoid off-site contamination.	Not applicable to Switzerland
Upgrading of accident management measures for extreme natural events, including for example measures to ensure core cooling and spent fuel pool cooling, the provision of alternate water sources for the reactor and for the spent fuel pool, the availability of the electrical power supply, measures to ensure containment integrity, and filtration strategies and hydrogen management for the containment; the development of probabilistic safety assessments to identify additional accident management measures should be considered as a possible future activity.	See Article 18
Measures taken or planned to ensure the effective independence of the regulatory body from undue influence, including, where appropriate, information on the hosting of IRRS missions.	See Articles 7 and 8
Enhancements of emergency preparedness and response measures, including for example for multi-unit sites, approaches and methods of source term estimation and initiatives in the field of remediation. The enhancements should include defining the additional responsibilities up to appropriate levels of the national government and the development of procedures and joint actions of various agencies and improvements in international cooperation.	See Article 16
Information on how IAEA safety standards are taken into account.	See Article 7
Information on activities undertaken to enhance openness and transparency for all stakeholders.	See Articles 8 and 12
Safety culture and human and organizational factors were identified as crosscutting issues, which affect the consideration of external events, design, severe accident management, including operator training, the good functioning of national organizations and emergency preparedness and response. Particular attention should be given to these in preparation of National Reports for the next Review Meeting.	See Article 12

Article 6 – Existing nuclear installations

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

The general safety of Swiss NPPs was satisfactory at the time the Convention came into force. All NPPs are subject to extensive reviews at least every 10 years (periodic safety review – PSR); the safety of all NPPs has been reliably established on the basis of deterministic and probabilistic assessments, operational performance and aspects of safety culture.

The **first generation of NPPs** in Switzerland (Beznau and Mühleberg) started operation between 1969 and 1972. At that time, the Swiss Federal Nuclear Safety Commission was responsible for the review and assessment of applications for site, construction and operating licences. It relied mainly on the US regulations and guidance dating from the period as the two reactors came from the USA.

However, certain principles of nuclear safety were not universally acknowledged at that time and so no account was taken of them, e.g.:

- separation criteria for electro-technical and mechanical equipment as a way of protecting an NPP from common cause failures resulting from fire or internal flooding, for example;
- rigorous application of the single failure criterion, including those relating to supporting systems in the event of a loss of offsite power;
- protection of residual heat removal (RHR) systems against external events (e.g. aircraft crashes, earthquakes, floods, lightning and sabotage);
- supplementary shutdown capability in a remote area if the main control room was lost.

By 1980, the safety authorities had demanded two major backfitting projects in order to improve RHR systems in first generation plants. These projects, which extended over several years, were known as "NANO" for the PWR twin-unit at Beznau NPP and "SUSAN" for the BWR at Mühleberg NPP. In addition, a seismic requalification was carried out in the late 1980s. This back-fitting project consisted primarily of adding one or two fully separated shutdown and RHR systems, including support systems, which addressed the above four issues. For further information on backfitting works, see Articles 14 and 18.

Extensive reviews were conducted at both plants following these major backfitting projects. For the Mühleberg NPP, the review was completed in 1992, and in 1994 for the Beznau NPP. Following this backfitting work, the two plants were granted new operating licences. Concerning the Mühleberg NPP, a lawsuit on limiting the operating licence of the plant was rejected by the Swiss Federal Tribunal on 28 March 2013. Extensive review of these two NPPs was in the form of PSRs. For the Mühleberg NPP, the assessments of the PSRs were completed in 2002 and 2007, for the Beznau NPP in 2004. The most recent PSR for the Mühleberg NPP was submitted towards the end of 2010 and the Inspectorate's review report is due in 2013. The most recent PSR for the Beznau NPP was submitted towards the end of 2012 and the Inspectorate's review report is due in 2015. In December 2012, the inspectorate published its review report on the long-term operation of the Mühleberg NPP. The review report on the long-term operation of the Beznau NPP was published in 2010. There are no fundamental reasons precluding long-term operation. Several requirements to be achieved in order to ensure safe long-term operation of the plant were defined.

The second generation of NPPs in Switzerland started operation in 1979 (Gösgen) and 1984 (Leibstadt). They had a higher degree of redundancy and their protection against external events was significantly better than that in the first generation plants. Some further improvements were introduced during licensing and construction (in particular, inclusion of a special emergency heat removal system at the Leibstadt NPP).

In 1993, all plants were back-fitted with a filtered containment venting system to mitigate the consequences of severe accidents (e.g. failure of RHR systems). In addition to the NANO feed water system, an emergency feed water system was installed in both units of Beznau in the year 1999 and 2000. This was done to improve the reliability and the capacity of the auxiliary feed water system. In both Beznau units, improvements were also made to the reactor protection system and the control systems for separation, redundancy, self-supervision, testability and reliability of power supply by replacing the original systems with a state-of-the-art computerised system in 2000 and 2001.

Table 1 (see Introduction) contains an overview of the main technical characteristics of the Swiss NPPs.

Both second generation plants have undergone PSRs. For the Leibstadt plant, the first review was performed in 1996 together with a review of the 14.7 % power uprate request for the utility. The most recent PSR for the Leibstadt NPP was submitted to the Inspectorate towards the end of 2006 and the latter's review report was published in August 2009. The first PSR for the Gösgen plant was completed in 1999. The second PSR for the Gösgen NPP was submitted to the Inspectorate towards the end of 2008 and the latter's review report was published in August 2012.

The most important measures introduced after the most recent PSRs were as follows:

Gösgen NPP: Several deterministic and probabilistic analyses have to be performed. Possible plant modifications may be derived from their results. No plant modifications were directly required after the review. The probabilistic safety analysis (PSA) has to be adapted to the current state of the art.

Leibstadt NPP: Only minor modifications were required after the review. They mainly related to improving the response to anticipated transients without scrams and modifications to maintenance/ageing/in-service inspection programmes, lightning countermeasures and accident analyses.

Aerial view of the Leibstadt NPP
Source: Kernkraftwerk Leibstadt AG

After the Fukushima Accident, additional safety reviews were performed. All Swiss nuclear power plants were required to back-fit two additional external feed options to resupply spent fuel pools with coolant. An external storage facility at Reitnau has been in place since June 2011, containing various operational resources for emergencies that can readily be called up. If transport by road is not possible, there is the option of air transportation by helicopters. Mobile accident management equipment stored on-site has been significantly upgraded.

For further information on measures taken after the Fukushima Accident see Articles 16-19.

Developments and Conclusion

Upgrading required in response to the accident of Fukushima was identified in due time. Implementation has been proceeding according to plan.

Article 7 – Legislative and regulatory framework

Clause 1: Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.

The legislative and regulatory framework in Switzerland for the peaceful use of nuclear energy, the safety of nuclear installations 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.

Federal Constitution of the Swiss Confederation (1st level)

Articles 90 and 118 of the Federal Constitution stipulate that legislation on the use of nuclear energy and on radiological protection is enacted exclusively at the federal (national) level. As a result, the authorities of the Confederation have exclusive authority to establish legislation in the field of radiation protection and the use of nuclear energy.

Federal Acts (2nd level)

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

- Nuclear Energy Act (2003);
- Radiological Protection Act (1991);
- Act on the Swiss Federal Nuclear Safety Inspectorate ENSI (ENSI Act, 2007).

Nuclear Energy Act

The Nuclear Energy Act regulates the peaceful use of nuclear energy. It applies to nuclear goods, nuclear installations, and radioactive waste that is generated in nuclear installations or that is surrendered to the federal collection centre.

The most important provisions of the Nuclear Energy Act are:

- basic principles of nuclear safety, including the precautionary principle, the protection of the people and the environment, and measures to prevent sabotage and the proliferation of nuclear material;
- a licensing procedure describing authorisations (licences) for the siting, construction (including design), operation (including commissioning) and decommissioning of nuclear installations;
- the general responsibilities of the licensee, including the responsibility for the safety of the installation, the obligation of NPPs to conduct systematic and periodic safety reviews and to back-fit installations to the extent that is necessary based on worldwide operating experience and the state of current backfitting technology;

- regulations on decommissioning and on the disposal of radioactive waste, including the licensee's obligation to decommission and dispose of waste at its own cost, and special provisions relating to deep geological repositories;
- the designation of ENSI as the supervisory authority for nuclear safety and security;
- provisions regarding the authority and powers of the supervisory authorities, including the right to (i) access all relevant information and documentation to make comprehensive assessment and carry out effective controls, (ii) enter nuclear installations without prior notification, and (iii) order the application of any measure necessary and appropriate to maintain nuclear safety and security;
- the funding of the supervisory authorities by fees collected from the licence holders and applicants;
- criminal sanctions.

Radiological Protection Act

- The Radiological Protection Act has a comprehensive scope: it applies to all activities, installations, events and situations that may involve an ionising radiation hazard. It includes the following:
- fundamental principles of radiation protection (justification and limitation of exposure, dose limits);
- licensing obligation for the handling (including use, storage, transport, disposal, import, export) of radioactive substances;
- protection for persons who are occupationally exposed to radiation and for the general population;
- permanent monitoring of the environment;
- protection of the population in the event of increased radioactivity (emergency response organisation and emergency measures).

ENSI Act

The Act on the Swiss Federal Nuclear Safety Inspectorate ENSI came into force on 1 January 2009, when the Inspectorate was separated from the Swiss Federal Office of Energy. The Inspectorate was founded as a new organisation, taking over the staff and responsibilities of its predecessor which had been part of the Swiss Federal Office of Energy (see Article 8(2)).

Ordinances (3rd level)

All significant provisions that establish binding legal rules must be enacted in the form of a federal act. However, the legislator has, to some extent, the competence to delegate its legislative powers to the executive branch. It can delegate to the government (or a subordinate authority) the competence to elaborate and issue ordinances containing detailed regulations. Ordinances require a legal basis in a federal act, although this basis may be of a rather general nature.

In the field of nuclear energy and radiation protection, a number of highly relevant federal ordinances have been issued by the Federal Council or a Department (Ministry). The most important ones are the following:

- Nuclear Energy Ordinance;
- Radiological Protection Ordinance (currently under revision);
- Ordinance on Safety-Classified Vessels and Piping in Nuclear Installations;
- Ordinance on the Qualifications of Personnel in Nuclear Installations;
- Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations;
- Ordinance on the Methodology and Boundary Conditions for the Evaluation of the Criteria for the Provisional Taking-out-of-Service of Nuclear Power Plants;
- Ordinance on the Federal Nuclear Safety Commission;
- Ordinance on the Swiss Federal Nuclear Safety Inspectorate;
- Several ordinances on emergency preparedness, emergency organisation, iodine prophylactics, alerts to the authorities and public etc. (see Article 16);
- Several ordinances on security issues that are not the subject of this report, e.g. security guards, trustworthiness checks for employees, protection of information or thread assumptions and security measures for nuclear installations and nuclear materials.

Regulatory guidelines (4th level)

The Inspectorate issues guidelines either in its capacity as a regulatory authority or based on an explicit delegation in an ordinance. Most of the delegation to issue guidelines can be found in the Nuclear Energy Ordinance and in the Radiological Protection Ordinance. Guidelines are support documents that formalise the implementation of legal requirements and facilitate uniformity of implementation practices. They also give concrete form to the state-of-the-art in science and technology. The content of the guidelines is "semi-mandatory", i.e. ENSI may allow deviations from the guidelines in individual cases provided that the suggested solution guarantees at least an equivalent level of nuclear safety and security.

International Conventions

Switzerland has ratified various international conventions, in particular the following:

- Convention on Nuclear Safety;
- Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management;
- Convention on Early Notification of a Nuclear Accident;
- Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency.

In addition, various bilateral agreements that Switzerland has agreed upon with different countries are in place.

Clause 2(i): The legislative and regulatory framework shall provide for the establishment of applicable national safety requirements and regulations.

National requirements

Safety requirements and regulations are specified in acts, ordinances and regulatory guidelines. Whereas acts and ordinances have legal force, guidelines are, as mentioned above, semi-mandatory. The Inspectorate may allow deviations from the guidelines in individual cases provided that the suggested solution ensures at least an equivalent level of nuclear safety or security.

After the Nuclear Energy Act and the Nuclear Energy Ordinance entered into force in February 2005, ENSI started a special project to ensure that its guidelines were complete. The guidelines were divided into three categories based on the classification introduced by ENSI for its oversight activities, which distinguishes between assessments of facilities and monitoring of operations:

- Series A: Guidelines covering the assessment of facilities;
- Series B: Guidelines covering the surveillance of operations;
- Series G: Guidelines with general requirements (covering both the assessment of facilities and surveillance of operations).

In this process, ENSI was able to identify gaps in former regulations, especially in its own guidelines. The majority of the new guidelines are enacted as of March 2013. The ENSI guideline system places particular emphasis on consistency and comprehensiveness.

Annex 5 contains a list of the regulatory guidelines currently in force. The current status of the guidelines is available on the Inspectorate's website (http://www.ensi.ch/de/category/dokumente/richtlinien/).

With respect to regulatory guidelines, the Inspectorate has established a Committee for the so-called "Regulatory Basis", which meets on a monthly basis, examines and surveys the guidelines, and reviews draft guidelines to ensure their consistency with the regulatory framework and the accuracy of the content. The specification of a guideline lists all relevant IAEA requirements and guides as well as the relevant WENRA reference levels. Once the draft guideline including the explanatory report has undergone an internal hearing, it is subject to an external consultation round. All interested parties, to which belong all existing nuclear facilities, the Federal Offices of Energy and of Public Health, Federal Commissions, and the Swiss cantons, may submit comments. The comments are carefully evaluated, and the corresponding ENSI decisions are documented in a "public consultation report". Comments not considered in the final version of the guideline have to be justified. The final draft is closely examined by the Committee for the Regulatory Basis. Finally, the guideline is adopted by ENSI's Director.

When it becomes apparent that some aspects of a guideline no longer reflect the state of the art, ENSI initiates a revision of the guideline. 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.

International harmonisation

In addition to the IAEA and the OECD Nuclear Energy Agency, the Western European Nuclear Regulators' Association WENRA is a major driving force in efforts to harmonise nuclear safety requirements at the European level. Switzerland was one of the founding members and is chairing WENRA since 2012. WENRA provides regulatory authorities with a single forum to which they can contribute their years of experience in regulating a range of nuclear facilities as well as in elaborating and implementing standards. Based on this expertise, so-called Safety Reference Levels (SRLs), which are based on the IAEA safety standards, are issued. The SRLs may be adopted and incorporated into national legislation. The implementation is monitored by the corresponding WENRA working group.

ENSI Director General Hans Wanner presenting as WENRA Chairman at the IAEA's Conference on Effective Nuclear Regulatory Systems in Ottawa, April 2013
Source: ENSI

The Inspectorate participates in the following WENRA groups: "Reactor Harmonisation Working Group" and "Working Group on Waste and Decommissioning". The Swiss self-assessment in the area of "Reactor Harmonisation" identified a number of SRLs which ought to be incorporated into the Swiss regulatory framework. By the end of 2012, approximately three quarters of these SRLs were part of the Inspectorate's new regulations. In the area of spent fuel storage and decommissioning, the incorporation of the SRLs is successfully completed. Some remaining discrepancies relating to the SRL in the area of waste will be incorporated into the Swiss regulatory framework by the end of 2013.

Simultaneously with the work on the SRLs, the Reactor Harmonisation Working Group has addressed the requirements for new reactors. The corresponding report on safety objectives is available on WENRA's website.

The Inspectorate takes part in several IAEA committees. At the beginning of the planning process for a new guideline or a revision of a guideline, the Inspectorate evaluates the existing Safety Fundamentals and Safety Requirements with respect to relevance to the guideline. Every guideline is accompanied by an explanatory report, which sets out the incorporation of international requirements in a special chapter. With regard to the IRRS mission in 2011, the Inspectorate carried out a review of the extent to which the IAEA Safety Fundamentals and Safety Requirements had been incorporated in Swiss law, including a reference to WENRA Reference levels. Discrepancies between Swiss law and internationally harmonised standards have been identified, are remedied, and in case of non-incorporation need to be explained.

Clause (2)(ii): The legislative and regulatory framework shall provide for a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence.

The system of licensing results from the Nuclear Energy Act and the Radiological Protection Act described above in Clause (1) of this Article. The complex licensing procedures affect the responsibilities of many authorities. An important instrument for coordination is the so-called "concentrated decision procedure": the authority whose responsibility is primarily affected acts as a "lead authority" and decides on all relevant aspects. The other authorities that could claim jurisdiction refrain from taking their own decisions. Instead, their opinions are submitted to the lead authority which has to duly consider them.

In Switzerland, three main types of licence exist:

- general licence;
- construction licence;
- operating licence.

With the exception of the general licence, every licensing decision can be challenged in court. Constructing or operating a nuclear installation without a licence is a criminal offence according to the Nuclear Energy Act.

Licensing procedure

The general licence is required for the siting of a nuclear facility and defines the site, the purpose and the essential features of the planned facility, and the maximum permissible radiation dose to the public due to the facility. The licence also specifies a time delay within which the licence holder must submit an application for a construction licence.

The application has to contain detailed information on the site characteristics, the purpose and outline of the project, the expected radiation exposure in the plant's surroundings, important information on organisation and personnel, an environmental impact report, a report on compliance with spatial planning requirements and a concept for decommissioning or, in case of deep geological repositories, for the monitoring period and closure.

The process of granting a general licence starts with the review and assessment of the application by ENSI. The result of the regulatory review and assessment is documented in a Safety Evaluation Report (SER). ENSI may suggest licence conditions. The SER is then evaluated by the Federal Nuclear Safety Commission.

As the licensing process affects responsibilities of other federal authorities as well as cantons and neighbouring countries, the concentrated decision procedure set out above applies. The Department of the Environment, Transport, Energy and Communications is the lead authority, and has to consider the opinions of the other authorities involved, especially those responsible for environmental protection and land use, planning and construction. The application and the corresponding reviews by the federal and cantonal authorities are published as official documents and are subject to a three-month-consultation period during which everyone can raise objections. The process ends with a decision of the Federal Council, which has to be ratified by the Parliament. Eventually, the decision may be subject to a countrywide popular vote, a so-called (optional) referendum.

The construction licence specifies the licence holder, the location of the installation, the planned reactor thermal power output or the capacity of the installation, the main elements of technical implementation, a brief outline of emergency protection measures, and most specially a list identifying all structures, systems and components of the installation that may only be constructed or installed after a permit has been issued by the relevant supervisory authority (namely ENSI). Further conditions may be attached to the licence as proposed by the competent authorities (e.g. by ENSI). The licence also specifies a time delay within which the licence holder must start with the construction works.

The application for a construction licence has to contain a Safety Analysis Report, an environmental impact report, a report on compliance with spatial planning requirements, a quality management programme for the planning and construction phase, an emergency preparedness concept and a decommissioning plan or, in case of deep geological repositories, a project for the monitoring period and a plan for the closure of the installation. It must include a report on compliance of the project with the general licence conditions.

The concentrated decision procedure also applies, the Swiss Federal Office of Energy being the lead authority. As with the review of the application for a general licence, various federal offices are involved in evaluating those issues related to their specific responsibilities. With the exception of the environmental impact and spatial planning, the ENSI Safety Evaluation Report for a construction licence application covers all areas mentioned above.

The licensing process also involves the canton where the facility is to be constructed and the public. The application and the assessment reports are made public and those entitled may file an objection. The construction licence is drafted by the Federal Office of Energy and eventually issued by the Department of Environment, Transport, Energy and Communications.

The operating licence specifies the licence holder, the permitted reactor thermal power output or capacity of the facility, the limits for release of radioactive substances into the environment, the measures for environmental surveillance, the safety, security, and emergency measures to be taken by the licence holder during operation of the installation, and most specially the levels of start-up that require a permit from the relevant supervisory authority (namely ENSI) prior to commencement of operation of the installation. Further conditions may be attached to the licence as proposed by the competent authorities (e.g. by ENSI).

The application for an construction licence has to contain the Final Safety Analysis Report, various technical documentation necessary for operation (as defined in Annex 3 of the Nuclear Energy Ordinance), and evidence of insurance cover. It must include a report on compliance of the project with the general and construction licence conditions.

With the exception of the insurance cover, the ENSI Safety Evaluation Report for an operating licence application addresses all areas mentioned above.

The procedure for granting an operating licence is essentially the same as for granting a construction licence.

To control the conditions of the licence, a "permit procedure" has been instituted. The permits granted by the supervisory authorities as part of a valid licence are defined in the Nuclear Energy Ordinance or in the licence. They include selected elements of the construction work, the manufacture of important components, assembly and wiring on site, sets of commissioning tests as well as any safety-relevant changes to the installation during operation. Therefore, this permit procedure can be considered as an enforcement tool (see Clause 2(iv) of this article).

Clause (2)(iii): The legislative and regulatory framework shall provide for a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences.

The legal basis for inspections by the Inspectorate is provided in the Nuclear Energy Act. It grants the Inspectorate a right of access to all relevant information and documentation, including documentation located in the offices of supplier companies, to make comprehensive assessment and carry out effective controls, to enter nuclear installations without prior notification, and to order the application of any measure necessary and appropriate to maintain nuclear safety and security.

The aim of regulatory inspections is to ensure that the licensee complies with its primary responsibility for safety. The Inspectorate, with the help of experts working on its behalf, reviews the licensee's programmes and independently assesses the performance of the licensee by (i) observing specific activities, and by (ii) carrying out its own inspections and taking its own measurements.

Clause 2(iv): The legislative and regulatory framework shall provide for the enforcement of applicable regulations and of the terms of the licences, including suspension, modification or revocation.

The licensing and regulatory authorities have enforcement powers based on the Nuclear Energy Act. They can order any measure necessary to protect persons, property and other important rights, to safeguard Switzerland's national security, to ensure compliance with its international commitments and check that measures have been implemented.

In terms of licences, the licensing authorities (Federal Council; Department of the Environment, Transport, Energy and Communications) will not grant a licence (general licence, licence for construction, commissioning, operation, modification or decommissioning of NPPs) unless the legal requirements are met. The licensing authority shall withdraw a licence if the prerequisites for granting it are not, or are no longer, met. The withdrawal of a general licence also results in the withdrawal of the construction and operating licences. The Inspectorate has the authority to suspend or withdraw permits.

The supervisory authorities are required to issue regulations on measures necessary and reasonable to maintain nuclear safety and security. The Nuclear Energy Act provides provisions for the special case of an immediate threat. An immediate threat is defined as an objective situation that, if not hindered in its evolution, could lead with high probability to damage. In the event of an immediate threat, the Inspectorate may impose immediate measures that deviate from the issued licence or an order. In particular, ENSI may order an immediate plant shutdown and allow restart only when the necessary corrective actions have been implemented by the licence holder. If necessary, the supervisory authorities may seize nuclear goods or radioactive waste and eliminate potential threats and charge the cost to the owner. They may seek intervention by cantonal and communal police forces, including the investigating arm of the customs authorities. If the provisions of the Act are breached, the supervisory authorities may call in the relevant federal police authority. The Federal Council may order the precautionary shutdown of a nuclear power plant if an extraordinary situation exists.

Developments and Conclusion

The Nuclear Energy Act and the Nuclear Energy Ordinance came into force in 2005 and are well established. New ordinances and guidelines issued by the Inspectorate have been introduced. By involving the stakeholders in the procedure of issuing guidelines (especially hearings), the regulatory process is transparent. Furthermore each new regulatory guideline includes the related international WENRA and IAEA requirements.

Article 8 – Regulatory body

Clause 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 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.

Organisation and competence of the regulatory body

Licensing

The Federal Council is the authority that grants general licences. The Department of the Environment, Transport, Energy and Communications grants construction licences and operating licences for nuclear facilities (see Article 7). For the three kinds of licences mentioned, the Swiss Federal Office of Energy is responsible for the coordination of the application procedure. In addition, the Swiss Federal Office of Energy issues licences for the handling of nuclear materials and radioactive waste.

Supervision

The Swiss Federal Nuclear Safety Inspectorate is the supervisory authority for nuclear safety, including radiological protection and nuclear security.

Its responsibilities and duties are as follows:

- to establish safety and security criteria and requirements that reflect operational experience and the state of science and technology;
- to prepare safety and security evaluation reports (SER) to support decisions by the licensing authority;
- to monitor compliance with regulations, including inspections and reports, and to request documentation on aspects of nuclear safety, nuclear security and radiological protection;
- to grant, suspend or withdraw permits;
- to order the application of measures necessary and appropriate to maintain nuclear safety and security, including the precautionary and active protection of personnel in NPPs, the public and the environment against radiation hazards;
- to ensure on-site and off-site emergency planning and the dissemination of appropriate information in an emergency according to Article 16.

Advisory committee

The Federal Nuclear Safety Commission (NSC) is designated as an advisory committee to the Federal Council and the Department of the Environment, Transport, Energy and Communications. It is involved in the licensing process as it reviews and comments on the safety evaluation reports prepared by the supervisory authorities.

The NSC consists of 5 to 7 part-time members, supported by a secretariat and, if necessary, supplemented by experts in specific disciplines. Its members are appointed by the Federal Council at the suggestion of the Federal Department of the Environment, Transport, Energy and Communication DETEC. The Commission may make suggestions to DETEC regarding new appointments. All 7 members are appointed on a personal basis and so do not represent their organisations. Members have a broad range of expertise including most, if not all, the disciplines relating to reactor safety, radiation protection, emergency preparedness, waste management, human and organisational factors and transport safety.

The NSC examines fundamental issues concerning nuclear safety and participates in legislative work in the field of nuclear safety. Among the responsibilities of the NSC, as defined in the Ordinance on the Federal Nuclear Safety Commission, are the following:

- to comment on new legislation or amendments and the development of regulations relating to nuclear safety and to recommend additions or amendments to regulations;
- to recommend measures to improve the safety of nuclear installations;
- to suggest research projects in the field of nuclear safety.

Others

The authorities listed below have responsibilities associated with the operation of NPPs. However, they are not involved in the licensing process and have no authority over the plants:

- the National Emergency Operations Centre – part of the Federal Office of Civil Protection in the Federal Department of Defence, Civil Protection and Sports – in charge of all emergency situations, including those arising from events at NPPs and relating to the protection of the public and the environment;
- the Division of Radiological Protection at the Federal Office of Public Health – in charge of the radiological monitoring of the environment (in the vicinity of nuclear installations);
- several advisory committees to the government or governmental departments covering aspects of radiological protection, emergency planning and waste disposal.

Financial and human resources

Costs incurred by the safety authorities (with the exception of the regulatory framework and information to the public), totalling some 60 million Swiss francs per year, are mainly covered by fees from licensees. Nuclear safety research promoted and endorsed by the regulatory body has a budget of about 5 million Swiss francs: some 2 million Swiss francs come from public funds and 3 million Swiss francs from the NPPs.

Supervisory authorities

On 1 January 2009, the Swiss Federal Nuclear Safety Inspectorate ENSI was formally separated from the Swiss Federal Office of Energy. It is now a stand-alone organisation controlled by its own management board (ENSI board) and with its own budget. This gives the Inspectorate complete flexibility over budget decisions and independence when recruiting personnel.

The Inspectorate currently has a staff of about 120 specialists covering the following fields:

- site inspection (5);
- reactor safety (60);
- radiation protection and emergency preparedness (20);
- waste management and transport safety (20);
- human and organisational factors (5);
- security (5);
- regulatory framework and international affairs (5).

Some additional 20 staff are involved in administration and infrastructure tasks. The number of staff has increased continuously over the past years from 110 (2009) to about 145 (2013).

Many of the additional collaborators were recruited in 2009 and 2010 for handling the applications for new NPPs. After the accident in Fukushima when the application procedures were suspended, they were used to analyse and to handle the consequences of this accident. In order to maintain the necessary number of staff for the years to come, a human capital management concept was developed in 2012. The concept will be implemented step by step to 2015.

Independent consultants are commissioned in certain specialist fields. In special technical areas (e.g. civil engineering), substantial financial means are spent every year. The Swiss Association for Technical Inspections, an independent private company, is responsible for monitoring the manufacture, repair, replacement, modification and in-service inspection of pressure-boundary components.

Quality management

The Inspectorate uses a process-oriented Management System, which was granted ISO 9001 certification (quality management) in December 2001 and ISO 14001 certification (environmental management) in November 2007. The current certificates are valid until the end of November 2013. It is also planned to obtain OHSAS 18001 certification (safety & health management) in 2014.

The Management System is applied to all relevant activities and includes the Inspectorate's safety, quality and environmental policies as well as the performance agreement between the ENSI board and the Inspectorate. The performance agreement includes strategic and operational goals as well as the budget allowance for the Inspectorate for one year. All system documents can be easily accessed by all staff members using an easy-to-use IT tool.

The Management System is subject to continuous improvement ranging from self-evaluation to internal audits, management reviews, evaluation of performance indicators and routine checks by the certification agency.

- Internal audits: ISO 9001 requires that an institution conducts an audit of its activities at appropriate intervals to verify that operations still comply with the requirements of the quality system. A team of around 10 staff members, assigned to this function and trained as quality auditors, carries out the internal audits on the basis of an annual audit plan. All processes are subject to an internal audit at least once every three years.
- Management reviews: These are carried out twice a year by senior management at the Inspectorate in order to assess the quality of staff performance (e.g. by appraising performance indicators) and to reflect changes that have occurred (or are expected to occur) in the organisation, staffing, procedures, activities and workload. Senior management is also responsible for ensuring the implementation within a specified period of actions identified by an internal audit, surveillance or reassessment visit by IRRS or the certification body together with complaints from customers and internal suggestions for improvements. This process is supported and managed by a sophisticated but simple IT tool.
- Performance indicators: Performance indicators are defined for each process, including the indicators contained in the performance mandate. The results are evaluated by the owners of the process and reviewed in conjunction with the management review mentioned above.
- External audits: Having undergone a IRRS mission by an IAEA International Regulatory Review Team in 2011, external audits in this reporting period were restricted to the annual supervisory and renewal audits required for ISO 9001 and 14001 certification by the certification company SQS and the annual financial audits carried out by KPMG. Periodical external audits, including IAEA missions, are required by the ENSI Act and the ENSI Ordinance.

These mechanisms and measures provide the means for continuous assessment and opportunities for improvements to the Management System. They also facilitate the introduction of the New Public Management Elements and generally strengthen the Inspectorate's regulatory effectiveness.

Knowledge management and training

Knowledge management and training measures are an integral part of the Inspectorate's Management System. The process includes an annually updated systematic compilation of the skill and knowledge requirements for each organisational unit. Staff training is based on this compilation. The Inspectorate operates a career development programme in order to exploit staff potential. In addition, it tries to replace employees who resign at a very early stage in order to have a degree of overlap between the person leaving and his/her successor.

The Inspectorate has also increased its involvement and participation in nuclear safety assistance programmes at many levels.

This includes participation in international working groups and IAEA services, such as the IRRS and OSART missions, staff exchanges with foreign regulators and inspection workshops in other countries. There is also close collaboration with the Swiss Federal Institute of Technology.

Cooperation with neighbouring countries

Switzerland has concluded agreements on the bilateral exchange of information on nuclear safety and radiation protection issues with its counterparts in many countries, in particular with its neighbours Germany and France. As a minimum, the agreements include early notification of nuclear accidents or extraordinary radiological situations. Collaboration with France, Germany, Italy and Austria also includes standing bi-national committees.

The German-Swiss and French-Swiss committees are the most active because those countries have sizeable nuclear power programmes. They go well beyond early notification and include the exchange of information on all relevant aspects of nuclear safety and radiation protection. Each has a permanent technical working group that meets at least once a year. Collaboration with France includes inspections of nuclear installations in both countries conducted jointly by members of the French and Swiss safety authorities. Both German-Swiss and French-Swiss commissions have proved instrumental in harmonising and coordinating trans-border emergency management. For further information on this topic, please also refer to Article 17.

Openness and transparency of regulatory activities

Due to its independent status (see clause 2), 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.

After the accident in Fukushima, ENSI created a Section responsible for communication. The five staff members are responsible for the organisation of the information activities and work closely with the management.

Under the Nuclear Energy Act (Article 74), the Inspectorate "shall regularly inform the general public about the condition of nuclear installations 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, Facebook, YouTube, etc. ENSI is committed to objectivity and avoids any speculation or placation.

In addition to annual reporting (Regulatory Oversight Report, Research and Experience Report, Radiation Protection Report and Business Report), it publishes reports on current topics – e.g. earthquakes, plane crashes, disposal of radioactive waste, etc. After the Fukushima accident, an interdisciplinary team of ENSI experts (the "Japan Analysis Team") reconstructed the events of the accident and subjected them to in-depth analysis. The results were presented to the public in four reports between August and December 2011. Also, the National EU Stress Test Report, the Peer Review Report and Action Plans following the analysis were made public.

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 Swiss Federal Office of Energy 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 (Swiss Federal Office of Energy), from other bodies with supervisory or supportive roles (ENSI, Swiss Federal Office of Topography [swisstopo]), from commissions (Federal Nuclear Safety Commission [NSC], from the National Cooperative for the Disposal of Radioactive Waste [Nagra], from the cantons), and includes one representative from each of the siting regions.

A similar panel was created by ENSI in 2012 for topics of safety of NPPs. The Technical Forum on NPPs is led by ENSI and discusses and answers technical and scientific questions asked by the population, communes, organisations, cantons and authorities in neighbouring states. The forum consists of representatives of the NPPs, NGOs, communities near NPP siting, cantons and authorities in neighbouring states as well as experts.

IRRS Mission to Switzerland

A two-week IRRS mission with a team of 24 experts from 14 countries visited Switzerland in November 2011. The International Atomic Energy Agency (IAEA) completed the final report by the review mission, under the auspices of the Integrated Regulatory Review Service (IRRS), in May 2012. It contains 19 "Good Practices", 12 recommendations and 18 suggestions. By the end of 2012, the Inspectorate drafted an action plan for the suggested improvements in view of the IRRS follow-up mission which is likely to take place in 2015.

Regarding the regulatory body, the IRRS team noted that "ENSI is institutionally, financially and politically independent". A Good Practice was given to the fact that the ENSI ordinance requires ENSI to undergo an IRRS mission periodically. On the other hand, the team made two suggestions. One was related to staffing: "ENSI should ensure there is sufficient competent staff to complete the development of the decommissioning program, to fulfil its duties regarding the safety of radioactive waste management and to further develop ENSI's emergency preparedness". The second addressed the government, which "should ensure that relevant authorities, commissions and committees, for example the NSC, involved in nuclear safety matters, provide its recommendations and advice directly to ENSI before it issues its final decision. This should be done in an open and transparent manner, in order to allow ENSI to make an informed decision". As a consequence of the first suggestion, ENSI established a section for decommissioning in August 2012 which will be further developed this year. In addition, a Human Capital Management concept was developed in 2012 which will be implemented step by step over the next three years.

Within the framework of the IRRS mission, the Management System was also assessed. The system as a whole was considered as a Good Practice: "The ENSI management system is properly established and supported by software applications, which provide a comprehensive platform to ensure that the system works properly, is user friendly and allows interconnection among various management system processes". Nevertheless, the team identified some potential for improvement and made two suggestions. One refers to the fact that not all features of safety culture are directly addressed in the Management System: "ENSI should explicitly address safety culture in its management system to achieve a common understanding of the key safety culture aspects within the organization". The second addresses organisational changes: "ENSI should establish an appropriate approach in the management system to address organizational changes". The safety culture aspects are subject to an on-going project, the results will be implemented in the Management System by 2014. Concerning organisational changes, a process for their management has already been developed and will make part of the Management System by fall 2013.

Intensive preparations for the IRRS mission under way at ENSI a few days before the mission is due to commence, November 2011.
Source: ENSI

Clause 2: Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilisation of nuclear energy.

Swiss nuclear power plants

Swiss NPPs are operated by private companies. Cantons and municipalities are the most important shareholders in these companies. The federal administration does not hold shares in the nuclear industry. The regulatory body is therefore not directly linked to any person or organisation with a commercial interest in nuclear power.

Separation of the supervisory authority for nuclear safety from other governmental bodies concerned with the use and promotion of nuclear energy

The Nuclear Energy Act requires the supervisory authorities to be independent of technical directives and formally independent of the licensing authorities. It also clarifies and expands the position, duties and responsibilities of the Inspectorate as the supervisory authority for nuclear safety in terms of the development of safety criteria and the maintenance of nuclear safety. The Swiss Federal Office of Energy is in charge of the execution of energy legislation. It deals with questions of energy economics and politics and considers issues relating to the security of energy supply.

Until 2008, the Inspectorate was part of the Swiss Federal Office of Energy, although at the technical level its actions were independent of the rest of the Office and the Federal Department of Environment, Transport, Energy and Communication. The legal review and assessment of applications by the Inspectorate was based solely on nuclear safety criteria and excluded any other consideration.

In order to grant the Inspectorate complete independence in law and to achieve formal separation between the Inspectorate and the licensing authorities, new legislation was passed: the Act on the Swiss Federal Nuclear Safety Inspectorate ENSI. In passing this Act on 22 June 2007, the National Council and the Council of States, the two parliamentary chambers in Switzerland, resolved to convert the Inspectorate into a body constituted under public law but formally, institutionally and financially independent. The Act on the Swiss Federal Nuclear Safety Inspectorate ENSI came into force on 1 January 2009 and on that date the Inspectorate was separated from the Swiss Federal Office of Energy. A new organisation was established, which took on the staff and responsibilities of the former organisation that had been part of the Swiss Federal Office of Energy. The new Inspectorate is supervised by the ENSI Board whose members are elected by the Federal Council and report directly to it.

Developments and Conclusion

The Management System of the Inspectorate is well established and provides effective support for both management and daily operations. The entire system was considered as a Good Practice in the IRRS mission of 2011. It is subject to regular minor modification in order to develop and improve the Management System. However, the basic structure of the system remains the same and still covers the requirements set down in the related ISO and IAEA standards.

Since the beginning of 2009, the Inspectorate has been an independent body constituted under public law. It reports direct to the Government but is completely separate from the Swiss Federal Office of Energy. In other words, the regulatory body is now legally, institutionally, politically and financially independent. The remit and the staff of the Inspectorate have not changed except that nuclear security has been added to its responsibilities.

Aerial view of the Gösgen NPP.
Source: Kernkraftwerk Gösgen-Däniken AG

Article 9 – Responsibility of the licence holder

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

Article 22 of the Swiss Nuclear Energy Act sets out the general obligations on the part of the licence holder. It expressly states that the licence holder is responsible for the safety of the installation and its operation. It further details the most important duties of licence holders as follows:

- to accord nuclear safety sufficient priority at all times when operating the nuclear installation and in particular to comply with prescribed limits and conditions;
- to establish a suitable organisation and employ an adequate number of appropriately qualified personnel;
- to take measures to ensure that the installation is kept in good condition;
- to carry out inspections and systematic safety and security evaluations throughout the entire life of the installation;
- to conduct a comprehensive periodic safety review in the NPPs;
- to report periodically to the regulatory authorities about the condition and operation of the installation and notify them without delay about any reportable events;
- to backfit the installation to the necessary extent on the basis of operational experience and the current state of backfitting technology, and beyond insofar as further upgrading is appropriate and results in a further reduction of risk to humans and the environment;
- to monitor scientific and technological developments, and compare operating experience and findings with those of other installations of a similar nature;
- to keep complete documentation on technical installation and on the operation of the installation, and amend the safety analysis report and security analysis report as necessary;
- to carry out appropriate measures to secure quality assurance for all activities conducted within the installation;
- to keep the decommissioning plan or the project for the monitoring period and the plan for the closure of the installation up to date.

During daily oversight activities (e.g. inspections, document reviews, safety reviews, regulatory meetings), reviews of modifications that require a permit, and safety expert reports, the Inspectorate verifies that decisions taken by the licensee meet the above stated general obligations on safety, i.e. that the licence holder retains responsibility for the safety of the installation and its operation.

All NPPs have a well-established network of contractors and have good contacts with their vendors. The responsibilities of contracted organisations that carry out safety relevant duties are laid down in contracts between the licensees and the corresponding external companies. The procedure for drawing up these contracts is part of the plant's management system and is inspected by the Inspectorate in accordance with the regulatory guidelines on the organisation of NPPs. Contracted personnel that carry out safety relevant tasks within a nuclear installation are required to comply with the policies and procedures of the NPP regarding safety. The regulatory guideline on organisation stipulates that the licence holder cannot transfer its responsibility for the safety of the installation and its operation to third parties or external organisations.

All NPPs are members of WANO and benefit from an extensive information exchange on operational experience within this network. In addition, WANO serves as an adviser to the operators in several operational areas. In fact, many of the programmes to enhance human performance in nuclear installations recommended by WANO (e.g. managers in the field, operational decision making, pre-job-briefing) are implemented in the Swiss NPPs.

In 2006 the Leibstadt NPP and the Beznau NPP established a safety controlling based on their own initiative. In each plant, the safety controlling is conducted by a senior staff person (safety controller) who is critical and open minded to safety issues. The safety controller – who has no operational duties – independently reviews a whole range of safety aspects, e.g. safety awareness and provision in daily work processes, safety provision in decision-making and in the management system's processes, and resource allocation in respect of safety. The safety controller notifies the plant manager of issues relating to safety and reports to the CEO of the plant. The safety controller's mandate lasts for about 3 years.

In 2012 the Inspectorate carried out specialist discussions to understand the significance and implications of the Fukushima accident with respect to the safety culture of Swiss NPPs (see Article 12). During these discussions, the senior management also explored the way they exercised their leadership responsibility in their NPP in response to the Fukushima accident. While reflecting their leadership behaviour, they thereby identified a number of leadership skills that proved valuable and helpful for their staff to understand and cope with the effects the accident of Fukushima had on their own NPP. These discussions allowed the Inspectorate to gain thorough insights into the way the senior management takes over leadership responsibility in unexpected situations.

All Swiss licence holders have established long standing and open relationships with the local communities. Besides regular meetings with local officials where suggestions and concerns are addressed, every site maintains a visitor centre which is freely accessible to any interested party. On appointment, it is also possible to tour the nuclear plants and to access its main buildings. In the last forty years more than a million people have taken advantage of this opportunity.

The licence holders also participate in two technical safety fora chaired by ENSI (see Article 8). Their main purposes are to receive, discuss and answer questions from the public about technical safety aspects of nuclear power plants and geological repositories.

It is also worth mentioning that the direct democratic system of Switzerland leads to numerous local and national referenda concerning nuclear energy and nuclear waste. As a result, frequent and transparent communication with the public is a high priority, not only for licence holders but for all stakeholders in nuclear energy. For example, the siting process (sectoral plan) for geological repositories for nuclear waste foresees extensive interaction with, and participation of, the public which surpasses common communication practices.

The licence holders are owned in the majority by cantons or communities. As a result, many locally elected officials are board members, formalising another means of contact between the licence holders and the direct representatives of the public.

The changed perception in society and the associated discussions about the use of nuclear energy in Switzerland did not remarkably affect the personnel fluctuation rate in the NPPs. However, the NPPs did start to elaborate personnel development measures, personnel binding measures as well as personnel recruitment measures. The NPPs report to the Inspectorate that personnel recruitment currently demands greater effort. The reasons for this greater effort, however, must also be seen with the changes in the perception and reputation of the engineering professions, which is leading to a lack of skilled workers and problems in finding new recruits.

At the beginning of the nuclear industry in Switzerland, the Swiss NPPs founded the "Group of Swiss NPP Managers" (Directors). The group itself and the subgroups in the areas of Operation, Training, Management System, Human System Interface, etc., meet regularly several times a year for exchange of experience and for the development of new concepts.

Developments and Conclusion

The present report gives practical examples of how Switzerland complies with this Article.

Article 10 – Priority to safety

Each Contracting Party shall take the appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

To give the necessary priority to safety by organisations engaged in activities related to nuclear facilities is a general obligation of each licence holder, as stated in the Swiss Nuclear Energy Act. All licensees have implemented this obligation in their management system and have established an operating policy that gives due priority to nuclear safety. This operating policy is communicated to all staff in the NPP and submitted with other documents to the Inspectorate. Modifications to the operating policy of an NPP require a permit in accordance with the Nuclear Energy Ordinance.

The obligation to give the necessary priority to safety is also demonstrated by the commitment of these organisations to external comparison, peer review, and improvement. All Swiss NPPs underwent Operational Safety Review Teams (OSART) missions, including the follow-up missions. In December 2011, Switzerland called for another OSART mission to the Mühleberg NPP which reached 40 years of commercial operation in 2012. The OSART mission took place in October 2012 (see Article 19). Every Swiss NPP is also a member of the World Association of Nuclear Operators (WANO) and, since 2005, all Swiss NPPs have been involved in the WANO peer review process. The scheduled cycle for WANO peer reviews and WANO follow-up missions is about six years. Due to this six year cycle, no review took place in the years 2010 and 2012. In 2011, however, peer reviews were performed in the Beznau and the Leibstadt NPP, and in March 2013 the WANO follow-up mission took place in the Beznau NPP.

ENSI also demonstrated a commitment to peer review and improvement, by hosting an IRRS mission in 2011 (see Article 8).

Furthermore, it is essential that Switzerland's national security is safeguarded and that the country complies with its international commitments at all times. In its supervisory functions, the regulatory body has a legal obligation to afford the highest priority to nuclear safety.

From a technical standpoint (i.e. design and construction), Swiss NPPs comply with the current state of science and technology by virtue of the fact that their original design has been strengthened through backfitting. However, the Swiss response to the Fukushima accident also resulted in technical measures to improve the safety of the NPPs (see Articles 6 and 16-19).

Personnel in all plants are well aware of the safety implications of their activities and this level of awareness is continuously reinforced by safety-related training. The safety culture in all Swiss NPPs is an important means in fostering high levels of safety (see Article 12). All plants reflect this understanding of the importance of safety culture by designing programmes to improve it. These programmes take the form of training sessions, workshops, investigation of safety significant events, self-assessments, etc.

Occasionally, there is a difference of opinion between the safety authority and NPPs on the need for certain regulatory requirements. In the ensuing discussions, a cost benefit analysis is conducted to compare the cost and the technical justification for the required regulation. To ensure that the decision-making process is transparent, the Inspectorate uses the following graded approach in order to decide whether a safety measure is justified:

- safety measures required by legislation (this includes licence conditions);
- recommended safety measures based on the state of science and technology;
- safety measures that appear desirable on the basis of experience and current backfitting technology and are also reasonable based on a cost-benefit analysis.

Developments and Conclusion

All Swiss organisations engaged in activities related to nuclear facilities comply with the obligation to give the highest priority to safety. All licensees have implemented this obligation in their management systems. It is also demonstrated by their commitment to external comparison, peer review, and improvement.

Article 11 – Financial and human resources

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.

Swiss nuclear legislation stipulates that nuclear installations must be kept in good condition and the licensee must provide persons with responsibility for the safe operation of a nuclear installation with the necessary resources.

Licensees are well-established companies with a good financial record. They are in the majority owned by cantons (states) or communities. To date, they have covered all costs associated with the construction, operation and maintenance (including replacement of obsolete or worn components) of their NPP. They have also paid fees to the regulatory body (see Article 8). They voluntarily implemented many modifications or backfitting measures shown to be necessary by virtue of developments in science and technology. These voluntary updates are in addition to those required by the safety authorities (see Articles 6 and 18).

If, for any reason (e.g. inadequate financial resources), the licensee could or would not implement any future backfitting measures considered necessary and required by the safety authorities, the licensing authority would suspend or revoke its operating licence. An NPP facing such a suspension or withdrawal of a licence would have an interest in ensuring that requirements are met if it wished to continue normal operations.

A decommissioning fund has been established as required by the Swiss Nuclear Energy Act. It covers the cost of decommissioning, including later dismantling. It is financed by regular contributions from the licence holder. In 2011 the licensees published a new set of decommissioning studies which took into consideration the latest experiences from on-going decommissioning efforts internationally. The new study foresaw increased costs and lead immediately to increases in the fees paid into the funds. If after the final shutdown the resources paid in the fund during the operation of the plant are insufficient to cover the cost of decommissioning an NPP, the licensee is still required to pay the difference. If the licensee is financially not capable of doing so, the licensees of the other NPPs would be required to intervene and to cover the deficit.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.

Requirements regarding qualified staff

Under the Swiss Nuclear Energy Act, there must be a sufficient number of qualified staff with the expertise required to manage and control a nuclear installation during all phases of its life cycle. A minimum level of staffing with qualified personnel is stipulated for the plants on a 24-hour basis. This ensures that adequate staff is present in the plant at all times to operate under normal conditions, to initiate alarms and for the first measures required in case of an emergency.

Moreover, all employees of Swiss NPPs are members of the respective Emergency Response Organization (ERO), so the plants can always draw on a sufficiently large pool of specialists for their ERO.

The specific minimum qualifications and training of specialised staff are laid down in the relevant ordinances (Nuclear Energy Ordinance, the Ordinance governing the requirements for personnel in nuclear installations, the Ordinance relating to checks on the trustworthiness of personnel and the Ordinance on security guards). In addition to the technical qualification, the Ordinance governing the requirements for personnel in nuclear installations includes that NPP personnel have to be medically as well as psychologically fit for their functions. In this context, NPPs conduct tests for psychotropic substances calling into question the fitness for the job.

Staff working at the Gösgen NPP.
Source: Kernkraftwerk Gösgen-Däniken AG

Staffing

The Nuclear Energy Ordinance and related guidelines issued by the Inspectorate stipulate the organisational arrangements required for the operation of nuclear installations. The Nuclear Energy Ordinance stipulates that the facility must be structured in a way that ensures internal responsibility for at least the following activities and areas:

- operation of the installation in all operating modes;
- maintenance, material technology and testing methods, technical support;
- design and monitoring of the reactor core;
- radiation protection and radioactive waste;
- water chemistry and use of chemicals additives;
- emergency planning and preparedness;
- supervision and assessment of nuclear safety;
- security;
- quality assurance for services provided by contractors;
- initial and continuing training of personnel;
- fostering of safety awareness.

There are no specific requirements with regard to staffing levels in NPPs. At the end of 2012, the Mühleberg NPP had a workforce of 345, the twin-unit Beznau NPP had a workforce of 547, the Gösgen NPP had a workforce of 503 and the Leibstadt NPP had a workforce of 541. These figures represent a substantial increase in staffing at all Swiss NPPs since 2009.

All Swiss plants have long been implementing programmes to ensure early replacement of retiring staff to guarantee that sufficient time is available for the transfer of know-how to new employees. In addition to these programmes, the NPPs increasingly started to elaborate personnel development measures, personnel binding measures as well as personnel recruitment measures. These measures must be seen primarily as accompanying measures to compensate for the changes in the perception and reputation of the engineering professions, which is leading to a lack of skilled workers and problems in finding new recruits. At present, the changed perception in society and the associated discussions about the use of nuclear energy in Switzerland has not remarkably affected the personnel fluctuation rate in the NPPs.

In addition to employing their own personnel, licensees use contractors, particularly for maintenance during the annual refuelling outages and plant modifications. They include specialists from the manufacturer or supplier of major components or systems and other external experts for specific tasks. During these outages, the Inspectorate oversees the qualification and reliability of the contractors' personnel.

Methods used for the analysis of competence, availability and sufficiency of additional staff required for severe accident management, including contracted personnel or personnel from other nuclear installations

The requirements for knowledge, skills and competence of the staff in NPPs are established in the "Ordinance on the Requirements for the Personnel of Nuclear Installations", in the "Ordinance about Education and Training in Radiation Protection", in the Guideline B10 "Education, Qualification and Requalification of Personnel", in the Guideline B11 "Emergency Exercises" and in the Guideline B13 "Training and Continuing Education of the Radiation Protection Personnel", which cover actions in radiation protection in incidences and accidents. The Inspectorate examines the fulfilment of these requirements by recognition of education and training courses and/or the recognition of individual competences. Furthermore, the availability and competence of professionals for severe accidents management are checked annually by means of inspections of emergency preparedness exercises at all NPPs. These inspections prove that, for example, the radiation protection personnel is able to act in accident situations in appropriate ways. Investigations on necessary improvements about the sufficiency of staff have been started with expert discussion between the Inspectorate and NPPs in consideration of international experience exchange, e.g. in the ISOE Expert Group on "Occupational Radiation Protection in Severe Accident Management and post-accident Recovery" and in the WGHOF of NEA, CSNI on "Human Performance under Extreme Conditions". Finally, the last update of the Guideline B11 now requires plant emergency exercises to be carried out with an emphasis on the engagement of the plant fire brigade. Such exercises are to be organised on a regular basis and the participation of plant external fire brigades within such plant emergency exercises is now foreseen as well. Such exercises primarily serve the purpose of training and verification of the operational readiness of the plant fire brigade.

Licensing of operators

The control room operators, shift supervisors, and stand-by safety engineers working in NPPs need a licence. Licences are granted by the NPP to specialists who satisfy the conditions in the Ordinance governing the requirements for personnel in nuclear installations. The licensee can only grant a licence to an operator if the candidate passes the examinations specified in the before mentioned Ordinance. The examination board consists of representatives from the licensee and the Inspectorate. To pass an examination, the candidate must have the unanimous consent of both parties.

Education and training

The Ordinance governing the requirements for personnel in nuclear installations specifies the education, knowledge and experience required by the personnel that perform safety-relevant activities in nuclear installations (e.g. plant managers, licensed operators, personnel carrying out maintenance duties).

The personnel selected as potential candidates to obtain a licence, i.e. reactor operators, shift supervisors and radiation protection experts, must have successfully completed a vocational training of 3 – 4 years in a technical profession and have a minimum of two years' experience in their profession (the latter is not compulsory for radiation protection experts) before starting their operator's and radiation protection expert training, respectively. Stand-by safety engineers must be in the possession of a shift supervisor's licence as well as of an engineering school or university degree.

The Reactor School at the PSI provides specific training in nuclear fundamentals, the basics of electrical and mechanical engineering, water chemistry, safety concepts and radioprotection. The selection procedure for all licensed control room personnel includes aptitude tests. Under the Ordinance governing the requirements for personnel in nuclear installations, plant managers must have an engineering or university degree, basic knowledge of nuclear engineering and the specific knowledge required for the individual function together with management experience and experience in the relevant NPP.

The education and training required for control room personnel to obtain a licence is given in summary form below:

- Field operators: Employees wishing to become licensed control room personnel must start as field operators. There is no licensing at this level. However, it is common for such operators to have passed an officially recognised examination. Courses and on-the-job training provide them with a good understanding of the NPP and also a basic understanding of radiation protection, physics and nuclear engineering.
- Reactor operators: This function requires a formal licence. Candidates for positions as reactor operators must have worked for one or two years as a field operator. They must complete a detailed theory course at the Reactor School at the PSI or an equivalent institution. On completion of this basic education, candidates complete plant-specific training. This takes the form of various courses at the NPP, on-the-job training and simulator training.
- Shift supervisors: Applicants for this function must be experienced reactor operators (one to three years of experience). They receive additional education and training in leadership, specific plant behaviour, procedures and also undergo full-scope simulator training with their team.
- Stand-by safety engineers: Shift supervisors with an engineering school or university degree can become stand-by safety engineers. In particular, they need further training in leadership under unfavourable conditions plus an extensive and detailed knowledge of emergency procedures.

Radiation protection specialists and radiation protection technicians are trained at the Radiation Protection School at the PSI or an equivalent institution abroad. The final examinations of candidates for both functions are supervised by the Inspectorate.

Adequate recurrent training exists for all of the above functions. It comprises simulator training (except for radiation protection experts), plant-specific courses and theoretical courses, usually at the Reactor School and the Radiation Protection School at the PSI. The training of licensed control room personnel is provided by members of the training section of the relevant operational department. They are professionals and are trained in adult education.

All Swiss NPPs have full-scope replica simulators on site. Thus, each NPP has its own site-specific simulator training, which is also used for requalification purposes. Training activities are supervised by the Inspectorate.

Non-licensed personnel in NPPs are also well educated and trained. Regular retraining is provided to ensure that personnel are up to date with advances in science and technology and plant modifications.

The financial resources allocated to training are defined in the annual budget produced by the NPP. The annual management meeting between NPPs and the Inspectorate includes an overview of this budget.

In order to maintain specific expertise in nuclear technology within Switzerland, Swiss NPPs sponsor a dedicated professorship at the Swiss Federal Institute of Technology, Zurich.

Developments and Conclusion

The existing nuclear installations have adequate financial resources to support the safety of each nuclear installation. They also have sufficient qualified staff with appropriate education and training for all safety-related activities together with adequate retraining opportunities.

Article 12 – Human factors

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

Organisation and Safety Culture

The obligation of the licensee to establish a suitable organisation (i.e. organisational structures and processes) is firmly embedded at several places in the Swiss legislative framework. The Nuclear Energy Ordinance sets out requirements concerning the organisation that are specified in detail in the guideline "Organisation of Nuclear Power Installations". The guideline describes the requirements of the Inspectorate in terms of organisational structure and work processes of the NPPs together with the requirements to be taken into account by the operating organisation to ensure the safe management of technical as well as organisational changes. The guideline also stipulates that the operating organisation must give top priority to safety in all plant activities.

The guideline on Organisation of Nuclear Power Installations is currently under revision. The aim of the revision is to incorporate the IAEA requirement on management systems as well as the WENRA reference levels on organisational requirements into the regulatory framework by adapting them to the Swiss circumstances. The revision of the guideline will cover the operation as well as the post-operation phase of a nuclear installation. The revised guideline will be implemented in the course of 2013.

Attention is also given to the concept of safety culture. The actual as well as the revised version of the guideline on organisation stipulates that the licensee has to anchor measures in its management system to observe, to assess, and to strengthen its safety culture. Further, the licensee must also define the meaning of the term as well as the principles and prominent features of safety culture in a document that is considered binding for all employees.

The Inspectorate has conducted a series of oversight activities, e.g. inspections and technical discussions in the field of organisation as well as safety culture. In addition to these ordinary oversight instruments for organisational as well as plant engineering issues, the Inspectorate employs a specific method to oversee safety culture: specialist discussions on safety culture issues. The aim of these discussions is to establish a platform where the licensees can reflect on safety culture topics previously set by the Inspectorate. The discussions are facilitated in an open and constructive way by the Inspectorate.

In the aftermath of Fukushima, the Inspectorate formed an interdisciplinary analysis team to understand the scope and complexity of the accident in Fukushima. The analysis team also included experts in the field of people and organisation. In 2011 the Inspectorate published its analysis of the accident. One of these reports was dedicated to the analysis in the field of people and organisation (see: www.ensi.ch). It shows that human factors play a key part not only in preventing an accident but also in bringing it under control. The organisations of operators and authorities in which people work must take account of human factors by means of appropriate structures and procedures, and with the help of a suitable safety culture. And they must be able to cope with the unexpected.

Based on these findings in the field of people and organisation, the Inspectorate conducted a specialist discussion on safety culture in 2012. The aim of the discussion was to understand the significance and implications of the Fukushima accident with respect to the safety culture of Swiss NPPs. The target group of the discussions were the members of the senior management in the NPPs. The discussions yielded debates of hypothesis like "the accident in Fukushima represents a fundamental surprise and questions basic assumptions" and initiated the reflection on prominent pillars of safety culture in unexpected situations.

The response programme launched by the Inspectorate in the wake of the Fukushima accident as well as other external influences forced the NPPs to adapt their organisation structure to new scenarios. To ensure that organisational changes do not impact negatively on safety, the Inspectorate set out clear requirements for the management of organisational changes in its guidelines on the organisation of nuclear power installations.

Human Factors Engineering

The Nuclear Energy Ordinance lays down a series of design principles for NPPs, including a principle relating to human factors engineering: "Work stations and processes for the operation and maintenance of the installation must be designed so that they take account of human capabilities and their limits". The Inspectorate pays particular attention to this principle when it oversees modifications that affect human-machine interfaces. Since 2007 the Inspectorate demands a human factors engineering programme together with the initial concept of modernisation projects. By means of the human factors engineering programme, the licensee has to describe how human and organisational factors (e.g. a human-centred design process, integration of operating experience from predecessor or similar systems, multidisciplinary project management) are continuously and systematically integrated throughout the entire modification project.

The human factors engineering programme adopts a graded approach. This ensures that appropriate resources are allocated in accordance with the criteria in Paragraph 2.6 of the IAEA Safety Standard GS-R-3.

Event Analysis

All NPPs conduct thorough investigations of human and organisational factors whenever they are identified as the root cause or a contributing factor in events with a relevance to safety. If these investigations identify weaknesses in these areas, this triggers an assessment of similar situations in other NPPs.

The Nuclear Energy Ordinance states that all NPPs must appoint a committee to analyse events and outcomes attributable to human and organisational factors. All NPPs have appointed such committees, who receive adequate education and training on a regular basis.

Transparency and effectiveness of communication among operators

During normal operation:

The operators actively communicate their experience and results at an international level with regards to international missions (e.g. WANO, OSART). In fact, all Swiss NPPs underwent OSART missions including a follow-up mission (the last follow-up mission took place in October 2012 in the Mühleberg NPP) and all of them have implemented the recommendations listed in the OSART reports. All Swiss OSART reports are derestricted and available to the public. For further information with regard to transparency and effectiveness among operators during normal operation, please refer to Article 9.

During an emergency:

To ensure communication in an emergency, dedicated telephone and fax lines between the NPPs, the Inspectorate and the National Emergency Operations Centre are available. These communication systems are tested once a month. Moreover, because the Leibstadt and Beznau NPPs are close to the national border, special plans have been agreed with Germany. These plans are designed to ensure the same level of protection on both sides of the border for the public and the environment. They also seek to harmonise procedures. Dedicated telephone lines exist for communication between authorities. Plans and procedures are updated regularly by bilateral working groups as part of the German-Swiss Commission for the Safety of Nuclear Installations. For further information on this topic, please refer to Article 16.

Transparency and effectiveness of communication among regulators

ENSI as an independent body constituted under public law reports directly to the government and is fully separated from the Swiss Federal Office of Energy. 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 defined exceptions, for instance security-related information, personal data, or trade secrets. ENSI regularly informs the public about its activities. For more detailed information with regards to this topic, please refer to Article 8.

Furthermore, Switzerland has signed agreements on the exchange of information with Austria, France, Germany and Italy. Within these committees, national regulators exchange their experience and information on nuclear regulatory issues once a year. For further information, please refer to Article 17, Clause 4.

Transparency and effectiveness of communication among international organisations

With regards to exchange with international bodies, ENSI is already represented in more than 70 international committees with the goal of exchanging operational and regulatory experience, developing the state of the art in science and technology to a level up to international standards. The majority of these bodies are part of the International Atomic Energy Agency (IAEA) and the Nuclear Energy

Agency (NEA) of the OECD. ENSI furthermore actively participates in organisations covering national bodies: as Chair of the Western European Nuclear Regulators' Association (WENRA), as observer in the European Nuclear Safety Regulators' Group (ENSREG) together with the European Nuclear Energy Forum (ENEF), and as a member of the European Union Clearinghouse.

All Swiss country reports for the Convention on Nuclear Safety (CNS) and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management are also published on ENSI's website.

Developments and Conclusion

In accordance with the Nuclear Energy Ordinance, the Inspectorate has continued to establish requirements applying to human and organisational factors and has pursued its effort to oversee these requirements in projects to modernise plants. The Inspectorate has also continued to develop methods to oversee the organisation of NPPs as well as their safety culture.

Screenshot of ENSI's Website
Source: ENSI

Article 13 – Quality assurance

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.

All Swiss NPPs have an integrated management system and are certified under ISO 9001 (Quality Management), OHSAS 18001 (Occupational Health and Safety) and ISO 14001 (Environmental Management) norms. All NPPs have incorporated appropriate self-assessment processes in their management systems. The management systems are audited periodically by the certification institute and the certificates are renewed on a regular basis. During the reporting period, all Swiss NPP allocated resources to verify their management system against the requirements of the IAEA Safety Standard GS-R-3.

The Inspectorate concentrates its supervisory activities on the aspects of the licensee's management system that are relevant to safety. It does this by performing inspections of safety-relevant processes like, for example, the plant modification process, the event analysis process, and different work processes during outage periods.

Regulatory inspections are also performed in respect of the quality management documentation, the results of internal and external audits and resultant improvement measures. Specific inspections are conducted if major changes are made to the management system requiring notification to the Inspectorate.

All NPP activities other than normal operation, e. g. backfitting, replacement and modifications to systems and components, need a permit. In order to achieve the regulatory approval, the Inspectorate assesses the quality assurance measures as well as the quality plans of these activities. During the reporting period, the Inspectorate started to intensify its oversight activities in the area of quality control with special attention to safety relevant documents of the licensees submitted to the Inspectorate. The reason for this is an accumulation of submitted documents of insufficient quality. The oversight is taking into account the recommendation of the IRRS Mission from 2011 to establish a regulatory requirement for licensees to independently verify all safety information prior to its submittal to the regulatory body.

The Inspectorate requires all Swiss NPPs to include specific quality management rules on the transport of radioactive materials in their management system. These rules comply with the IAEA Safety Standard TS-R-1 and were approved by the Inspectorate following the positive results of an audit. Regular audits take place at 2 – 3 year intervals.

Developments and Conclusion

All Swiss NPPs have an integrated management system that is certified under ISO 9001. The management systems are audited periodically by the certification institute and the certificates are renewed on a regular basis. The Inspectorate regularly performs inspections to assess the effectiveness of quality assurance measures incorporated in the management system.

Article 14 – Assessment and verification of safety

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body.

Overview of the Contracting Party's arrangements and regulatory requirements to perform comprehensive and systematic safety assessments

For existing plants, a Periodic Safety Review (PSR) is required at least every ten years. Important elements of a PSR are an update of the Safety Analysis Report (SAR), an assessment of design base accidents, an assessment of the ageing surveillance programme, an update of the Probabilistic Safety Analysis (PSA) and an evaluation of operating experience in the last 10 years. The details (scope and process) of a PSR are defined in the Inspectorate's Guideline R-48. This guideline is currently being updated.

Modifications to or the backfitting of components and documents important to safety (e.g. Technical Specifications) must be approved by the Inspectorate. The Inspectorate's associated review may involve inspections (see Clause 2).

Relevant data from inspections, event assessments and safety indicators are collated and provide a foundation for the systematic assessment of operating safety which is carried out annually (see Clause 2).

The above safety analyses are explicitly specified in the Nuclear Energy Ordinance as the requirements for the analysis and reports to be submitted for decommissioning projects. The following paragraphs provide further information on certain safety analyses.

Further reviews and assessments of the design base are mandatory if events of INES 2 and higher occurred in a national or international NPP. As a direct consequence of the major accident in Japan, the Inspectorate issued three formal orders (on 18 March 2011, 1 April 2011 and 5 May 2011) in which the operators of the Swiss nuclear power plants were required to implement immediate measures and to conduct additional reassessments. The Inspectorate ordered immediate measures which comprised the establishment of an external emergency storage facility for the Swiss NPPs, including the necessary plant-specific connections, and backfitting measures to ensure the provision of external injection means into the spent fuel pools. The additional reassessments, which were to be carried out immediately, focused on the design basis of Swiss NPPs against earthquakes, external flooding, and combination thereof. Investigations were also requested regarding the coolant supply for the safety systems and the spent fuel pool cooling, taking into account the immediate lessons learnt from the accident in Japan. Additional studies were carried out to assess the probability of an explosion caused by hydrogen production in the spent fuel pools. This was considered to be the main reason for the explosion at the Fukushima NPP in the early stages of the investigation.

Safety assessments within the licensing process and safety analysis reports for different stages in the lifetime of nuclear installations

As a consequence of the accident at the Fukushima Daiichi NPP, plans for new-builds have been suspended by the Swiss government. On-going activities regarding safety assessment of the different stages in the lifetime of nuclear installations consist of periodic assessments included in the next topic and assessments of long-term operation for existing Swiss NPP's.

Long-Term Operation

Around 2004 ENSI started to develop an approach for the evaluation of long term operation (LTO) of nuclear power plants in Switzerland. ENSI's approach is based on international recommendations, IAEA-Safety Guides NS-G-2.6 and 2.12, and IAEA-SALTO Guidelines, WENRA Reactor Safety Reference Levels K and I, and on the Swiss legal basis, Nuclear Energy Act, SR 732.1, Nuclear Energy Ordinance, SR 732.11, DETEC Ordinance on the Methodology and the General Conditions for Checking the Criteria for the Provisional Taking out of Service of Nuclear Power Plants, SR 732.114.5 and the ENSI-Guidelines B01, B06 and NE14. The LTO safety case shall cover two main areas: material ageing and conceptual ageing. In the first area the focus is on the ageing management programs (e.g. maintenance, in-service inspection, in-service testing) and on the status of major plant components (e.g. RPV, containment, selected reactor coolant pipings) with respect to the relevant ageing mechanisms including forecast analyses over the next reporting period. Within the area of conceptual ageing the focus is on the plant safety concept (updated deterministic and probabilistic analyses) and on backfits (considering the advancements in the state-of-the-art of backfitting technology). In particular the licensee is required to demonstrate that the limits described in the DETEC Ordinance SR 732.114.5 are kept, an infringement implying that the NPP has to be provisionally shut down.

The required LTO safety cases were submitted by the licensees in 2008 for the Beznau NPP and in 2010 for the Mühleberg NPP. Results of ENSI review are described in the LTO safety evaluation reports dated November 2010 for the Beznau NPP and December 2012 for the Mühleberg NPP and hereafter briefly summarized.

With regard to the ageing management program of the Beznau NPP ENSI established that the LTO requirements are essentially met for the safety-related electrical and mechanical equipment as well as for the concrete structures. Nevertheless, it is known that the neutron embrittlement of the Beznau-1 RPV and the corrosion degradation of the steel containment of Beznau-1 are more developed than in case of Beznau-2. Therefore, additional detailed analyses using state-of-the-art technology methods and mitigation measures were required by ENSI. Finally, it was observed by ENSI that there is no indication that the terms and conditions for a provisional shut-down of the Beznau NPP will be fulfilled at least for an additional period of 10 years of operation.

As a result of the LTO review it was confirmed by ENSI that the design basis of the Beznau NPP was kept updated with internationally accepted safety standards and methodology. Backfitting measures, as requested by the Nuclear Energy Act, were continuously implemented. The backfitting of structures as well as electrical and mechanical equipment was performed in consideration of the state-of-the-art of backfitting technology. ENSI gave a positive review to an application of the Beznau

NPP aiming at improving the emergency power supply with the substitution of the hydropower station with diesel generators located in separated buildings designed against the newest earthquakes and flooding hazards. Taking into account the improved emergency power supply and other backfitting measures it will be possible to further improve safety of Beznau-1 and -2.

With regard to the ageing management program of the Mühleberg NPP ENSI concluded that it essentially complies with the LTO requirements. Nevertheless, improvements were identified for the ageing management of mechanical equipment of safety class 4. Furthermore, ENSI asked for replacement of all those electrical cables 1E for which design documentation is not available anymore. As regards the status of major components detailed assessments of RPV irradiation embrittlement, reactor coolant piping as well as fracture mechanics analyses of the core shroud cracking were carried out using state-of-the-art methods. ENSI required an improvement of the safety concept for the tie rods on the core shroud in case that one or more circumferential welds would unexpectedly fail. Questions were raised on the testing program and analysis with state-of-the-art methods for areas with limited access of the steel containment of the Mühleberg NPP. Finally, it was observed by ENSI that there is no indication that the terms and conditions for a provisional shutdown of the Mühleberg NPP will be fulfilled at least for an additional period of 10 years of operation.

With respect to the deterministic and probabilistic safety analyses of the Mühleberg NPP it was confirmed by ENSI that the design basis was kept updated with internationally accepted safety standards and methodology. Backfitting measures, as requested by the Nuclear Energy Act, were continuously implemented. Nevertheless after the accident in Fukushima safety analyses were reviewed taking into account the most updated hazard assumptions for earthquakes and flooding. After in-depth review of the licensee's safety cases, ENSI requested additional backfits:

- backfitting of an additional cooling water supply independent from the Aare river,
- backfitting of an additional cooling system for the spent fuel pool designed against the newest earthquakes and flooding hazards,
- upgrading of the spent fuel pool instrumentation,
- backfitting of an additional residual heat removal cooling system.

Taking into account these backfitting measures it will be possible to further improve the safety of NPP Mühleberg.

Periodic safety assessments of nuclear installations during operation using deterministic and probabilistic methods of analysis, as appropriate and, conducted according to appropriate standards and practices

In addition to the continuous review and evaluation of plant modifications, the Periodic Safety Review (PSR) is an important control mechanism for both licensees and the Inspectorate. It enables them to identify and assess the actual state of safety in a plant in order to ensure the compliance with legal requirements, the provisions of the licenses and the official stipulations of the Inspectorate. The actual plant status and past operating experience are compared against the current state of science and technology and operating experience from other plants. The licensee carries out the PSR and the Inspectorate evaluates the PSR report submitted by the licensee. The Inspectorate adds its own experience from previous inspections, assessments and reviews.

The concept of defence in depth as described in the IAEA Safety Standard NS-R-1 plays a central role in the PSR and its evaluation. In its report, the licensee is required:

- to explain the plant-specific implementation of safety policy;
- to assess the operating performance and management of the plant;
- to perform a deterministic safety status evaluation;
- to perform a probabilistic safety analysis.

Based on the evaluation mentioned here above, the licensee must demonstrate that the fundamental safety functions specified in SSR-2/1 and the radiological protection issues are effective in both normal and abnormal plant operation. The licensee must also demonstrate how the evolving state of science and technology is taken into account in the plant's design and operation and how the experience gained from similar plants worldwide is integrated. In addition, in its assessment of operating experience over the last 10 years, the licensee must pay particular attention to human and organisational factors and their impact on safety. The Inspectorate's assessment also considers the licensee's safety culture. The PSR includes not only a review of the plant's current safety status but also an assessment of its future safety status.

Deterministic analysis

The Nuclear Energy Ordinance requires Swiss nuclear power plants (NPPs) to implement a Deterministic Safety Status Analysis (DSSA). The Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations assigns one of three categories to the design-basis accidents according to their frequency of occurrence and defines technical criteria of compliance and related safety objectives dependent on the assigned accident category. The review of DSSA aims to verify the expected behaviour of the plant under assumed abnormal conditions as defined in the Inspectorate's Guideline A01, which has been in force since July 2009. Based on a set of accident scenarios, the licensee must demonstrate that the relevant plant and core-specific parameters remain within safe limits and comply with the technical criteria. In addition, the licensee must demonstrate that it complies with the individual dose limits for the public, as defined in the Radiological Protection Ordinance. The guideline ENSI-A01 focuses specifically on:

- suitability, validation and compliance with best estimate computer software; conservative initial and boundary conditions for the analysis are to be used.
- compatibility of analysis assumptions with system and component design;
- conservatism of simplifications and assumptions in the analysis; and
- adequacy of assumed single failures following initiating events.

The Inspectorate's review also includes evaluations of design basis analyses (e.g. loss of coolant accidents, etc.) using appropriate program codes and its own plant models, which are being further developed, in keeping with the backfitting measures of the plant.

Beyond-design-basis accidents (BDBA), which refer to rare external events including common-cause failures or combination of failures, are also addressed in the Inspectorate's Guideline A01, section related to Design Extension Conditions (DEC). The main technical objective of considering the design extension conditions is to provide assurance that the design of the plant is such as to prevent accident conditions not considered design basis accident conditions or to mitigate their consequences as far as is reasonably practicable. In case of non-compliance of the deterministic analyses with the requirements defined in the Inspectorate's Guideline A01, the licensee must submit an implementation plan containing a schedule for the required steps. The goal is to achieve a deterministic safety status which satisfies entirely the requirements of the current rules and standards.

Probabilistic analysis

The Nuclear Energy Ordinance requires Swiss nuclear power plants (NPPs) to use Probabilistic Safety Analysis (PSA). The Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations requires the probabilistic consideration of beyond-design-basis accidents. In addition, there are two PSA guidelines aimed at harmonising the development and use of PSA:

- Guideline A05 defines the quality and scope of requirements for the plant-specific Level 1 and Level 2 PSA for NPPs and other nuclear installations.
- Guideline A06 formalises the requirements for applying PSA to NPPs. It defines general principles, requirements for the review and upgrade of PSAs and the required scope of PSA applications.

All Swiss NPPs maintain plant-specific Level 1 and Level 2 studies, including internal and external events such as fire, flooding, earthquakes, aircraft impacts and high winds. Full power as well as low power and shutdown modes are considered in both the Level 1 and Level 2 PSA. However, for one NPP the Level 2 PSA for shutdown mode is still under development.

PSA studies are reviewed and updated regularly in order to reflect PSA-relevant plant hardware and operational changes. As part of the Periodic Safety Review (PSR), PSA studies are revised as needed to reflect advances in methods and current operating experience. At least once every five years, PSA models are updated to reflect plant modifications and the availability of additional reliability data. Guideline A06 also defines the conditions for updating the PSA models at other times for plant modifications not yet incorporated in the PSA models but which may have an impact on PSA results.

The Inspectorate's PSA review aims to develop a thorough understanding of plant attributes, its vulnerability to potential severe accidents and plant-specific operating characteristics. The review focuses on a general evaluation of PSA models, assumptions, analytical methods, data and numerical results and also focuses on understanding the range of uncertainties in core-damage frequency, fuel-damage frequency, containment performance and radioactive releases.

The requirements of Guideline A05 form the main basis of the review. At the beginning of the review, ENSI verifies whether the PSA documentation is complete and assesses the PSA approach and analytical methods, as well as the plant design features intended to prevent and mitigate potential severe accidents. Based on the results of this evaluation, the Inspectorate submits requests for additional information to the licensee and its responses are used in the review. In addition, site audits, including plant walk downs, are conducted. A detailed regulatory review of the

PSA is conducted in particular within the PSR.

To ensure that both the licensee and the Inspectorate are made fully aware of the relevant risks identified in the PSA studies, the following fields of application of a PSA are specified in Guideline A06 as a binding requirement:

- probabilistic evaluation of the safety level;
- evaluation of the balance of risk contributions;
- probabilistic evaluation of plant modifications including technical specifications;
- assessment of components contributing to risk;
- probabilistic evaluation of operating experience (two types of analyses are conducted: analysis of the annual, plant-specific cumulative risk and an analysis of any event affecting PSA-relevant structures, systems and components).

Further applications of PSA include the use of PSA as a basis for the development of Accident Management measures and Severe Accident Guidances (SAMGs). The Level 2 PSA is used as a technical basis for the development of SAMGs. SAMGs have been developed for all Swiss nuclear power plants.

According to the latest results of probabilistic safety analyses, the safety objectives of the IAEA for existing nuclear power plants – recommending a core damage frequency of less than 10^{-4} per year and recommending a large early release frequency of less than 10^{-5} per year – are met by all Swiss nuclear power plants.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.

As already mentioned in the response to Clause 1, appropriate safety analyses must be submitted to the Inspectorate in support of an application, as required before any modification or back-fitting to safety-related systems or components. The following proofs are required before any such permit can be granted: evidence of the suitability of the manufacturing process and of the assembly and commissioning processes, evidence of compliance with safety limits, details of the dedicated start-up tests as required, procedure for periodic inspections and audits, and finally probabilistic evaluation in view of the impact on the plant core damage frequency. These proofs are required in order to ensure that each modification or backfitting measure conforms to previously approved safety requirements and that the relevant safety margins and operational limits are maintained.

Overview of the Contracting Party's arrangements and regulatory requirements for the verification of safety

The Inspectorate's arrangements and regulatory requirements for the verification of safety address the outage activities and refueling process, backfitting and replacement programmes, inspections, information meetings, and the review of extraordinary licensee's reports and derived plant modifications which are issued by the Inspectorate in terms of national or international events of INES 2 and higher.

Fukushima

In the scope of the EU stress test and as required by the Inspectorate's orders, the operators of the Swiss nuclear power plants submitted their reports. The Inspectorate has reviewed them. The submission by the Swiss NPPs and the results of the Inspectorate's review confirm that the Swiss NPPs display a high level of protection against the impacts of earthquakes, flooding and other natural hazards, as well as loss of electrical power and ultimate heat sink. For the performed analyses, the current hazard assumptions, e.g. PRP Intermediate Hazard for earthquakes, have been taken into account. The existing safety margins determined are attributable to the robust design of the special emergency systems at all Swiss NPPs. The systems have a special protection against external events, and they also have an independent power supply and a separate supply of cooling water. In addition, the Swiss NPPs have implemented extensive preventive and mitigative provisions which safeguard the fundamental safety functions, i.e. control of reactivity, cooling of the fuel assemblies, and confinement of radioactive substances.

Also, an external emergency storage facility for all Swiss NPPs has been installed. As in the national report to the EU stress test, eight new "open points" (see Annex 3) were identified which the Inspectorate will follow up to further improve the safety of the Swiss nuclear power plants. These open points, together with the checkpoints (see Annex 2) identified in the analysis of the events at Fukushima, are being processed according to their importance and urgency in an action plan. The action plan should be detailed on a yearly basis and illustrate the forthcoming oversight activities related to Fukushima. The Inspectorate has set the ambitious goal of investigating the identified issues and implementing the derived measures.

Additional investigations done by the Swiss NPPs with regard to hydrogen production by radiolysis in the spent fuel pools, hydrogen deflagration and explosion are being reviewed by the Inspectorate. As a result, hydrogen deflagrations and explosions initiated by the total failure of spent fuel pool cooling including additional loss of coolant can be certainly excluded within the period of three days.

Periodic Safety Reviews (PSR)

As part of the PSR that are carried out every ten years, the condition of the NPPs and their operational management are reviewed to ensure the compliance with legal requirements, the provisions of the licenses and the official stipulations of the Inspectorate. Finally, the compliance of the plant condition with the approval bases is examined in the course of ongoing supervision and during inspections by – and technical discussions with – the supervisory authority.

Main elements of programmes for continued verification of safety (in-service inspection, surveillance, functional testing of systems, etc.)

Outage activities and refuelling

During each refuelling outage, the plant is subjected to a review which covers many aspects. Below are some examples:

- The Inspectorate monitors in-service inspections, preventive maintenance and repairs/modifications to safety-related mechanical equipment undertaken by licensees to maintain or enhance plant safety. Its mandated expert, the Swiss Association for Technical Inspections, supervises and verifies these activities using a combination of selective supervisory and random checks. In contrast, the Inspectorate focuses on specific issues.
- The licensee carries out a review of mandatory periodic functional testing of systems and components, including switchover tests for the electricity supply. These tests are performed in accordance with written procedures and all test results are documented. The Inspectorate inspects selected tests and also reviews the results of the entire test programme.
- Cycle-specific fuel and core-related issues are reviewed as part of the "Refuelling Licensing Submittal" submitted by the licensee at the beginning of the plant-refuelling outage. The Inspectorate must approve fuel and core loading before any cycle start-up. The Inspectorate also reviews fuel handling and inspection and attends selected fuel inspection campaigns.

The Inspectorate issues a letter granting permission to restart plant operation after the maintenance/refuelling outage. In this letter, the Inspectorate gives its assessment of the outage maintenance and refuelling activities, the radiological status of the plant and the cycle-specific safety analyses. The permit may also include conditions for plant operation or requirements and recommendations for maintaining and improving plant safety. The Inspectorate documents its own activities during the outage in a separate outage report.

Backfitting and replacement

Backfitting and replacement of safety-related equipment are necessary when existing equipment no longer satisfies current standards and the state of the art or when it becomes difficult to maintain. The Inspectorate may also require backfitting or replacement of equipment, e.g. following a PSR. New equipment is mainly installed and commissioned during plant outages. The Inspectorate reviews the process for such activities and thereby monitors the process closely. In most cases, the Inspectorate must approve the design, installation, modification and commissioning of the equipment. A list of backfittings and improvements, also ordered and performed after Fukushima, is given in Article 18.

Inspection

Inspections in nuclear installations are primarily performed by the Inspectorate. In the field of mechanical engineering, some aspects of inspections are delegated to external experts who act exclusively on behalf of the Inspectorate.

The regulatory inspections by the Inspectorate serve to provide the basis for independent judgements on safety-related issues such as:

- quality measures during plant modifications and operation;
- availability of documentation (e.g. operating instructions, technical specifications, emergency instructions and emergency plans);
- adherence to operating instructions and technical specifications;
- plant operation and recording of safety performance;
- adequacy of PSA models in representing the current plant configuration and operational characteristics;
- housekeeping practices designed to prevent or mitigate fire and the effects of seismic hazards;
- availability and training of operating personnel;
- radiation protection;
- human factors engineering (e.g. human-system interface);
- organisation and safety culture;
- protection against sabotage and malicious acts.

The inspections cover all aspects of engineering relevant to safety (including fire protection), the relevant disciplines of natural sciences (e.g. reactor physics, water chemistry) and social sciences (e.g. work and occupational psychology).

The Inspectorate plans inspections in accordance with its Basic Inspection Programme, which provides a systematic basis for **periodic inspections**. The inspection intervals are based on the safety-relevance of the items (components, systems, processes) to be inspected and on operating experience.

In addition to the above periodic inspections, the Inspectorate's management defines **issue-based inspections**. They focus on specific issues identified in the annual systematic safety assessment described below. If necessary, **reactive inspections** are carried out, e.g. in response to international experience, events or plant modifications proposed by the licensee.

Inspections are performed at any time and are more frequent during outages than during normal operation. In most cases, the licensee is given advance notice of inspections. This ensures that activities to be addressed by the inspection are compatible with the inspection, that components are accessible and that the relevant staff are available for discussions. Inspections by the site inspector (see below) are usually unannounced.

Most inspections are performed during the operation of nuclear installations, although a few inspections cover research reactors, which have been shut down.

A full-time site inspector is appointed for each NPP. Other less critical nuclear installations have been allotted to part-time installation inspectors. As the Inspectorate's offices at Brugg and the NPP sites are in relatively close proximity, regional offices are not required. For the same reason, there are no resident inspectors, although regular unannounced visits occur.

During normal operation, the site inspector is present at the site one day per week on average. During outages, the site inspector is present for four or five days. Inspections by specialists focus on specific issues, whereas site inspectors develop a more general view of the NPP. Findings of potential interest are reported by the site inspector back to the specialists at the Inspectorate. The duties of site inspectors are not limited to inspections. They also act as a vital link between the licensee and the Inspectorate. Site inspectors take the lead role in the systematic safety assessments (see below), which are part of the process of integrated oversight. Site inspectors also contribute to the annual regulatory oversight report published by the Inspectorate on their particular site.

Information meetings

Each site inspector (see above) conducts monthly meetings with the respective licensee in order to obtain the latest information on plant status and performance.

Members of the management of the Inspectorate and the licensee meet annually for an information meeting at which the licensee reports on plant operation. The meetings also discuss special issues and on-going or planned projects. The Inspectorate then gives its view on the various topics and clarifies current or future requirements (safety-related requirements are normally presented to the licensee before any enforcement).

In addition, there is an annual meeting between senior managers from the Inspectorate and the licensee in order to discuss current safety issues. There are also annual management meetings between the Inspectorate's senior management and senior managers from all nuclear installations, including ZWILAG and PSI.

In addition to these regular information meetings, the Inspectorate may arrange meetings on specific issues at any time deemed appropriate.

Elements of ageing management programme(s)

Review of Ageing Surveillance Programme

In 1991 Swiss NPPs were requested by ENSI to introduce an Ageing Surveillance Programme (ASP). The aim of this programme is to collect information about ageing mechanisms and ageing-related events of structures, systems and components (SSCs) in order to maintain the safety margins and safety functions of SSCs throughout the life of the plant.

The ASP is part of the overall maintenance strategy for Swiss NPPs. It addresses issues of civil engineering, electrical and mechanical components and focuses on SSCs important to safety. More specifically, the ASP aims to provide information on ageing and degradation mechanisms associated with component materials, environmental effects, operational history, etc. It is designed to identify and close gaps in the maintenance programme for every component important to safety.

In November 2004 the Guideline R-51 was issued by the Swiss Nuclear Safety Authority, the former HSK (now ENSI). Guideline R-51 specifies requirements for the implementation of a Nuclear Power Plant Ageing Management Programme. The ASP guideline was updated and issued as Guideline ENSI-B01 in August 2011. The revised guideline is based on Article 35 of the Nuclear Energy Ordinance and the IAEA Safety Standard "Ageing Management of Nuclear Power Plants" NS-G-2.12. In the new guideline ENSI-B01, Swiss NPPs are requested to assess internal and external ageing-relevant events. Furthermore, current results and conclusions of the ageing surveillance programme, e.g. laboratory results, are considered in the revision of the guideline.

The Swiss ASPs cover mechanical and electrical components, concrete structures and buildings with a safety classification. Non-classified components are covered whenever the concerned components are risk-relevant. The guideline requires updating the ASP documents to reflect any new safety-related results or at least once every ten years.

Since 2004, all Swiss NPPs have prepared a set of ageing management documents in accordance with the requirements of Guideline R-51. At present, the revision of this ageing management documentation is on going based upon the new requirements of Guideline ENSI-B01. Extensive experience has accrued, which helps utilities implement and improve the ageing surveillance programme. ENSI is thus able to monitor the NPP ageing management activities.

Periodic testing, maintenance tasks and in-service inspections, as well as routine controls, are performed in accordance with planned schedules or whenever required. Based upon recently strengthened requirements on ageing surveillance programmes, the annual refuelling outage also provides an opportunity for additional inspections with suitable non-destructive evaluation methods (NDE) or other examinations such as metallographic investigations. Guideline ENSI-B07 requires applying qualified testing methods for in-service inspection of the safety-relevant vessels and piping.

Arrangements for internal review by the licence holder of safety cases to be submitted to the regulatory body

Reporting

Article 37 and Annex 5 of the Nuclear Energy Ordinance specify the periodical reports to be submitted to the regulatory body in order to assess the status and operation of the facility. Article 38 and Annex 6 address the reporting of planned activities, events and findings of relevance to safety. Article 39 governs the reporting obligations in the area of security. The Nuclear Energy Ordinance delegates the detailed requirements in terms of the content of the report to the Inspectorate. These aspects are covered in Guidelines B02 and B03, both of which came into force in 2009. Guideline B02 deals with periodic reporting, e.g. monthly reports, annual safety reports and outage reports. Guideline B03 addresses the reporting of planned activities, events and findings of relevance to safety. Data relating to general plant performance, including radiological characteristics and plant modifications for which a permit is not required, have to be reported periodically (monthly or yearly). However, events such as equipment failures, scrams and the failure of mandatory tests have to be reported within the (short) period of time specified in Annex 6 of the Nuclear Energy Ordinance.

The licensee also has to review information on international events available through various channels such as WANO, IAEA and supplier information letters. The insights gained from these reviews have to be reported on a monthly basis. A set of safety indicators has been defined and the raw data for these indicators have to be included in the monthly reports.

Reports by licensees may trigger regulatory requirements or recommendations for improvement. The Inspectorate also reviews information from international events as well as insights from safety research. Those reviews may also trigger regulatory action and, if appropriate, requirements or recommendations to the licensee.

Regulatory review and control activities

Integrated Oversight: Annual Systematic Safety Assessment

Under the Inspectorate's integrated oversight approach – an approach continuously refined since the last report – all aspects of relevance to nuclear safety are integrated into a single comprehensive oversight strategy. The aim is two-fold: firstly, the Inspectorate must ensure it has sufficient information on the design, state and effectiveness of all safety provisions so that it can provide a realistic assessment of the safety of each nuclear installation. Secondly, the Inspectorate must ensure it takes adequate and effective measures if it detects a weakness in a safety provision. Every assessment and action must be justified and traceable.

In order to obtain a realistic picture of the safety of each installation, the Inspectorate operates a systematic safety assessment system. Firstly, safety information is structured based on the following key issues:

- requirements subdivided into design and operational requirements;
- operating experience subdivided into state and behaviour of the plant and state and performance of human factors and organisation.

Secondly, information is structured based on the following safety goals:

- safety functions;
- levels of defence in depth and barrier integrity.

For each NPP, data is collected as shown in the Tables 2a and 2b.

Currently, inspection findings, operator licensing results, event analysis results, safety-indicator data and information in the periodic licensee reports are evaluated annually as part of the integrated oversight process.

Table 2a: Safety Assessment Table – Defence in Depth

Goals \ Subject		Requirements		Operational experience	
		Design requirements	Operational requirements	State and behaviour of the plant	State and behaviour of man and organisation
Levels of defence in depth	Level 1				
	Level 2				
	Level 3				
	Level 4				
	Level 5				
Barrier integrity	Fuel integrity				
	Integrity of the primary cooling system boundary				
	Containment integrity				
overall defence in depth aspects					

Table 2b: Safety Assessment Table – Safety Functions

Goals \ Subject		Requirements		Operational experience	
		Design requirements	Operational requirements	State and behaviour of the plant	State and behaviour of man and organisation
Safety functions	Controlling reactivity				
	Cooling the fuel				
	Confining radioactive materials				
	Limiting exposure to radiation				
	overall aspects				

Each finding identified during an inspection is assigned to one or more cells in each table (defence in depth and fundamental safety function). The same process is used for the event analysis results, and each direct or indirect cause along with each safety-relevant effect is detailed. Finally, operator licensing results and the safety indicator assessments are stated.

Findings are rated on a scale based on the International Nuclear Event Scale (INES). The scale is designed to assess all levels of safety performance ranging from good practice to a severe accident on an identical scale. The categories are defined as follows:

- **Category G: Good practice**

  All requirements are fulfilled and the practice of other NPPs is clearly exceeded.

- **Category N: Normality**

  All requirements are fulfilled.

- **Category V: Need for Improvement**

  Deviations from requirements in documents not requiring formal authorisation by the Inspectorate fall into this category

- **Category A: Deviation**

  Deviations from normal operation within operational limits and conditions

- **Categories 1 to 7**

  Rating based on the INES Manual

Categories V and A correspond to INES 0. Findings from inspections rated INES 1 or higher are classified as events. Findings rated A are checked to see whether they have to be classified as events. Any finding in category V or higher requires action.

Inspection data, operator licensing data, event-analysis data, safety-indicator data and the periodic licensee report data are entered in a database. A software tool allows the display of safety assessment data and it is possible to display the ratings in a table for any period and any installation. Each rating is linked to a source document. The ratings for each NPP are evaluated annually. The result of this evaluation influences the focus of future inspections. Insights gained from the annual safety assessment of each plant are included in the annual regulatory oversight report published by the Inspectorate.

Article 15 – Radiation protection

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

Based on the recommendations of the International Commission on Radiological Protection (ICRP) (mainly Publication No. 60), both the Radiological Protection Act and the Radiological Protection Ordinance were revised and entered into force in 1994. The Inspectorate has subsequently issued revised and adapted versions of most of its relevant guidelines:

- R-07: Guideline for radiation protection zones in nuclear installations and in the Paul Scherrer Institute;
- B04: Clearance of materials and zones from controlled areas;
- B09: Determining and reporting of doses of occupationally radiation exposed per-sonnel;
- G13: Radiation protection measuring instruments in nuclear facilities, basic concepts, standards and testing;
- G14: Calculation of the radiation exposure in the vicinity of nuclear installations due to emissions of radioactive materials;
- G15: Radiation protection objectives of nuclear installations.

The Radiological Protection Ordinance was revised in October 2007. Relevant changes, among others, were the distinction of the dose factors for infants (1 a), children (10 a) and adults as well as the dose factors of irradiation for plume and soil. Another novelty was that the requirement of notification to the authority was reduced for radioactive sources by a factor of 100.

The last review of the Radiological Protection Ordinance was carried out in January 2009 in order to obtain compatibility with the new Nuclear Energy Act. The Radiation Protection Ordinance is currently under revision to obtain inter alia compatibility with the new European Safety Directive, Version 24th February 2010 (final).

In January 2013 a new ordinance concerning the official gauging of radiation protection measuring instruments came into force. A new ordinance is in preparation concerning the handling of unsealed radioactive material in nuclear facilities, in which detailed requirements on buildings and equipment are foreseen. This ordinance shall partially replace the Inspectorate's guideline R-07.

Dose limits

The Radiological Protection Ordinance limits the general maximum individual total dose for NPP personnel (plant personnel and contractors) as a rule to 20 mSv per year. Exceptionally, a limit of 50 mSv per year, but not exceeding 100 mSv in five years, can be authorised by the Inspectorate. Up to now, there has been no request to the regulatory body to extend the dose up to 50 mSv per year.

Since 1993, all annual collective doses have remained well below 4 man-Sv per unit and all have been kept below 2 man-Sv per year since 1995 except in one case. The annual collective doses of the last 20 years are illustrated in Figure 2 (note: the Beznau NPP consists of two units, both located on the same site).

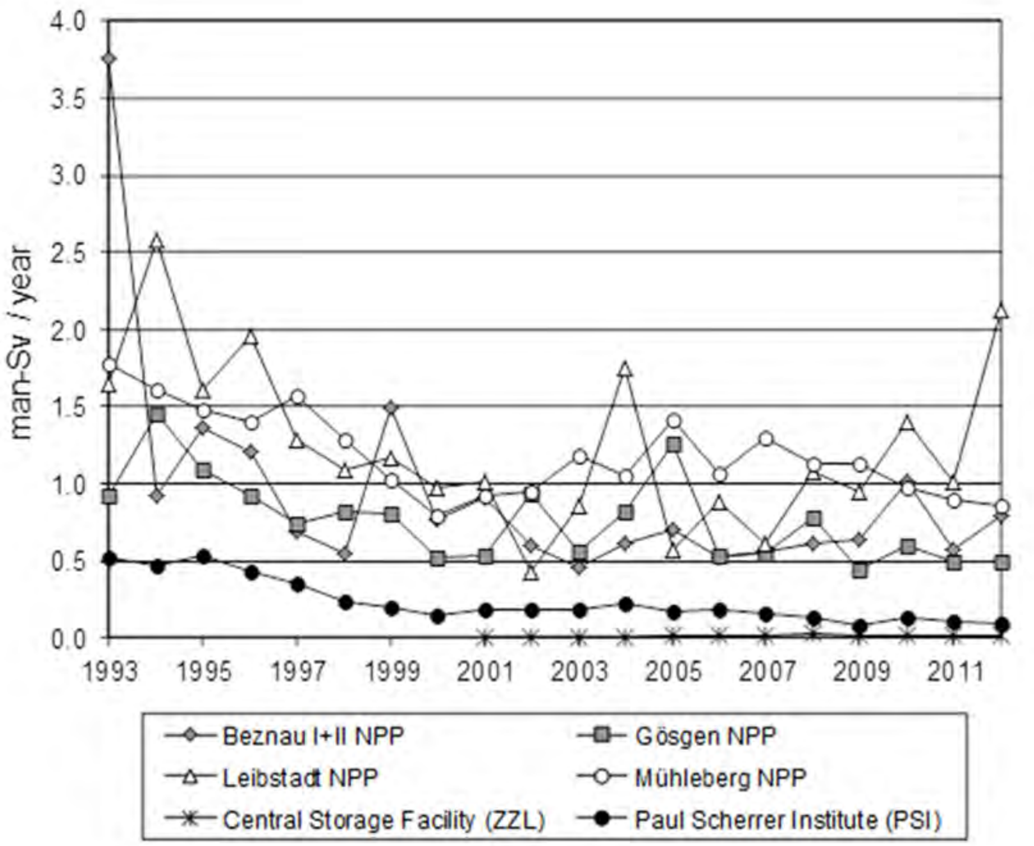


Figure 2: Annual collective doses for the personnel in Swiss NPPs, the Central Interim Storage Facility (ZZL) and the research institute PSI. All peaks are related to extraordinary work performed: in 1993, the steam generators of Beznau NPP I were exchanged with a collective dose of 1.2 man-Sv. In 1999, the same work was performed at Beznau NPP II with a collective dose of 0.64 man-Sv. This dose reduction can be largely attributed to "lessons learned" from earlier similar operations and to the optimisation of radiation protection. Extensive structural alteration works related to the planned power upgrade resulted in higher collective doses in 1994 and 1996 at Leibstadt NPP. In 2004, additional inspections carried out at Leibstadt NPP implicated a higher collective dose. The exchange of the primary safety valve in 2005 occurred within the project PISA at Gösgen NPP and led to an increase of the collective dose. The unplanned repair of crack in a welding of a reactor pressure vessel nozzle in Leibstadt NPP resulted in an increase of the accumulated dose in 2012.

An incident of category 2 on the INES rating occurred at the Leibstadt NPP during the outage in 2010. During the planned maintenance, replacement of cables on the IFTS (Inclined Fuel Transfer System) by a diver in the spent fuel pool resulted in an overexposure. Before the exchange of the cables started, a dose rate scatter of the diver's work location was determined with a submerged probe. No high dose rate was measured within this area. During the work, the diver spotted an unidentified object. After asking the diving supervisor, he was told to grab the piece and put it into the tool basket. While lifting the basket to the surface, but still well submerged, the area radiation monitor gave an alarm. Hence, the basket was descended again. The following investigation showed that this object was a top part of a Dry Tube (housing of neutron monitors in the reactor core), highly activated by neutron flux. In 2006 Dry Tubes were removed and cut in pieces in the reactor cavity. It seems likely that during this procedure the top part of a Dry Tube was sheared off and had since then laid unnoticed on the bottom of the spent fuel pool. The dose rate measured was above 100 Sv/h. The diver's electronic dosimeter showed a value of 40.1 mSv on the display and correctly gave an alarm. The diver's TLD were immediately evaluated on site. The following doses were obtained: whole body: 19 mSv, right finger: 1123 mSv, left hand: 306 mSv, left foot: 11 mSv. The dose limit for hands of 500 mSv/a was therefore exceeded. The results evaluated with the TLD and EPD for the whole body were contradictory. Hence, a radiation protection expert assessed the dose rate by calculation on behalf of ENSI: the whole body dose: 28 mSv, the hand dose: 7500 mSv. As a result, the diver accumulated an individual dose beyond the statutory annual dose limit of 20 mSv per year. Apart from this and one additional incident in 2009, which occurred in Beznau NPP (reported in detail at the report CNS 2010), there have been no further incidents of plant personal or contractors accumulating individual dose limits in excess of the annual limit of 20 mSv whilst working in Swiss NPPs since 1994.

The dose due to non-natural sources for a person of the general population is limited to 1 mSv per year by the Radiological Protection Ordinance. The Inspectorate's guideline G-15 defines a source-related dose constraint of 0.3 mSv per year as the maximum allowed dose for persons living nearby nuclear installations resulting from emissions and direct radiation for each NPP site (independent of the number of reactors). Direct radiation may not cause a corresponding dose of more than 0.1 mSv per year.

A nuclear facility has to be designed in such a way that the source-related dose constraints are not exceeded as a result of incidents with an occurrence greater than 0.01 per year and the dose limit for members of the public is not exceeded by incidents with an occurrence greater than 0.0001 per year.

The Inspectorate's guideline G14 defines the rules for the calculation of doses due to emissions and discharges. The maximum allowed emissions are defined in the licences, based on the characteristics of the NPP and on the results of the dose calculations, taking into consideration the ALARA principle. Calculated doses on the base of annual emissions for a virtual most exposed group of the population, including the exposure due to deposition from former years, have always been well below of 0.2 mSv per year. Since 1994, calculated values due to annual releases have been below 0.01 mSv per year for all Swiss NPPs. These facts are illustrated in Figure 4. For all Swiss NPPs, doses due to direct radiation have always been below 0.1 mSv per year. Thus, it is shown that the sum of the annual dose caused by direct radiation and emission has always been below the source-related dose constraint.

Steps taken to ensure that radiation exposure is kept as low as reasonably achievable

Over the years, NPP-specific methods have been progressively used to keep radiation exposure arising from the operation and maintenance work of NPPs as low as reasonably achievable. Since the year 1994, when the new dose limit of 20 mSv came into force, this limit was exceeded only once by the incident in Beznau I NNP in 2009. The mean individual doses for plant personnel and contractors (see Figure 3) show a decreasing trend over the last couple of years in all Swiss NPPs, indicating the significant efforts made particularly since 1988.

The most significant dose reduction measures undertaken at the Swiss NPPs during the last years are compiled in Table 3.

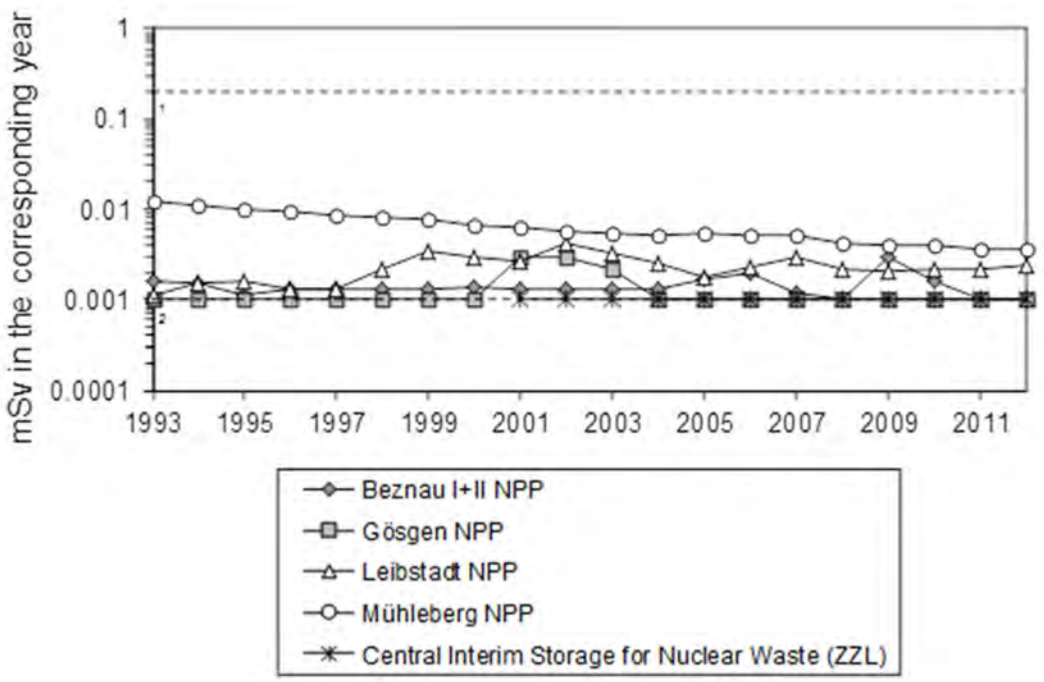
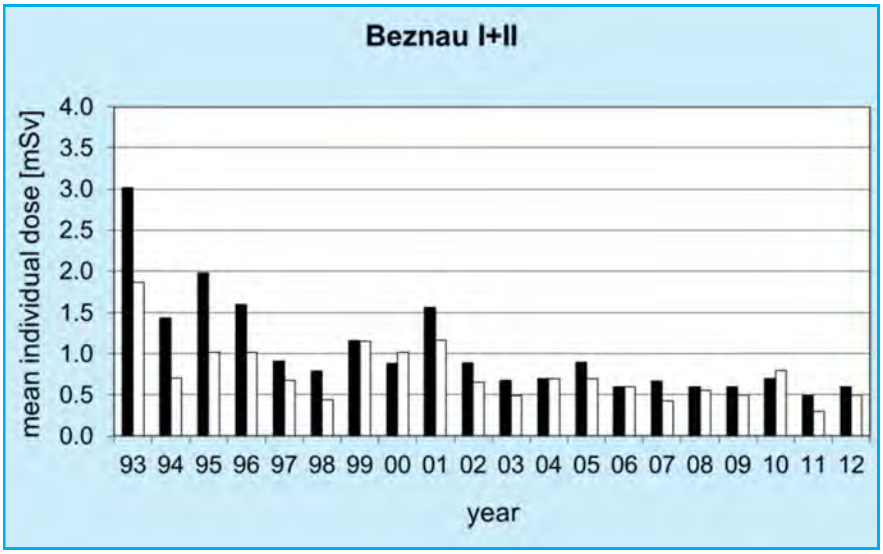


Figure 3: Doses calculated on the base of annual emissions from the Swiss NPPs and the Central Interim Storage Facility (ZZL) without contribution of direct radiation. The annual doses are calculated for a virtual most exposed group of the population, including the exposure due to deposition from former years. The higher value for the Mühleberg NPP is related to an emission of radioactive particles in 1986 (a malfunction of the waste treatment system of dry resin).

1. *0.2 mSv per year value (source-related dose constraint minus direct radiation constraint).*
2. *Values below 0.001 mSv per year are not shown as such on the figure.*
3. *Virtual person, permanently located at the main plume area, consuming all food produced locally and all drinking water from the river downstream of the NPP in question.*

In order to keep the doses low in a reasonable way under consideration of optimisation, the ICRP in publication 75 recommends the use of operational dose constraints based on estimated levels achievable by the application of good practice. In this sense, the Inspectorate's guideline G15 requires the NPP to determine dose planning objectives (e.g. max. individual doses or collective job doses) for the respective activities based on:

- empirical values for comparable activities in its own or a comparable installation;
- current radiological situation;
- international experience;
- optimisation processes.



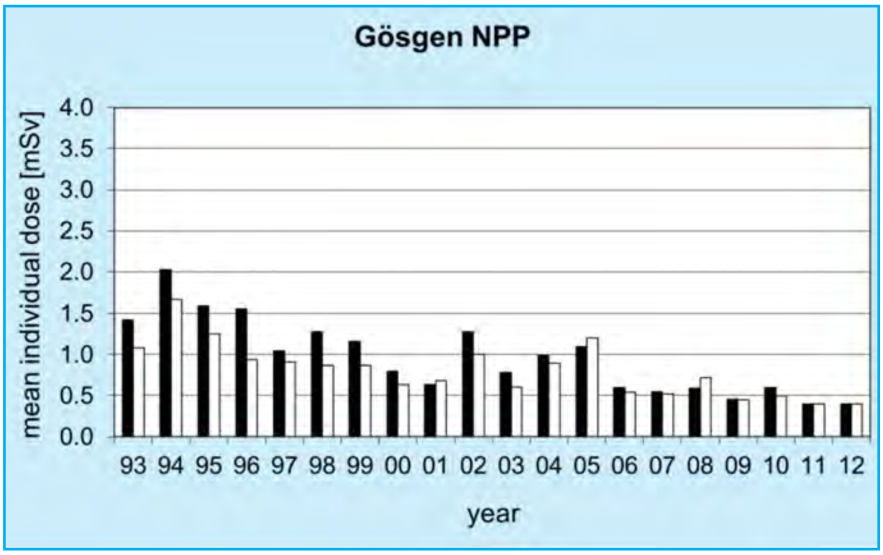
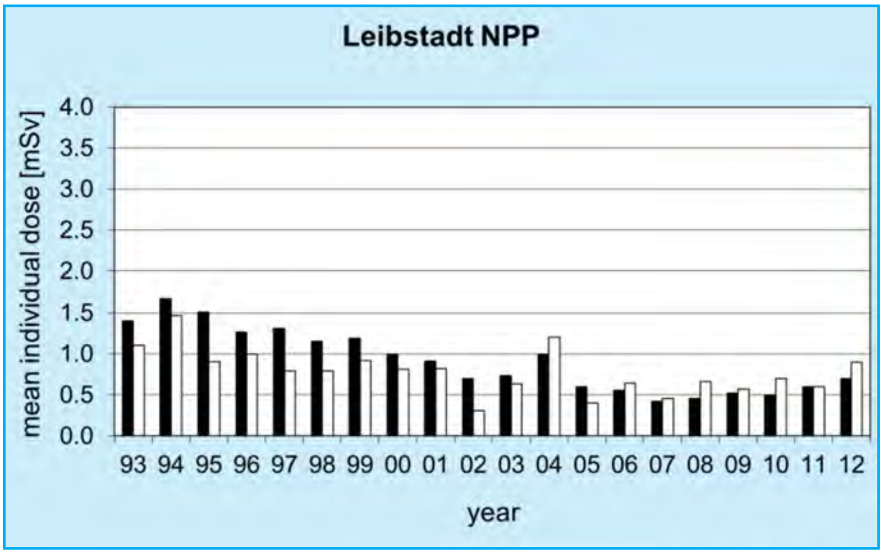


Figure 4: Mean individual dose of plant personnel (dark bars) and contractors (white bars) in Swiss NPPs.



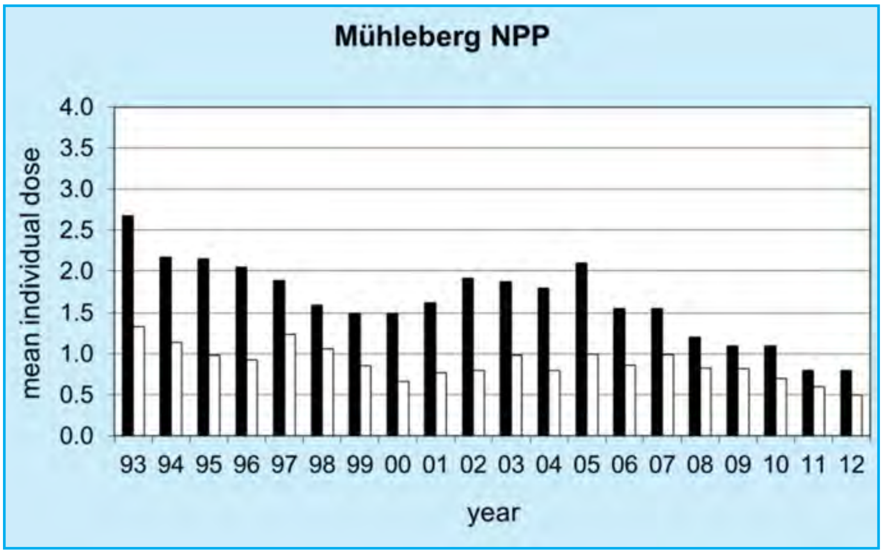


Figure 4: Mean individual dose of plant personnel (dark bars) and contractors (white bars) in Swiss NPPs.

Table 3: Main dose reduction measures in Swiss LWRs.

Plant	Average of collective dose during outage of the last five years [man-mSv]	Main dose reduction measures
Beznau I+II NPPs	568	• Temporary lead shielding (70 tons). • Low dose rate areas for personnel (<0.005 mSv/h). • Individual acoustic dose and dose rate warning. • Strong emphasis on training and motivation. • Daily job-specific follow up of doses vs. planning including interventions if necessary to keep the NPP-internal dose constraint of 10 mSv p.a. for workers. • Remote tools for primary system inspection. • Improved water chemistry, reducing fixation of colloids on primary system surfaces.
Mühleberg NPP	833	• Temporary lead shielding (85 tons). • Permanent racks for supporting removable lead sheets. • Use of a conveyor belt to transport the temporary lead shielding into the drywell. • Replacement of components with "Stellite" parts by components made from a cobalt-free alloy. • Daily follow up of job specific actual doses vs. planning doses. • Zn-64-depleted zinc feed in primary water. • Online noble chemistry (OLNC) primary water operation mode affected a reduction of the dose rates of the recirculation pipes. • Stopping the addition of hydrogen to the primary water system some hours before the reactor is shut down for the outage.

Plant	Average of collective dose during outage of the last five years [man-mSv]	Main dose reduction measures
Gösgen NPP	462	• Temporary lead shielding (up to 30 tons). • Highly compartmentalised containment with compartments made out of concrete. • Replacement of the old isolation system to new isolation cassettes on the primary coolant tubes. • Daily follow up of total and selected job specific actual doses vs. planning doses. • Extensive mock-up training. • Zn-64-depleted zinc feed in primary water. • Shut-down procedure individually adjusted to the current activity of the primary coolant water. • Chemical decontamination of all three reactor coolant pumps. • Wireless telephone set with sound depression used for work in noisy areas to increase the communication.
Leibstadt NPP	778	• Temporary lead shielding (32 tons). • Temporary shielding with water bags. • Job tickets (bar code) with online follow up. • Very detailed job planning for jobs implying collective doses > 50 man-mSv. • Job planning for jobs implying collective doses > 10 man-mSv. • Replacement of components with "Stellite" parts by components made from a cobalt-free alloy. • Zn-64-depleted zinc feed in primary water. • Extensive mock-up training. • Stopping the addition of hydrogen to the primary water system some hours before the reactor is shut down for the outage. • Extensive camera system in the power house to reduce the number of round tours. • Chemical decontamination of components and systems as required. • Application of wireless dosimeters for special kind of works in order to control the dose and dose rate on-line.

According to the Radiological Protection Ordinance, radiation protection is deemed to be optimised if the following conditions are met:

- Different possible solutions have been individually assessed and compared.
- The sequence of decisions that led to the particular solution is traceable.
- Due consideration has been given to the possible occurrence of incidents and the safe storage of radioactive sources which are no longer in use.

In detail the Inspectorate requires:

- Special quality management rules for the radiation protection department as a part of an NPP's QM system, (see Article 13) including procedures which define the determination of dose planning objectives, the optimisation process, the documentation as well as the relevant regulations regarding competencies.
- A radiation protection planning (including determination of dose planning objectives) in accordance with the internal procedure if the anticipated collective dose of a planned activity in a nuclear installation leads to higher individual or collective doses than the internally determined planning thresholds (typically 5, 10 or 20 man-mSv).
- A report addressed to the authority on radiation protection planning in the case of a planned shutdown, and if the planning of an activity results in an anticipated collective dose higher than 50 man-mSv.

The Inspectorate has to examine the dose planning objectives in detail if the expected annual collective dose exceeds 1.5 man-Sv per NPP. In this case, the Inspectorate will require optimisation measures, if appropriate.

The NPP has to compare the monitored doses with the dose planning objectives. If relevant deviations become obvious, the activity has to be stopped, the planning has to be revised and improvements have to be implemented.

In all Swiss NPPs, the waste water is collected and treated in batches. However, a different abatement technique is used for the treatment of waste water in every power plant. In Beznau NPP the radioactivity in the waste water is reduced by centrifugation, chemical precipitation and nanofiltration. In Gösgen NPP the evaporation and in Leibstadt NPP the centrifugation and evaporation technique are used, while in Mühleberg NPP the centrifugation and ion exchange technique is applied.

Three of the Swiss NPPs – Gösgen, Leibstadt and Mühleberg - have conventional offgas treatment systems which consist of catalytic recombiners, offgas-condensers, hold-up-lines, activated carbon filter columns, HEPA-filters and offgas pumps. Beznau NPP has a different system which works with four pressurised hold-up tanks. The NPPs have formulated site specific targets for liquid and gaseous discharges with the intention of keeping the doses for the general public low in a reasonable way under consideration of optimisation. To reduce the iodine gaseous discharges, KKL has backfitted the turbine building gland seal system with a filter system. The filter system cleans the feed water used for producing the gland seal steam.

Every ten years the licensee of each Swiss NPP has to perform a periodic safety review. In the context of this review, the licensee has to assess the liquid and gaseous discharges of his plant and to benchmark against the corresponding discharges of similar European reactors. As a result of this process, Beznau NPP improved the abatement system for liquid discharges by nanofiltration. Since 2007, the liquid discharges of Beznau NPP have been less than 1 GBq per year.

The licensee of the Mühleberg NPP performed a periodical safety review in 2005. The Inspectorate has assessed this review in depth. As a result, the licensee is reducing the activity without tritium in the liquid discharges to a target setting of 1 GBq per year until 2010. To reach this aim, the licensee studied the possibilities of reducing the quantity of waste water as well as separating different qualities of waste water for specific treatment. This work has resulted in a decrease of the activity released from 7 GBq (2007) to less than 3 GBq (2012) per year. Every four years, the torus of KKM is emptied for maintenance reasons, resulting in liquid discharges of about 6 GBq in these years.

Operating radiation protection organisation

To ensure independence of the radiation protection organisation from the operation department of the facility, the licensee has to carry out three requirements based on regulations in the radiation protection act:

- The licensee has to provide a direct communication link between the authorised radiation protection expert and the management representative of the licensee.
- The licensee has to delegate competences to the radiation protection experts to intervene in the operation of the NPP if radiation protection rules are violated.
- The licensee has to provide adequate personal resources in the radiation protection organisation. His staff has to be composed of professionals with approved education and training. Radiation protection relevant tasks are reserved for these professionals.

Detailed descriptions of these rules are part of each NPP's documentation necessary for the granting of a licence for operation. Modifications of the radiation protection rules of the NPP have to be authorised by the Inspectorate.

Regulatory control activities

As mentioned above, the Inspectorate reviews the radiation protection planning process of the NPPs as a part of its supervisory duties. Typically, these reviews are performed in conjunction with the radiation protection planning for oncoming outages.

Inspections concerning radiation protection matters are focused on the outage phases. Normally, these inspections are planned on the basis of the radiation protection planning of the plant several weeks in advance and are centred on activities with an anticipated collective dose greater than 50 man-mSv. Other routine inspections are performed in every NPP during operation in addition to specific inspections focused on special topics, like radiation instrumentation, contamination control, etc.

Additionally the Inspectorate reviews all periodical reports of the NPPs related to radiation protection measures. The Inspectorate operates a computerised data bank on radiological and chemical plant data provided monthly by the licensees.

Environmental radiological surveillance

The Radiological Protection Act establishes the legal basis for the radiological surveillance of the environment. More detailed requirements are laid down in the Radiological Protection Ordinance and in the legislation for foodstuffs. On this basis, the Inspectorate has issued discharge and environment monitoring regulations. These regulations contain requirements on the control of discharges and a complete programme on environmental monitoring of radioactivity and direct radiation in the vicinity of the facility. The programme is drawn up by the Federal Office of Public Health in cooperation with the Inspectorate, the National Emergency Operations Centre and the cantons. The programme is reviewed annually and modified as necessary.

The Inspectorate defines requirements for the measuring devices as well as how the measurements have to be carried out. It monitors the correct maintenance of the devices and audits the measurement book-keeping during annual inspections. In addition, it performs its own quarterly benchmark tests with each plant.

The environmental surveillance programme has three main aspects:

- Measurement of the emissions from the plant and comparison of the actual emissions with the limits set in the licence for the operation of the NPP. The limits are chosen in such a way that the dose for persons living in the vicinity of the plant remains well below the source-related dose constraint (see section "dose limits" above).
- Calculation of the dose from the measured emissions for the most exposed persons living in the vicinity of the NPP. The calculated values are compared directly with the source-related dose constraint. The models and parameters used for the calculation are defined in the Inspectorate's guideline G14.
- Programme for the radiological surveillance of emissions. The environment is monitored nation wide by the Federal Office of Public Health. The vicinity of the NPPs is additionally monitored by the NPP and the Inspectorate independently. The programme includes online measurements of the dose rate near the plants (MADUK, see Article 16), as well as regular sampling and measurements of air, aerosol fallout, water, soil, plants and foodstuffs.

The results are published in annual reports of the Inspectorate. A summary of the results of the entire environmental radiological surveillance is also published in the annual report of the Federal Office of Public Health.

Developments and Conclusion

The figures with the annual collective doses for the personnel in Swiss NPPs, the mean individual dose of plant personnel and contractors, and the annual doses for a virtual most exposed group of the population were actualised with the data up to the year 2012.

Furthermore, the text of the 2010 report was completed with the results of the licensees' activities to keep the discharges as low as reasonably achievable.

Article 16 – Emergency preparedness

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.

Prior to the start-up of a new NPP, on-site and off-site emergency plans must be established and approved by the Inspectorate. The general requirements for emergency preparedness are based on the following acts, ordinances, Inspectorate's guidelines and concepts:

Acts:

- Nuclear Energy Act;
- Radiological Protection Act.

Ordinances:

- Nuclear Energy Ordinance;
- Radiological Protection Ordinance;
- Ordinance on Emergency Preparedness in the Vicinity of Nuclear Installations (Emergency Preparedness Ordinance);
- Ordinance on the Organisation of Operations in Connection with NBC and Natural Events;
- Ordinance on Iodine Prophylactics in the Case of a Nuclear Accident;
- Ordinance on Alerting the Authorities and the Public;
- Ordinance on Foreign Substances and Food Contaminants.

Guidelines:

- Emergency exercises (Guideline B11);
- Emergency preparedness in nuclear installations (Guideline B12);
- Organisation of nuclear installations (Guideline G07);
- Source term analysis (Guideline A08).

Concepts

- Concept for the emergency protection in the vicinity of nuclear power plants, Federal Commission for NBC Protection (2006).

A working group was set up by the Federal Council (IDA NOMEX) in May 2011 to review emergency preparedness measures in case of extreme events in Switzerland. The group's report "Review of Emergency Preparedness Measures in Switzerland", which is available on the Inspectorate's website (www.ensi.ch), was adopted by the Federal Council in July 2012 and describes a series of organisational and legislative measures which have proven to be necessary as a result of the review conducted. These include, for example, measures in the field of equipment and material, emergency planning zones, scenarios for emergency planning and large scale evacuations. The Inspectorate has further set up an action plan for the follow-up of emergency preparedness and response issues identified in its analysis of the event in Fukushima.

On-site emergency organisation

Each NPP has plant-specific documents on emergency preparedness, which include the following:

- operating procedures for abnormal situations;
- emergency operating procedures;
- severe accident management guidance (SAMG);
- procedures for reporting to the Inspectorate and to the National Emergency Operations Centre;
- procedure for reporting to cantonal police for fast-evolving accidents.

The emergency preparedness documentation of the NPPs is reviewed regularly.

SAMG programmes have been implemented at all Swiss NPPs: all plants have appropriate validated guidance for the mitigation of severe accidents during full-power operation. Validation is the result of emergency exercises at which the Inspectorate is an observer. In addition to the full-power SAMG, all plants have developed special guidance for low power/shutdown conditions. The existing strategies to cope with Station Blackout (SBO) scenarios have been extended. As a result, additional equipment has been installed or stored on the plant sites and the existing accident management procedures will be adapted accordingly.

Furthermore, as a result of the Fukushima accident, the Inspectorate required the operators of the Swiss NPPs to organise additional storage of accident management equipment at an external site. The goal is to store part of the accident management equipment – in addition to the extensive equipment on each NPP site – at a site that would not be affected by an earthquake or flood on site. Since June 2011, this additional equipment is stored at the centralised storage facility Reitnau. The availability of adequate resources such as diesel motor driven pumps, diesel generators, hoses, cables, borating agents, tools and personal protection equipment from Reitnau should be available within eight hours upon request. For a situation where transport to the power plant by road is impossible, there is the option of air transportation via military helicopter. The operators intend to test the severe accident equipment stored at Reitnau during their regular emergency exercises.

To ensure communication in an emergency, dedicated telephone and fax lines between the NPPs, the Inspectorate and the National Emergency Operations Centre are available. These communication systems are tested once a month. The IDA NOMEX report further emphasized the importance of redundant and failsafe communication systems. As a result, the requirements on redundancy and safety against failure of such systems will be reviewed and defined. Such requirements were defined for monitoring (plant parameters and environment dose rate measurement data) and prognosis systems in 2012.

Aspects of short-term operability and habitability of emergency control centres during nuclear accidents have been assessed within inspections in 2012. Further inspections are planned to ensure that nuclear power plants have suitable, seismically robust, appropriately protected, ventilated and well-equipped emergency rooms and substitute emergency rooms.

A helicopter transporting mobile accident management equipment from Switzerland's external storage facility in Reitnau to NPP Leibstadt, during an emergency exercise in May 2013.
Source: ENSI

Off-site emergency organisation

The off-site emergency organisation is based on resources built up as part of the general protection concept developed for the Swiss population as a whole. They consist of a well-developed shelter infrastructure and well-trained troops for fire and disaster intervention. The emergency preparedness for events in Swiss nuclear installations in which a considerable release of radioactivity cannot be excluded is regulated under the Emergency Preparedness Ordinance. In the event of a radiological emergency, the Federal NBCN Crisis Management Board (FMB NBCN) coordinates civil and military support at federal and regional levels.

The Ordinance on the Organisation of Operations in Connection with NBCN is the legal basis for the FMB NBCN. The Federal NBCN Crisis Management Board is responsible for suggesting appropriate measures to the Federal Council (government), who then issues the associated instructions to cantonal authorities and the general population. The Federal NBCN Crisis Management Board runs a stand-by emergency service, the National Emergency Operations Centre (NEOC), which is responsible for alerting and informing the public and for initiating early countermeasures in the event of a radiological accident.

The major organisations involved in emergency preparedness have the following responsibilities:

- NPPs are responsible for detecting and assessing an accident, for implementing on-site countermeasures to control it and for disseminating information immediately and continuously to the relevant off-site authorities. According to the Emergency Preparedness Ordinance and Guideline A08, the NPPs are further responsible for the timely determination of the source term and its communication to the Inspectorate.
- The Inspectorate is responsible for judging the adequacy of on-site countermeasures implemented by NPP staff. It makes predictions about the possible dispersion of the radioactivity in the environment and about the consequences of such dispersion. The Inspectorate also advises the National Emergency Operations Centre in ordering protective measures for the population.
- The National Emergency Operations Centre is responsible for the preparedness of the Federal NBCN Crisis Management Board which has the task to prepare the decisions to be taken by the Federal Council on countermeasures after the emergency phase of an accident.
- An automatic dose rate monitoring and emergency response data system (MADUK/ANPA) has been installed around all NPPs in Switzerland. The system monitors dose rates continuously at 12 to 17 locations in the vicinity of each NPP. The data is transmitted online to the Inspectorate and the National Emergency Operations Centre. The Ministry of the Environment of Baden-Württemberg (Germany) receives online data from the dose rate monitors in the vicinity of the Beznau NPP and Leibstadt NPP. All data is also available on the Inspectorate's website (www.ensi.ch). For further information please refer to Article 15. A second automatic network (NADAM) monitors the external dose rate on the national territory. The data is available on the NEOC's website.

The MADUK/ANPA system also provides the Inspectorate with online access to measurement data for about 25 important plant parameters. The Inspectorate uses special software – the Accident Diagnostics, Analysis and Management system ADAM – to visualise these measurements, to diagnose the state of the plant and to simulate how an accident may develop. Furthermore, ADAM includes a module called STEP (Source Term Estimation Program), which allows a source term estimation considering actual plant parameters.

The Inspectorate has set up an automated system for radiological prognosis. Calculations are performed hourly using the ADPIC-Dispersion code (Monte-Carlo) with actual and forecast meteorological data. The results of these calculations are also made available to the National Emergency Operations Centre and the responsible authorities in Germany. In the event of an accident, the radiological impact on the basis of available source term is calculated within about 30 minutes. Since 2011 a new project, whose aim is to implement a new and modernised system for dispersion calculations, has been launched. This system, which is based on JRODOS (Java-based Real-time online decision support system) and LASAT (Lagrangian Simulation of Aerosol-Transport), will be operated by the Inspectorate at the locations of the Inspectorate and the National Emergency Operations Centre, thus ensuring a full redundancy.

- The National Emergency Operations Centre is responsible for the overall assessment of an emergency situation and for the transmission of warnings to the cantonal and federal authorities. It has also to decide on initial countermeasures to protect the population and to transmit the alarms (sirens) together with the behavioural instructions disseminated by radio broadcast. The National Emergency Operations Centre is responsible for coordinating measurement teams, data processing and evaluation, for assessing the radiological situation and to share these results with other emergency related information with all the relevant response organisations on a secured electronic platform. It is also responsible for informing and communicating with international partners (neighbouring countries and international organisations).
- The Federal NBCN Crisis Management Board is responsible for the cooperation in connection with NBCN events and the coordination of operations. The Board has a committee and a permanent staff unit. The members of the Board are the directors and chiefs all major federal offices, amongst others the Director of the Federal Office of Public Health, the Director of the Federal Office for Civil Protection, the Chief of the Swiss Army Command Staff, the Director of the Swiss Federal Nuclear Safety Inspectorate and representatives of cantonal government conferences. Within their area of responsibility, they take the necessary precautions for coping with radiological emergency events.
- The cantonal and communal authorities are responsible for executing protective countermeasures for the public.
- The medical service of the Swiss army is responsible for the pre-distribution of iodine tablets to those living in Zones 1 and 2.
- The canton where the NPP is located is responsible for informing its citizens of the potential consequences of an accident in a facility and providing advice on how to respond in an emergency.

In the event of an accident, information is disseminated to the media by the above authorities in line with their individual responsibilities.

Emergency planning zones

Under the Emergency Preparedness Ordinance, each NPP in Switzerland has three distinct emergency planning zones:

- Zone 1 is the area around an NPP in which there could be acute danger to the public in the event of an accident and so for whom immediate protective measures are required. Depending on the NPP's power rating and the exhaust height of its stack, Zone 1 covers a radius of about 3 – 5 km.
- Zone 2 adjoins Zone 1. It encloses an area with an outer radius of about 20 km and is divided into 6 overlapping sectors. The public can be alerted in individual sectors as appropriate.
- The rest of Switzerland (outside Zones 1 and 2) is referred to as Zone 3. It is not expected that measures would be necessary to protect the public in Zone 3 during the passage of a radioactive plume. It is assumed that the measures actually required could be implemented without detailed pre-planning.

The outer border of Zones 1 and 2 generally follow the boundaries of the relevant municipal authorities. As a consequence of IDA NOMEX, scenarios for emergency planning and the concept of emergency planning zones are currently being reviewed.

Emergency protective measures

The primary objective of emergency protective measures in the vicinity of NPPs is the prevention of acute radiation sickness resulting from the accidental release of radioactive materials. In addition to this primary objective, emergency protective measures are designed to minimise the prevalence of long-term, genetic radiation damage.

Protective measures designated for the general public are based on the Dose-Measures Concept quoted in the Ordinance on the Organisation of Operations in Connection with NBC and Natural Events. This Concept describes the protective measures to be considered (see Table 4).

Table 4: Intervention levels

Protective measures	Dose acquired in the first year after the accident	Dose intervention level
Stay indoors for children, adolescents and pregnant women	Effective dose from external radiation and inhalation	1 mSv
Stay indoors, inside cellars or shelters	Effective dose from external radiation and inhalation	10 mSv
Evacuation	Effective dose from external radiation and inhalation	100 mSv
Take iodine tablets	Thyroidal dose from inhalation of radioactive iodine	50 mSv
Harvesting and grazing ban	Ordered as a precaution where any of the above measures is ordered as well as for areas in the downwind direction	-

In addition, the Ordinance on Foreign Substances and Food Contaminants contains limits and tolerance levels for foodstuffs. The limits correspond to the maximum permitted levels of radioactive food contamination under EURATOM regulations.

The protective measures applied during the cloud phase must be planned so that they can be implemented as a preventive measure in the initial phase of an accident. During the cloud phase, the primary measures include sheltering, taking of iodine tablets and possibly evacuation before any release. They reflect the following:

- The solid construction of houses in Switzerland and the high availability of private and public fallout shelters mean that in most cases sufficient protection is provided against the radioactive cloud shine in the cloud phase of an accident by shelter in houses, cellars or fallout-shelters. Therefore, this is considered as the most important protective measure. In order to prevent infiltration of radioactive material, windows and outside doors should be closed and air-conditioning systems turned off.
- Iodine tablets are distributed to all houses, schools and companies in Zones 1 and 2. In Zone 3, tablets are stored by the cantons so that they are available to the general public within 12 hours. The distribution concept of iodine tablets in Zone 3 will be discussed within the review of the concept of emergency planning zones.
- Evacuation of some members of the population (especially in Zone 1) during the initial phase of an accident will be considered provided that no release of radioactive materials is expected during the evacuation period. A basic document containing standard requirements for the planning of large-scale precautionary evacuations has been drafted.

Protective measures during the ground phase are based on the actual radiological situation in the environment as indicated by measurement data. Important protective measures are: staying indoors, evacuation after the cloud passage, restricted access to certain areas, restrictions on certain foodstuffs, countermeasures for agriculture, decontamination and medical support.

Alert procedures

If an accident occurs, the NPP is required to inform the Inspectorate and the National Emergency Operations Centre immediately. If the accident poses a threat to the public and the environment, this triggers a three-stage warning and alert procedure. To be effective, measures to protect the public should be taken before any radioactivity is released from the plant. Therefore, the warning and alert criteria are based primarily on the situation in the NPP.

- A **warning** is issued at the latest when a high dose-rate is monitored inside the containment. The warning (by a dedicated electronic system) puts federal, cantonal and municipal organisations (within Switzerland) on stand-by for a possible alert. The National Emergency Operations Centre informs the IAEA and authorities in neighbouring countries. It also activates the hotline operated by a professional medical call centre.
- The first **alert** is by siren (coupled with radio broadcast messages to the population) if an accident develops in such a way that it might lead to a dangerously high release of radioactive materials into the environment. This alert ensures that the population at risk is aware of the emergency situation, so that it can prepare to take counter-measures. Instructions are given over the radio.
- Further **alerts** by sirens are issued if necessary in order to give advice to the population on taking iodine tablets, staying indoors, using shelters, etc.

Special regulations exist for the initiation of countermeasures in the event of an accident involving auxiliary systems such as off-gas systems. They are required because releases may occur rapidly with such accidents. In this case, the NPP assesses the dose to the public. The decision to alert the public depends on the time available and the amount of any release. If the annual limit for the release of noble gases is likely to be released in less than 1 hour, which would result in a dose in the immediate vicinity of a plant of about 1 mSv, sirens will alert the public located in Emergency Planning Zone 1. The public will be advised to stay indoors for the next few hours. The NPP initiates the action and the cantonal police (responsible for countermeasures in Emergency Planning Zone 1) initiate the alert without waiting for an order from the National Emergency Operations Centre.

Emergency exercises

Each Swiss NPP conducts an emergency exercise every year. The outcomes of an exercise may lead to new measures to improve the functioning of the emergency organisation. Such measures are implemented into the training programmes of the members of the emergency organisation. According to the Inspectorate's Guideline B11, the yearly emergency exercise of each plant takes place in the presence of several representatives of the Inspectorate. A recent revision of this guideline allows the Inspectorate to require staff emergency exercises lasting up to 24 hours in order to check the adequacy of Severe Accident Management procedures and organisational measures especially for long-duration events. This requirement was implemented following a suggestion from the mission of the IAEA Integrated Regulatory Review Service, which took place in November 2011.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.

All those living in the vicinity of Swiss NPPs have been sent a leaflet from the cantonal authorities describing the potential dangers associated with a nuclear accident. The leaflet also explains existing countermeasures to cope with the consequences. The procedure for warning and alerting the population in case of accidents is described in Clause 1 of this Article.

Switzerland is party to the Convention on Early Notification and the Convention on Assistance. Switzerland has bilateral agreements covering notification and information exchange in case of a nuclear accident with its neighbours. Although Switzerland is not member of the European Union, it is part of the European Community Urgent Radiological Information Exchange Network (ECURIE). The National Emergency Operations Centre is responsible for the notification process and for providing the necessary information. Switzerland also participates in the INES reporting network and has undertaken to report all events rated as Level 2 or higher. If an incident occurs in an NPP, reporting is the responsibility of the Inspectorate. For other radiological incidents, it is the Federal Office of Public Health.

Because the Leibstadt and Beznau NPPs are close to the national border, special plans have been agreed with Germany. These plans are designed to ensure the same level of protection on both sides of the border for the public and the environment. They also seek to harmonise procedures. Dedicated telephone lines exist for communication between authorities. Plans and procedures are updated regularly by bilateral working groups as part of the German-Swiss Commission for the Safety of Nuclear Installations (see Article 17, Clause 4).

In case of an accident in an NPP, long-term consequences may extend beyond planning zones and so Switzerland has intensified its collaboration with France and Austria. For France, an expert group on nuclear emergency matters has been set up as part of the "Commission Franco-Suisse". For Austria, there is a yearly exchange of information. In November 2012, the "Commissione italo-svizzera CIS", a bilateral committee between Italy and Switzerland, met for the first time in Rome. A yearly exchange of information is also foreseen with Italy.

Emergency plans are not only tested at the national level. German authorities at both the local and federal level take part in exercises at the Leibstadt and Beznau NPPs. The next exercise with international participation is scheduled for 2013. Switzerland participates in exercises at the French NPPs of Fessenheim and Bugey, which are located some 30 km and 70 km from the Swiss border respectively.

The preparedness of Switzerland and its response at the international level is regularly verified by its participation in international exercises conducted by the IAEA or ECURIE. The OECD/NEA INEX exercises are another opportunity to verify certain aspects of emergency management. Switzerland usually participates in these exercises. In November 2011, the mission of the Integrated Regulatory Review Service (IRRS) reviewed, amongst other things, the Swiss concept for emergency preparedness and response. The IRRS issued good practices on this topic, as well as one recommendation and several suggestions, which will be followed up by the Inspectorate in the forthcoming years.

Emergency plans and procedures must be regularly improved and adapted to reflect new challenges and changing situations. Experts from several Swiss authorities take an active part in these activities. Switzerland also participates in working groups of HERCA and WENRA on emergency preparedness.

Finally, in order to improve the emergency response system at the national and international level, members of the Inspectorate and the National Emergency Operations Centre actively support the activities of the OECD/NEA working party on Nuclear Emergency Matters.

Clause 3: Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.

This Clause does not apply to Switzerland.

Developments and Conclusions

Since the fifth Swiss report, several ordinances relating to emergency preparedness have been revised: the Emergency Preparedness Ordinance, the Ordinance on the Organisation of Operations in Connection with NBC and Natural Events, the Ordinance on Alerting the Authorities and the Public, and the Ordinance on the National Emergency Operations Centre. The lessons learned from the accident of Fukushima have led to the initiation of numerous activities with the aim of improving preparedness and response capabilities both on and off site. The follow-up and completion of these activities will extend over several years.

Exercising the transport of mobile emergency equipment from the Reitnau External Sorage Facility to NPP Leibstadt during an Exercise in May 2013.
Source: ENSI

Article 17 – Siting

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime.

Under the Nuclear Energy Act and the Nuclear Energy Ordinance, a general licence for a nuclear installation can only be granted if the site is suitable. The procedures for granting a general licence and the associated requirements are discussed in the section on Article 7.

The Nuclear Energy Act contains a list of conditions governing the issue of a general licence. The first two are that humans and the environment shall be protected and that the granting of a licence does not conflict with other provisions of federal legislation, in particular legislation on environmental protection, preservation of the local natural and cultural heritage and the area development plan.

The Nuclear Energy Ordinance contains requirements relating to measures designed to prevent accidents initiated either within or outside the facility. For the purposes of the deterministic safety analysis, the Radiation Protection Ordinance gives dose constraints for the public during normal operation and for design-basis accidents. Based on this, the Inspectorate defines actual dose limits in Guideline G15 for normal operation, transients, and accidents. Dose constraints are ranked as a function of incident frequency. The Inspectorate's Guideline G-14 specifies the methodology and boundary conditions for dose assessments in normal operation for the public from radionuclide transfer and for accident analysis.

Under the Nuclear Energy Ordinance, the following reports shall be submitted with the application for a general licence:

- a safety analysis report (SAR);
- a security report;
- an environmental impact report;
- a report on compliance with area planning requirements;
- a concept for decommissioning;
- a report on the management of the resultant radioactive waste.

An integral part of the site evaluation is the assessment of external hazards. Specific requirements are provided in the Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations and include earthquakes, flooding, aircraft crashes, extreme weather conditions (winds, tornados, etc.), lightning, shock waves, and fire. The hazard analysis shall follow comprehensive impacts, e.g. on multiple units, as well as secondary effects like loss of external cooling water or power supply, mudslide, site access following an event, etc. Consequentially, the SAR shall account for all relevant factors relating to the site (natural characteristics and human activities), in particular:

- geology, seismology, hydrology (including flooding and ground water) and meteorology;
- population distribution, neighbouring industrial plants and installations;
- anticipated exposure to radiation in the vicinity of the facility;
- traffic infrastructure (road, rail, air, water) and transport frequencies.

For the purposes of the PSA, the Nuclear Energy Ordinance demands that the mean core damage frequency (CDF) for any newly constructed NPP is not greater than 10^{-5} per year. For existing NPPs, the licensee has to prove a CDF less than 10^{-4} per year (including external hazards), as required by the Ordinance on Hazard Assumptions and Evaluation of Protection Measures against Accidents in Nuclear Installations.

During the licensing procedure, the Inspectorate evaluates the site-related factors likely to affect the safety of a nuclear installation and produces a safety evaluation report (SER) in which it defines additional requirements for plant design, if necessary.

Before the construction of an NPP, the Federal Office of Public Health and the Inspectorate establish a programme for radiological surveillance in the vicinity of the NPP. The programme includes sampling and the measurement of air, water, soil and foodstuffs. The first set of data is collected before an NPP is commissioned and this is then used as a baseline when investigating the effects of an NPP after commissioning.

The relevant safety factors shall be evaluated whenever there are plans to build a relevant new feature (e.g. gas pipeline or industrial building) in the vicinity of an NPP.

Safety assessments shall be updated whenever relevant new findings or experience is available.

Following the Fukushima accident, the inspectorate initiated a re-evaluation of several hazards (see Clause 3).

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment.

Switzerland is a small and densely populated country. The number and size of suitable sites for NPPs are limited. The concept of safety by distance encounters natural limitations in Switzerland. Existing NPPs are sited in areas where population density is relatively low compared with the mean for industrialised regions in Switzerland. New NPPs were planned in the vicinity of existing sites. However, following the accident in Japan's Fukushima Daiichi nuclear power plant, the Federal Council decided to abandon nuclear energy in an orderly manner. Consequently, there are no plans to build new NPPs.

Clause 3: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for re-evaluating as necessary all relevant factors referred to in subparagraphs (1) and (2) so as to ensure the continued safety acceptability of the nuclear installation.

When re-evaluating the relevant factors, the procedure is basically the same as that applied to the initial review and assessment (see Clause 1 above). Because the reporting procedures applicable to power plants include the relevant site factors, any modifications to these factors are known (e.g. construction of a new industrial plant in the vicinity of the NPP). The notification by the licensee of such modifications normally includes an assessment of their possible consequences. Site-related factors are re-evaluated as part of the periodic safety review (PSR). In particular, the SAR (including the deterministic safety analysis) and the PSA are updated by the licensee and reviewed by the Inspectorate.

In essence, the re-evaluation processes help to ensure the continued safety acceptability of the NPP as it confirms the validity of earlier assessments or indicates the impact of changes to site-specific safety factors. The applicability and effectiveness of the Inspectorate's re-evaluation process are illustrated by the probabilistic reassessments of the hazards posed by earthquakes, external flooding and extreme weather conditions.

Earthquake

The large-scale project PEGASOS – a German acronym for "Probabilistic Seismic Hazard Analysis for Swiss Nuclear Power Plant Sites" – was carried out by the Swiss licensees in response to a requirement that came out of the Inspectorate's PSA review process. In order to achieve a thorough quantification of the uncertainty of seismic-hazard estimates, an extensive elicitation process was conducted involving technical experts, scientific institutions and engineering organisations from Europe and the USA. The complete project report was released in 2006 at an OECD specialists' meeting in Korea. A summary report in German can be downloaded from the Inspectorate's homepage.

In 2008, the Swiss licensees initiated a follow-up project, the PEGASOS Refinement Project (PRP). The project takes advantage of the most recent findings in earth sciences and new geological and geophysical investigations at the Swiss NPP sites. A particular objective is to reduce the uncertainty range of the PEGASOS results. As with the PEGASOS project, the PRP seeks primarily to characterise seismic sources, ground motion attenuation on rock and the local soil response at the NPP sites. In 2009, the scope of the PRP was extended to include the sites for the new Swiss NPPs that were proposed at that time. The Inspectorate is following the study closely through a system of continuous peer reviews similar to that for PEGASOS. It is expected that the final PRP report will be submitted to the Inspectorate in 2013. The projects PEGASOS and PRP follow the state of the art of the Senior Seismic Hazard Analysis Committee (SSHAC) level 4 methodology.

Based on the PEGASOS insights, the Inspectorate increased the level of seismic hazard to be used for the PSA studies and for the design of new safety-related structures and components. As a consequence of the Fukushima accident, the Inspectorate required the licensees to re-evaluate the seismic design with reference to available interim results from PRP (see Articles 14 and 18). Furthermore, in the context of the continuous backfitting process undertaken by the Swiss NPPs, the Inspectorate places particular emphasis on seismic safety. In addition to the major seismic backfitting projects completed in the past (e.g. installation of bunkered emergency systems), the components and structures backfitted more recently include electrical cabinets, motor control centres, cable trays, diesel-oil day tanks, pipe runs, control room bracing and masonry walls.

External Flood

For the design of the nuclear power plants, protection against flooding was originally determined on the basis of dam and/or weir breach scenarios or on a 1,000-year flood. In 2008, the flooding hazards for three sites were reassessed in the framework of the general licence applications for new nuclear power plants, which were intended to be built at already existing sites. The new flooding hazards were derived from either considering a 10,000-year flood or, in one case, an extreme flood scenario which actually gives rise to a higher discharge than the 10,000-year flood. The discharge values for the 10,000-year floods were calculated through extrapolation of river level data considering historical flood records, where appropriate. The flood levels were computed using a 2D-model for the flooding scenarios, including a detailed orographic representation. After the severe accidents in Fukushima, ENSI ordered the new results to be applied for the safety assessment of the existing nuclear power plants. Additionally, to evaluate the flooding risk comprehensively, ENSI asked the licensees to perform analyses regarding the effects of a total debris blockage of bridges, culverts or hydraulic installations near the sites. The analyses of the licensees indicate that total debris blockage does not cause cliffedge effects for the plants. However, for some plants ENSI required additional information.

Extreme weather conditions

For the purpose of the design of the plants, the hazard assumptions were defined on the basis of rules and standards valid at the time. It should be noted that the loads due to some extreme weather conditions, such as extreme winds, tornados and rainfall, are covered by other loads (e.g. aircraft crash or explosion), which form the current basis for the design of nuclear buildings that are important to safety.

In the course of the EU stress test, the Inspectorate identified the need for a re-evaluation of the existing hazard assumptions concerning extreme weather conditions and the associated proof of adequate protection in order to determine whether these elements are up to date.

The requirements for the re-evaluation of the probabilistic hazard analyses concerning extreme weather conditions were specified in 2012. At the end of 2012, the Swiss nuclear power plants submitted a common conceptual document regarding the performance of the probabilistic assessment of extreme weather conditions. The probabilistic hazard analyses and the proof of adequate protection of the plant against extreme weather conditions will be submitted to the Inspectorate by the end of 2013.

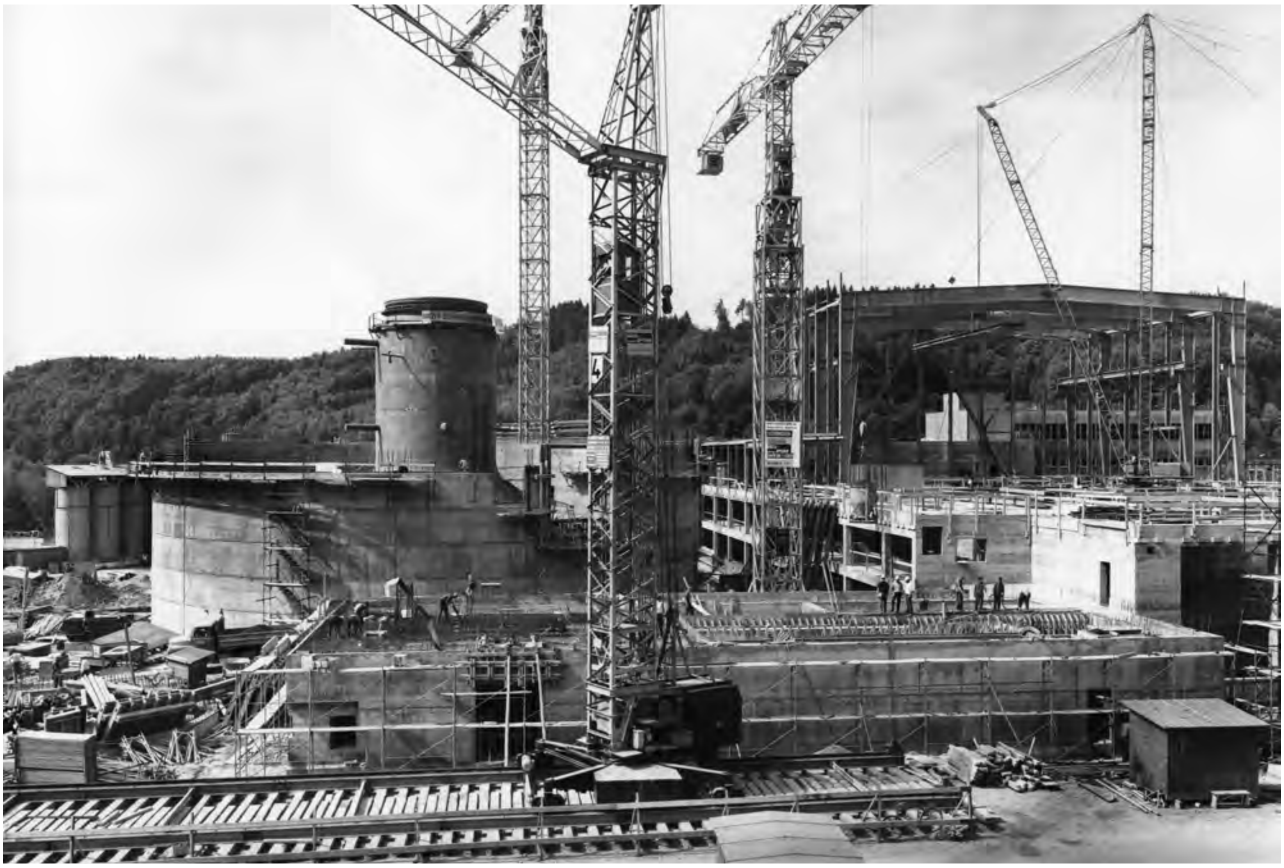
Clause 4: Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties, in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

Switzerland has signed agreements on the exchange of information with Austria, France, Germany and Italy. The German-Swiss Commission for the Safety of Nuclear Installations, including its working groups, the Franco-Swiss Nuclear Safety and radiological protection Commission and the Italian-Swiss Commission for the cooperation in Nuclear Safety meet annually to consult and exchange information and experience. They also define the terms of reference for individual working groups, e.g. exchange of operational experience, emergency protection planning and exercises, radiation protection, surveillance of ageing and waste disposal. In addition, representatives from Austria and Switzerland meet annually to share information on nuclear programmes, operational experience in nuclear installations and the legislative framework for nuclear safety and radiation protection. In 2011, the government decided to phase out the use of nuclear power in Switzerland. As a result, no new NPPs will be built.

Developments and Conclusion

Changes and developments: The comments on Clause 3 provide an update on the reassessment of the hazards posed by earthquakes, external flooding and extreme weather conditions.

Following the accident in Japan's Fukushima Daiichi nuclear power plant, the Federal Council decided to abandon nuclear energy in an orderly manner. Consequently, no new NPPs are planned for which site-relevant factors need to be evaluated.



Construction of the NPP Mühleberg in the 1960's
Source: BKW Energie AG

Article 18 – Design and construction

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur.

The design and construction of Swiss NPPs are based on US standards (Beznau I and II, Mühleberg, Leibstadt) and German standards (Gösgen) that applied at the time of construction. The standards used are still international and incorporate the principle of defence in depth. The various levels of defence ensure that the NPPs remain within safety limits in the event of a design-basis accident and that individual dose limits for the general public are not exceeded. In addition, systems, equipment and procedures exist to prevent or mitigate the release of radioactive materials into the environment in the event of a severe accident. Severe Accident Management Guidance (regarded as an element of defence in depth) exists in all Swiss NPPs (see Article 16).

The design and construction of Swiss NPPs were thoroughly assessed as part of the **licensing procedure**. The results of this assessment are part of the safety evaluation report (SER) and play an important role in licensing decisions (see Articles 7 and 14). In compliance with the IAEA Safety Standard NS-R-1, Switzerland included design requirements regarding redundancy, diversity, physical and functional separation, automation, and other fundamental design principles in Article 10 of the Nuclear Energy Ordinance and the Inspectorate's Guideline R-101.

After a licence has been granted, the design and construction of existing NPPs are reassessed periodically. An in-depth review comparing the actual design and the current state of science and technology is performed at least every 10 years (PSR, see Article 14).

It is also important to note that the Swiss Nuclear Energy Act art. 22 requires that the licence holder of a nuclear power plant is obliged to backfit the plant according to the "state of the art of the backfitting technology", and beyond it, under consideration of the appropriateness to implement further measures if these measures allow for further risk reduction.

The **first generation** of Swiss NPPs (**Beznau I and II, Mühleberg**) were constructed using designs from the late 1960s. Beznau NPP consists of two identical units of a Westinghouse 2-loop PWR type with a net electrical output of 365 MW each. Mühleberg NPP is a General Electric BWR/4 type with a net electrical output of 373 MW. They were constructed before the establishment of the general design criteria (GDC) in 1972 by the former US Atomic Energy Commission. A comparison between the design of first-generation NPPs and the requirements of the GDC revealed that the main design criteria had been recognised and incorporated in the design. These NPPs included several unique design features that were not standard at the time of construction:

- Double containment (free-standing leak-tight steel plus concrete outer shell);
- Load rejection and turbine trip without scram;
- Continuous emergency power supply from a nearby hydroelectric plant;
- Ground water as emergency feed water system (Beznau NPP);
- Doubled containment size in relation to reactor power (Mühleberg NPP);
- Hilltop reservoir to flood the core (Mühleberg NPP);
- Outer torus (Mühleberg NPP).

However, a review of the design by the Inspectorate came to the conclusion that the protection against external events of natural origin, especially earthquakes and flooding, and against man-made external events, e.g. aircraft crash, explosion or intrusion, is not sufficient. Furthermore, a lack of separation of safety-relevant systems was revealed.

The Inspectorate therefore demanded the backfitting of bunkered special emergency shutdown and residual heat removal systems. The systems had to be redundant and independent from the "normal" or conventional safety systems, including a diverse ultimate heat sink and an independent special emergency power supply, and protected against external events and against third party intervention (SUSAN, NANO, see Article 6). The special emergency buildings include a bunkered emergency control room from where the safe shutdown of the plant and the residual heat removal can be monitored and operated. The systems are designed to operate automatically in a special emergency case, without any operator action needed during the first 10 hours after initiation. The backfitting of bunkered special emergency systems was an important measure to strengthen the safety provisions against design basis accidents, as well as beyond design basis accidents.

In this context, another important safety improvement at Beznau NPP was the seismic requalification programme REQUA conducted until 1992 in order to strengthen the seismic resistance of the vital equipment of the plant. Furthermore, in 1989, the existing pressuriser relief valves at Beznau NPP were replaced by pilot-operated pressuriser safety/relief and isolation valves of the SEBIM type. These valves allow a primary pressure relief and a feed and bleed operation to be conducted.

In the early nineties, in the framework of the "Measures against Severe Accidents" developed by the Inspectorate after Chernobyl, hardened filtered containment venting systems were backfitted at Beznau (SIDRENT, 1992) and Mühleberg NPPs (CDS, 1992), allowing an active or passive venting of the containment in case of severe accidents. In 1988 already, the containment atmosphere of the Mühleberg NPP was inertised with nitrogen in order to prevent the formation of ignitable gas mixtures. Furthermore, in both NPPs, different means for alternative core cooling and alternative containment cooling were backfitted. For example, at Mühleberg NPP, a drywell spray system was installed in 1992 which allows flooding of the containment. In 1999, the backfitting of an emergency feed water system, in addition to the existing auxiliary feed water system, was completed at Beznau NPP unit 2. The system is located in a bunkered building which is protected against external hazards. The emergency feed water system for unit 1, located in the same building, has been operational since 2000. The feed water supply to the steam generators is backed up by a third system – the special emergency feed water system, which is integrated in the bunkered NANO system. In sum, the feed water supply at Beznau NPP is very reliable as a result of the high degree of redundancy und diversity.

Further measures for improving the safety are ongoing. At Beznau NPP, the hydroelectric emergency power supply will be replaced by an additional state-of-the-art, seismically robust emergency diesel generator system. This backfitting project, which was already initiated before the Fukushima events, is scheduled to be completed in 2014. Within this project, an additional, bunkered seal water injection pump and a secured long term water supply for the emergency feed water system will be backfitted. The Inspectorate also reviewed the Beznau NPP in the light of long-term operation (LTO), as unit 1 and unit 2 have been in operation for more than 43 years and 41 years, respectively. No further major backfitting measures were identified.

After Fukushima, the protection of the Swiss NPPs and their spent fuel pools (SFP) against external events had to be reassessed by the licence holders (see Article 14). Furthermore, the Inspectorate 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 the SFPs with a qualified accident-proof level and temperature instrumentation with indication of these parameters in the main control room as well as in the bunkered emergency control rooms. At Beznau and Mühleberg NPP, the Inspectorate ordered the backfitting of new redundant SFP cooling systems because the existing systems were not qualified as safety systems. The implementation of two physically separated lines for feeding the SFP was completed at Mühleberg NPP in 2012.

As a result of the reviews regarding earthquake resistance, Beznau NPP is furthermore required to improve the earthquake resistance of the SFP storage building, and has to implement a venting duct to remove heat and pressure generated by boiling SFP water in order to protect the building structure in case of beyond design basis accidents. The licence holder has initiated a backfitting project to implement the above mentioned improvements by 2014. The earthquake analyses for the Mühleberg NPP confirmed that the seismic protection measures are adequate, and no additional measures were required.

As a consequence of the flooding analyses, the intake structure of the special emergency system SUSAN at Mühleberg NPP was enhanced to prevent blocking by bedload, sediment, and debris transport by the Aare River. This took already place in 2011, as well as the provisioning of mobile flood walls. Nevertheless, the cooling water supply of safety and special emergency systems at Mühleberg NPP still relied on the Aare River only, using diversified intake structures. The Inspectorate ordered a diverse cooling water supply that is independent from the Aare River to be implemented. The flooding analyses for Beznau NPP confirmed that the flood protection measures are adequate, and no additional measures were required.

The Mühleberg NPP has been in operation for more than 40 years. In order to assess the requirements for a potential long-term operation (LTO), in 2012 the Inspectorate conducted a thorough safety review of the documents provided by the licence holder in the frame of the PSR 2010. Besides the required backfittings identified in the Fukushima reassessment process as mentioned above, the Inspectorate addressed deficiencies in the spatial separation of safety systems in the lower floor of the reactor building and improvements for stabilizing the core shroud which is affected by cracks. Up to now, the licence holder has initiated a backfitting project which contains a cooling water supply from a protected well, a qualified redundant SFP cooling system, and an additional independent safety injection and residual heat removal system installed in a new building. These backfittings have to be completed by 2017.

In October 2012, an IAEA OSART mission to Mühleberg NPP took place. The review team acknowledged the fast and thorough response to recent significant external operating experience events, including important plant modifications (see Article 19).

In conclusion, all first-generation NPPs have completed or are completing a comprehensive analysis and backfitting programme, and substantial improvements have been made. The results of the EU stress tests on these NPPs confirm this statement.

Regarding the realization of backfitting measures and plant modifications, the Inspectorate is supervising these activities very closely. The projects and modifications are subject to a four-step procedure, consisting of the concept, the detailed design, the installation, and the commissioning of the systems. The Inspectorate grants permissions for every step of the procedure after thorough examination of the appropriateness and compliance with national and international safety requirements.

The **second-generation** NPPs in Switzerland (Gösgen NPP, 1979, and Leibstadt NPP, 1984) were based on German design criteria or US design criteria, respectively. The bunkered special emergency shutdown and heat removal systems, which provide a very high degree of protection against external events and diversity to the conventional safety systems, including a diversified ultimate heat sink, were already integrated in the design from the beginning, requiring the US design of the Leibstadt NPP to be adapted to the specific Swiss demands regarding special emergency systems.

The safety status of the **Gösgen NPP**, a Siemens/KWU PWR with a gross electrical output of 1035 MW, has been continuously enhanced since its commissioning. In 1993, a filtered containment venting system was installed, allowing a passive or active venting of the containment in case of beyond design basis accidents.

In 1999, the reliability of the SFP cooling was enhanced by installing an additional independent train to the existing redundant trains for SFP cooling.

Beginning in 2001, the structures of several buildings were reinforced in order to improve the seismic resistance.

The provisions for conducting a primary pressure relief, the installation of three pilot-operated pressuriser safety/relief valves, were implemented in 2005.

These valves make it possible to conduct a primary pressure relief and a feed and bleed operation in beyond design accident conditions.

During the outages in 2006 and 2007, the existing containment sump suction strainers were replaced by new strainers of a filter cartridge type, enlarging the suction area from 10 m2 to a total of about 110 m2.

In 2008, an airplane crash and flood proof, earthquake-resistant building for the wet storage of spent fuel was taken into commission. The cooling of the fuel elements is ensured by a completely passive system, i.e. no electrical power and no cooling water supply is required to maintain the fuel in a safe state.

The original design of the **Leibstadt NPP**, GE BWR/6-238 Mark III, was complemented by the special emergency heat removal system SEHR in order to provide increased protection against external hazards, using groundwater from a protected well as an ultimate heat sink.

In the course of time, several backfitting measures were realized. The alternate rod insertion system ARI was introduced in 1988, which provides redundancy and diversity to the existing SCRAM system, reducing the risk of anticipated transients without SCRAM significantly. In the same year, a redundant safety parameter display system was introduced.

After the Barsebäck event in 1992, the existing suction strainers of the emergency cooling systems with a size of 2 m2 were replaced with strainers of 15 m2. This took place in 1993, as well as the backfitting of the hardened filtered containment venting system which allows active venting by opening a valve or passive venting by a rupture disc.

The ventilation of the main control room (MCR) was improved in 1996 in order to ensure the habitability of the MCR in case of accidents with release of radioactive material. The special emergency control room displays were extended by adding neutron flux, important containment data, and stack release parameters to the existing displays. Further enhancements were carried out regarding operational safety and availability.

After Fukushima, the reviews of the seismic and flood resistance of the Gösgen and Leibstadt NPPs in the case of a 10,000-year earthquake showed compliance with the current licensing basis, and the fundamental safety functions are ensured (see Article 14). Nevertheless, Gösgen NPP was further enhanced by several improvements regarding the protection against flooding and earthquake. The seismic robustness of specific safety important equipment was improved in 2012 or will be improved in the next two years. The assumption of a 10,000 year flood as new design specification led to several improvements, including the introduction of an automatic advance flood warning system, the specification of organisational and administrative measures in emergency procedures, an additional sealing of building shells, air inlets and doors, as well as the provision of mobile flood walls to ensure access to important buildings.

Another potential for improvement was identified by the Inspectorate regarding the seismic robustness of the containment venting systems of Gösgen and Leibstadt NPPs, where the seismic resistance was determined as adequate but the existing margins could be increased.

The measures regarding SFP cooling and SFP instrumentation – the provision of two physically separated lines/connections for feeding the SFPs from outside the buildings as an accident management measure, and backfitting of the SFPs with qualified accident-proof level and temperature instrumentation with indication of

The construction of the NPP Gösgen in 1975
Source: Kernkraftwerk Gösgen-Däniken AG

these parameters in the main control room as well as in the bunkered emergency control rooms – have already been implemented in Gösgen NPP and will be implemented in Leibstadt NPP in 2013.

After Fukushima, the Inspectorate conducted several inspections to assess the situation in the Swiss NPPs regarding issues that resulted from the accident management actions performed at Fukushima. The inspectorate verified the design, operability, and suitability of the filtered containment venting systems, taking into account possible adverse conditions, e.g. the loss of motive power of the valves to be opened, or radiological challenging conditions. It was verified that the venting valves can be opened in case of loss of power by provision of nitrogen accumulators that are stored on the spot, or by passive actuation by a rupture disk with defined opening pressure. The condition of the venting filters was also inspected. In another inspection, the suitability and habitability of the emergency operations centres was checked.

Furthermore, the Inspectorate conducted inspections to review the provisions of Swiss NPPs to cope with a long-lasting station blackout (SBO). Despite the fact that five redundant and diversified safety layers regarding electric power supply exist, further measures against a potential SBO were taken. Each plant developed an SBO strategy and is prepared to cope with an extended SBO of seven days by means of accident management measures, including the provision of, for example, nozzles for feeding steam generators with mobile pumps or fire trucks, mobile diesel generators, means for opening valves by manual action, the provision of sufficient fuel and lubricants for extended operation, and the revision of severe accident management guidelines for SBO.

Electrical systems

The design of electrical systems and components of the Swiss NPPs is mainly based on the standards set by the Institute of Electrical and Electronics Engineers (IEEE) and by the requirements of IAEA NS-R-1. These standards and requirements were also taken as a basis for the relevant guidelines of the Inspectorate. Depending on the safety significance of such equipment, safety class 1E or 0E is applied. Classification 1E is generally applied to all electrical systems in the emergency power supply within the NPP and to the special emergency electrical supply, as well as to the electrical components of the safety systems. For equipment classified as 1E, proof of qualification must be available for all the components involved in safety functions. This means that the design basis range of the components for ambient conditions are proven for normal operation as well as under adverse conditions regarding pressure, humidity, and radiation in case of an accident. Additionally, the components have to withstand the earthquake loads in case of a safe shutdown earthquake (SSE) at the location where they are installed, and the installation locations of such components have to be above or protected against the design basis flood levels. Electrical equipment classified as 0E is of lower safety significance. Such equipment is not subject to the qualification criteria applied for 1E equipment, and their seismic resistance is limited to the operating basis earthquake (OBE).

The criteria for independence of class 1E equipment and circuits, as well as the criteria for independence of electrical safety systems, which are defined by IEEE and Reg. Guide 1.75, are also part of the design. KTA 3503, which sets the standards for type testing of electrical modules of the safety instrumentation and control system, is also an accepted and applied standard.

Regarding the safety importance of a reliable and diversified electrical power supply for NPPs in order to prevent a station blackout (SBO), it is to be pointed out that the Swiss NPPs display an enhanced protection against the loss of electrical power. In addition to the emergency power supply, which is usually provided by diesel generators, an independent special emergency power supply by dedicated special emergency power diesel generators that are protected against external events is in place. These supplies, which ensure operation of the systems required for safety purposes, can be operated autonomously for several days (with the exclusive use of equipment stored at the NPP site).

The special emergency diesel generators constitute an important “safety layer” of the electrical power supply, but they are only part of the provisions that are set up. The design of the electrical power supply installation complies with the "defence in depth" principle and displays several levels of protection which are designated in this section as safety layers of the electrical energy supply.

The following safety layers are in place:

1st Safety Layer:	External main grid the generator feeds into
2nd Safety Layer:	Auxiliary power supply in island mode in case of failure of the main grid
3rd Safety Layer:	External reserve grid in case of failure of the external main grid and of the auxiliary power supply
4th Safety Layer:	Emergency electrical power supply from an emergency diesel generator or hydroelectric power plants (HPP) in case of failure of the first three safety layers for the supply of conventional safety systems
5th Safety Layer:	Special emergency electrical power supply from special emergency diesel generators for the supply of the special emergency systems
6th Safety Layer:	Local accident management (AM) equipment, such as mobile emergency power units and possible connections to nearby hydroelectric power plants
7th Safety Layer:	Accident management equipment stored at the central storage facility in Reitnau and other off-site locations (mobile emergency power units)

In order to cope with an SBO, battery-powered DC power supplies and mobile accident management diesel generators are available at all Swiss nuclear power plants. In addition, there is access to further accident management equipment in the central emergency storage facility at Reitnau. The preparedness of the operators to handle a SBO scenario was inspected by ENSI in 2012.

Instrumentation and control

Regarding instrumentation and control, the standards set by the International Electrotechnical Commission (IEC) are applied in addition to the classification criteria defined by IEEE documents. The safety relevance of instrumentation and control functions is assigned to categories according to IEC 61226, and the assignment to instrumentation and control systems is achieved according to IEC 61513.

The Periodic Safety Reviews carried out for the Swiss NPPs showed that the instrumentation for operational and safety systems as well as the independent accident monitoring instrumentation are designed according to international standards and national requirements, and consider the defence in depth principle. After the accidents at Fukushima, all Swiss NPPs were inspected and it was confirmed that the accident monitoring instrumentation is continuously supplied by batteries and AM diesel generators in the case of an SBO, thus providing the operators a survey of the most important plant parameters.

Seismic design of nuclear buildings

The nuclear buildings of the Swiss NPPs are classified into the structural classes I and II, according to the seismic classes I and II of the equipment placed in the buildings. Equipment and buildings of class I are designed to resist a safe shutdown earthquake (SSE), equipment and buildings of class II are able to resist an operating basis earthquake (OBE). In current practice, half of the SSE spectral accelerations are used for the OBE.

Originally, the class I structures of the first generation of Swiss NPPs (Beznau I and II, Mühleberg) were designed assuming a horizontal peak ground acceleration (PGA) of 0.12 g at the rock surface. In the 70s, it was established that an earthquake with an exceedance frequency of 10^{-4} per year, or an exceedance probability of 0.4% in 40 years, has to be considered for the SSE. This led to a seismic requalification of the first-generation Mühleberg NPP and Beznau in the 80s under assumption of a higher PGA of 0.15 g at the rock surface. The second generation NPPs Gösgen and Leibstadt were originally designed for a PGA of 0.15 g at the rock surface.

During operation, the buildings of the Swiss NPPs have been strengthened constantly. In all NPPs, the masonry walls which could endanger safety relevant equipment have been secured with steel constructions. In addition, the bearing reinforced concrete structures of different buildings have been strengthened. Examples are the building of the emergency feed water system of Gösgen NPP in 2008 and the first stage of reinforcing the SFP storage building of Beznau NPP in 2009, which were made more resistant to earthquake impacts by additional strongly reinforced walls. The robustness of the SFP storage building of Beznau NPP will further be improved in a second stage. The detailed planning documents of this second stage are currently under review by the Inspectorate. The construction work will begin in 2013.

Since 2002, raised earthquake impacts have been considered for new buildings and for strengthening measures for existing buildings. As a rule, the spectral accelerations of the SSE are raised by factors between 1.5 and 2.0. Examples of new buildings where enhanced seismic accelerations were considered are the new SFP storage building of Gösgen NPP and the diesel generator buildings of the new emergency power supply in Beznau NPP.

After Fukushima, the Inspectorate ordered the seismic safety of the Swiss NPPs to be reassessed. In the analysis, the operators had to consider the intermediate results of the PEGASOS Refinement Project (PRP) as seismic impact. The seismic safety of the buildings was computed with different extensive linear and non-linear calculation methods. The analyses, as well as the review of the Inspectorate, confirmed that the nuclear buildings also withstand the massively higher earthquake impact from PRP compared to the present SSE. The calculations have shown that under this impact the nuclear buildings basically still behave in a linearelastic manner. This means that high margins exist and that only moderate, non-relevant building damage is to be expected. In Table 5, the earthquake accelerations of the present SSE to the accelerations of the PRP Intermediate Hazard are compared.

In sum, the Swiss NPPs were designed and constructed in full accordance with IAEA requirements regarding defence in depth. The basic principles regarding redundancy, diversity, physical and functional separation, and automation were integrated in the Nuclear Energy Act, in the Nuclear Energy Ordinance, and in the guidelines issued by the Inspectorate, ensuring that those principles are implemented in the plants.

The systems and components are classified in safety classes and designed and manufactured according to proven codes like ASME and KTA. The Swiss NPPs are designed to withstand hazards of natural origin with a return period of 10,000 years, and have further margins beyond this. The seismic accelerations that were considered in the analyses are amongst the highest values in Europe. Furthermore, the plants possess a highly reliable power supply, reducing the risk of a SBO significantly.

Table 5: Comparison of earthquake accelerations of the present SSE to the accelerations of the PRP Intermediate Hazard

	Beznau NPP	Mühleberg NPP	Gösgen NPP	Leibstadt NPP
Horizontal PGA rock level SSE	0.15 g	0.15 g	0.15 g	0.15 g
Horizontal PGA basement reactor building SSE	0.15 g	0.15 g	0.15 g	0.21 g
Horizontal PGA rock level PRP Intermediate (10^{-4}, mean)	0.17 g	0.22 g	0.20 g	0.18 g
Horizontal PGA basement reactor building PRP Intermediate (10^{-4}, mean)	0.26 g	0.24 g	0.28 g	0.30 g

After commissioning, the plants were backfitted systematically, taking into account the lessons learned from national and international events. They underwent several periodic safety reviews. The NPPs were also subject to the ENSREG stress tests that were performed on European NPPs. The peer review which took place in 2012 confirmed that the degree of protection of Swiss NPPs is very high. Nevertheless, further backfittings will be implemented in order to provide continual improvement of nuclear safety.

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis.

Systems, structures and components (SSC) are subject to continuous refinement and regular testing to verify nuclear safety and fitness for service. Swiss NPPs are legally obliged to comply with the current state of science and technology. Therefore, the applied technologies for design and construction modifications as well as backfitting measures are proven by experience or qualified by testing or analysis, which is reviewed by the Inspectorate.

In Switzerland, the US ASME-Code is applied for the original design and construction of SCC related to safety as well for backfitting projects. Recognized non-nuclear codes and standards are used for some SCCs of safety classes 3 and 4. ENSI has installed guidelines for the approval of design specifications that are applied in case of design modifications or backfitting measures.

The Swiss SIA-Code is used for civil engineering purposes. For faulted loads, e.g. loss of coolant accidents, earthquakes, and aircraft crashes, the design incorporated special load combinations with special safety factors.

The various SSCs are classified in accordance with internationally recognised Nuclear Safety Classes. These classifications reflect their relevance to safety. Safety-classified components must fulfil high requirements in terms of design, materials, fabrication processes, maintenance and inspection. Nevertheless, some material and design deficiencies have appeared over time. The following paragraphs describe major examples of deficiencies, together with the steps taken by the Swiss NPPs to control, eliminate or mitigate them:

- In the late 1960s, the nickel-based material Alloy 600 was used extensively in the primary circuits of NPPs. Its manufacturing, corrosion and mechanical properties appeared favourable for the then operating conditions and service requirements. However, despite earlier experience, this material suffered from stress corrosion cracking in the LWR coolant environment. The steam generators of Beznau NPP I and II were replaced in 1993 and 1999 for that reason.
- A project is underway for the preventive replacement of reactor vessel heads at Beznau I and II in order to eliminate more Alloy 600 material. Alloy 182/82 welding material will be removed from the pressuriser in Gösgen NPP.
- Stainless steel components may suffer from stress corrosion cracking in the case of unfavourable manufacturing conditions such as sensitized material or local cold work. For this reason, the recirculation piping of the Mühleberg NPP was replaced in 1986. A project to replace the recirculation system at Leibstadt NPP is in progress.
- In 1990, the Mühleberg NPP was the first BWR worldwide to report horizontal cracks in the stainless steel core shroud welds. These were discovered during the annual in-service inspection. The design of the core shroud does not allow a simple replacement. As a precautionary measure, tie rods have been put in place. Even if there were full circumferential separation of the core shroud welds, these tie rods would hold the core shroud together and in place. In 2000, NPP Mühleberg introduced hydrogen water chemistry and noble metal chemical addition to protect the reactor internals against stress corrosion cracking. In 2005, the injection method was modified to OnLine NobleChemTM. Measurements of crack lengths have confirmed a considerable reduction in the rate of crack growth for most cracks since then. The newly qualified ultrasonic testing method confirmed that the circumferential cracks have not penetrated through the wall of the core shroud, but have stopped in the middle of the wall in most places. ENSI requires the Mühleberg NPP to improve the tie rod structure for long-term operation.

Article 14 describes the strategies for managing ageing problems as an integral part of a comprehensive ageing surveillance programme.

Clause 3: Each Contracting Party shall take the appropriate steps to ensure that the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

As mentioned in the comments on Clause 1 of this Article, Swiss NPPs were constructed using US or German designs and therefore met the requirements of these countries for reliable, stable and easily manageable operation, as well as the requirements in terms of human factors and the human-machine interface.

However, in NPP control rooms – the most important element of the human-machine interface – all Swiss NPPs have made improvements compared with the original design. They have introduced computerised process visualisation techniques to facilitate operational control in normal as well as abnormal conditions. The degree of automation has been increased to reduce the need for manual action for 30 minutes in the event of a design basis accident and for 10 hours in the case of an external event.

The Inspectorate pays particular attention to the consideration of human factors in the design of modifications of existing nuclear installations. Since 2007, the Inspectorate demands a human factors engineering programme from the licensees together with the initial concept of a modernisation project that affects human-machine interfaces (see Article 12). This ensures systematic and continuous consideration of human factors throughout the modernisation project. Below are some recent examples of modernisation that have an impact on the human-machine interfaces and where the Inspectorate is closely monitoring the human factors engineering process applied by the licensees:

- In the 1990s, the Beznau NPP installed two computerised systems to improve the human-system interface. The first is a computerised alarm system with a prioritisation scheme for displaying important messages with a safety function. The second is a computerised system for emergency operating procedures (EOPs) based on the printed EOPs. This system guides the shift supervisor step-by-step through the EOPs. Printed EOPs are available in case of computer failures. These computerised systems are currently being modified.
- In 2008, the Beznau NPP started a large plant-modernisation project to replace the existing hydroelectric power station that is part of the emergency power supply systems with seismically qualified diesel generators.
- The Beznau NPP replaced a remote control room for the control of processes with low safety significance with digital instrumentation and control systems. From a technical standpoint, the modification had low safety significance. From the perspective of the operating and maintenance personnel, however, the modification had a high safety impact as it completely changed the working environment as well as the working habits of the persons involved. In 2010, the Inspectorate approved the modified system based on a thorough safety demonstration by the licensee. The safety demonstration also included an integrated systems validation showing that the safety requirements for the operation and control of the modified systems have been fulfilled.
- In 2009, the Gösgen NPP announced that it planned to replace all instrumentation and control systems. This modification will have a major impact on the working conditions of the control room operators and in particular of the maintenance personnel.

Developments and Conclusion

Further backfitting measures to be taken depend on the assessments and analysis that are still to be performed as a consequence of the Fukushima events (see Article 14). Further improvements will also be made by implementing the requirements from the Inspectorate regarding long-term operation. The safety requirements for equipment used in beyond design basis conditions will be implemented in a new guideline in which updated design rules for the existing NPP will be laid down.

Article 19 – Operation

Clause 1: Each Contracting Party shall take the appropriate steps to ensure that the initial authorisation to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements.

All five Swiss NPPs have valid operating licences granted in accordance with the law. The initial operating licence includes the commissioning licence. Essentially, the granting of an operating licence is based on the following elements:

- an extensive set of technical and organisational documents as specified in Appendices 3 and 4 of the Nuclear Energy Ordinance and submitted by the applicant with the formal application;
- a safety evaluation report by the Inspectorate;
- proof of insurance;
- report that the plant conforms with the general licence and construction licence.

The Federal Nuclear Safety Commission may comment on the Inspectorate's safety evaluation report. The licensing procedure is described in the section on Article 7.

The operating licence includes authorisation for commissioning. The commissioning programme must be approved by the Inspectorate and consists of pre-operating and start-up tests as well as procedures for testing all equipment important for safety. The licensee conducts a design review to verify that the "as built state" properly reflects the proposed design in terms of safety requirements (safety criteria and licence conditions). Commissioning itself and all stages of start-up tests are under regulatory control as permits are required from the Inspectorate.

As part of the operating licence, the Inspectorate issues a specialist report for each new operating cycle after outage for maintenance and refuelling. This report is also the regulator's substantiated opinion that the NPP is safe for the next operating cycle in accordance with specified requirements. It is based on the Inspectorate's assessment of operating performance, including radiation protection, events during the last cycle, the results of maintenance and refuelling activities during the outage period, and approval of the reload licensing documentation (see Article 14).

Clause 2: Each Contracting Party shall take the appropriate steps to ensure that operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation.

see Clause 3 below

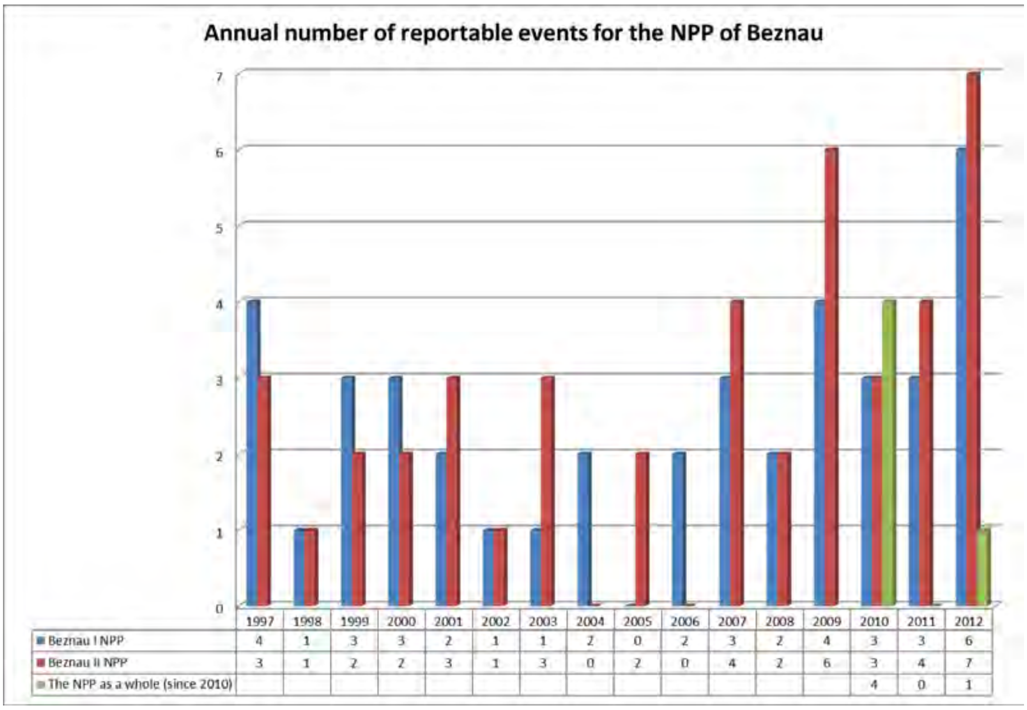
Clause 3: Each Contracting Party shall take the appropriate steps to ensure that operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures.

This Clause is closely linked to Clause 2 and so they are covered together in the following paragraphs.

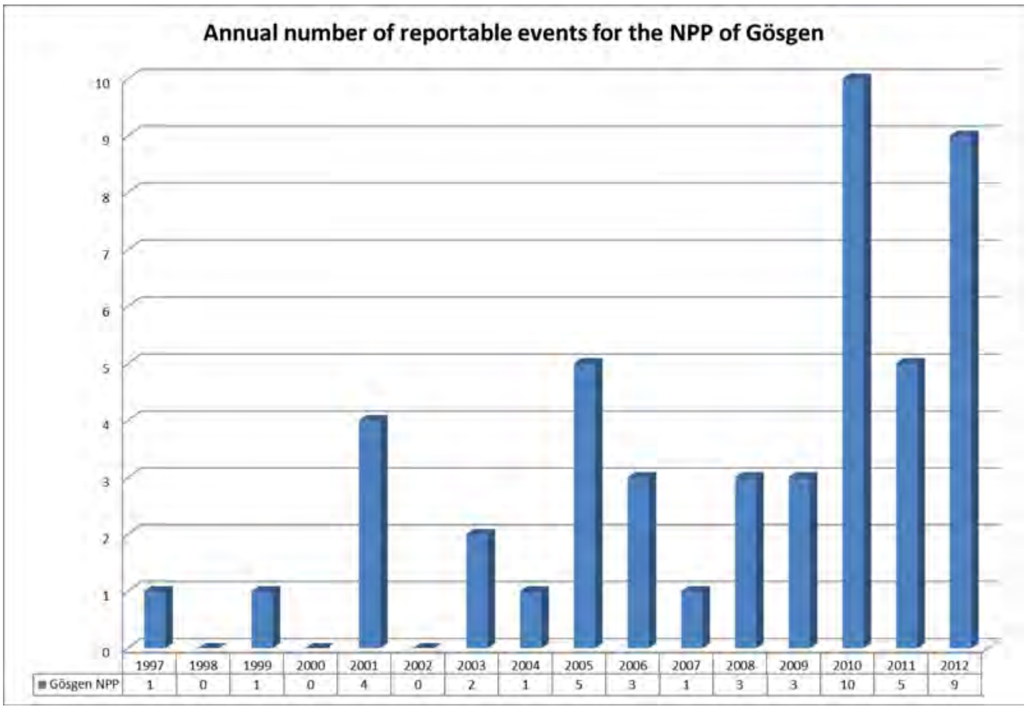
The operation of each NPP must comply with an appropriate set of limiting conditions for operation (LCO) approved by the Inspectorate. The LCO constitute boundary conditions for procedures and the instructions for normal operation. They are derived from safety analyses and test results and are included in the Technical Specifications for the plant. The Technical Specifications also contain the plant-specific surveillance requirements. Technical Specifications are based upon the Standard Technical Specifications issued by the reactor supplier. The initial Technical Specifications and later modifications require a permit from the Inspectorate. Modifications are required as a result of plant modifications, operational experience and new knowledge. Additional procedures implemented by licensees ensure the safe operation of NPPs. They are based on the regular verification of the operability of safety-related equipment. These procedures are used in the extensive surveillance programmes for maintenance, inspection and testing. They encompass in-service inspections using a non-destructive examination of components, periodic examinations of electronic, electrotechnical and mechanical equipment, periodic functional testing of systems and components, as well as an ageing surveillance programme (see Article 14). Non-destructive testing must accord with the Inspectorate’s Guideline B07.

The regulatory surveillance of plant operation relies on information obtained from the reports submitted by operating organisations (in accordance with the Inspectorate's Guidelines B02 and B03), on information collected during the Inspectorate's inspections and on its own measurements. Since the INES classification was introduced into Switzerland in 1992, there have been 11 events in Swiss NPPs rated at Level 1 on INES and 2 events at Level 2. The annual number of reportable events as specified in the Inspectorate’s Guideline B03 (until 2008 Guideline R-15) is shown in Figure 5 below. Because of changes in the criteria for event reporting, the figures for 2009 to 2012 are not comparable with those for 1996 to 2008.

The reporting system requires operating organisations to report periodically (monthly, annually, after refuelling outage) on operational performance and activities relating to safety. The most important of these are modifications to plant equipment, procedures and organisation and doses to personnel and the public. There is particular emphasis on event reporting and investigation. Lessons learned and event feedback are essential elements of operational experience. In addition, the level for event reporting in Switzerland is low and so the Inspectorate receives comprehensive reports on even minor events of relevance to safety. The analysis of incidents by both the utility and the Inspectorate is an important tool in efforts to increase nuclear safety (see also Clause 4).

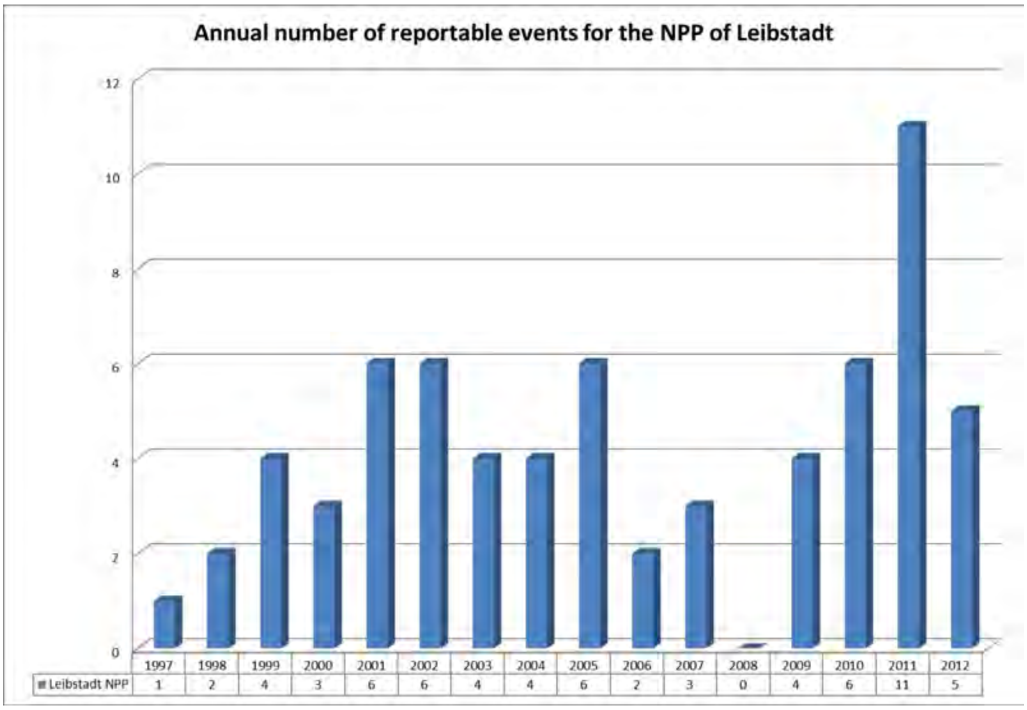


	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Beznau I NPP	4	1	3	3	2	1	1	2	0	2	3	2	4	3	3	6
Beznau II NPP	3	1	2	2	3	1	3	0	2	0	4	2	6	3	4	7
The NPP as a whole (since 2010)														4	0	1



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Gösgen NPP	1	0	1	0	4	0	2	1	5	3	1	3	3	10	5	9

Figure 5: Annual number of reportable events in Swiss NPPs.



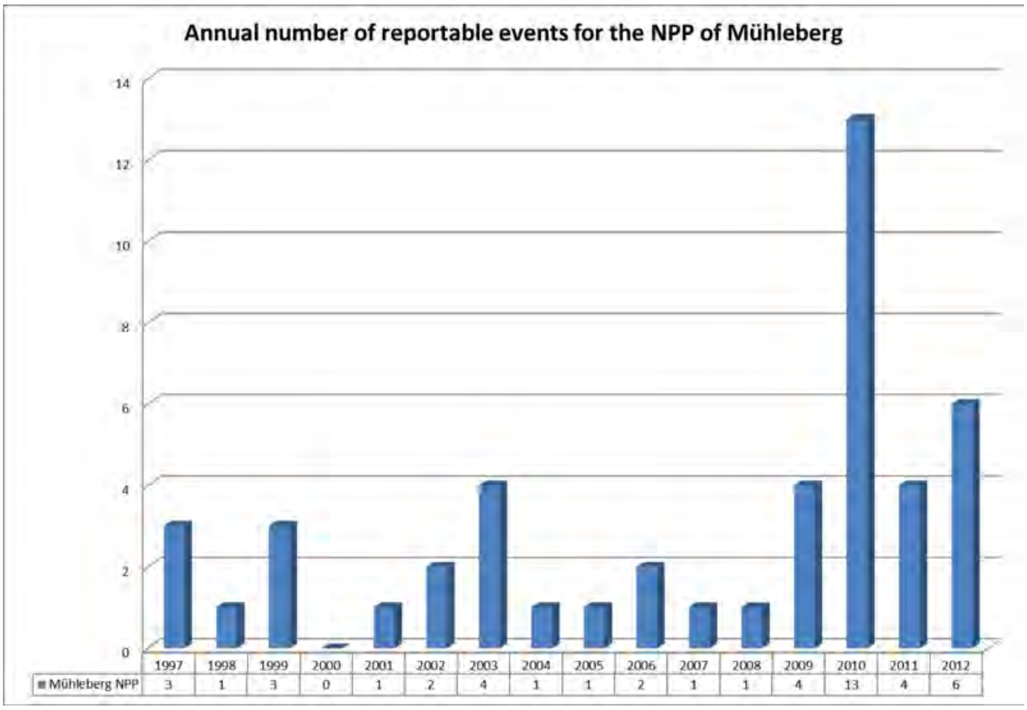


Figure 5: Annual number of reportable events in Swiss NPPs.

Clause 4: Each Contracting Party shall take the appropriate steps to ensure that procedures are established for responding to anticipated operational occurrences and to accidents.

In addition to the operating procedures for all modes of normal operation, each NPP has dedicated procedures for operational anomalies and emergency conditions. As means for supporting the response to emergency situations, emergency operation procedures (EOPs) are designed to bring the plant into a safe operational state, while the Severe Accident Management Guidance (SAMG) is designed to mitigate the consequences of accidents leading to fuel damage.

EOPs are a requirement of the Nuclear Energy Ordinance and they specify the measures required to manage incidents and accidents prior to core damage. In addition, the Nuclear Energy Ordinance requires the implementation of SAMG in order to mitigate severe accidents. The Nuclear Energy Ordinance delegates regulation on the content of EOPs and SAMG to guidelines published by the Inspectorate. Changes in the content of EOPs and SAMG shall be reported to the Inspectorate. Plants develop and implement EOPs and SAMG as part of the top-level organisational documents required by the Nuclear Energy Ordinance. They reflect the policy of the operating organisation. Plant modifications, operating and training experience, scientific and technological developments and lessons from events in NPPs trigger modifications to EOPs and SAMG if necessary.

The emergency procedures for NPPs include the steps for alerting the NPP stand-by safety engineer. They specify the duties of the stand-by safety engineer, in particular, the requirement to determine whether an emergency actually exists, to alert the plant's emergency staff and inform the Inspectorate if an event requires immediate reporting. The procedures also define the on-site criteria for alerts and alarms (see Article 16). Modifications to EOPs are verified and validated in the form in which they will be used in the plant, to ensure that they are compatible with the environment in which they will be used. The effectiveness of incorporation of human factors engineering principles are judged when validating them. The validation of EOPs is based on representative simulations, using the plant-specific simulator. Furthermore, spot checks of the adequacy of the EOPs are carried out within the review of selected cases of the human reliability analysis of the plant-specific PSA.

The implementation of SAMG is required by the Nuclear Energy Ordinance. Detailed requirements on SAMG are presented in the guideline on the emergency preparedness in nuclear installations (ENSI-B12). In all plants, SAMG is implemented covering all relevant operational states. Two NPPs closely followed (Beznau) or adapted (Leibstadt) the SAMG concept of the owners' group, Westinghouse PWR or WOG/BWROG, respectively. The Mühleberg NPP (GE BWR) and the Gösgen NPP (Siemens KWU PWR) developed new concepts. The SAMG for each Swiss plant is symptom-oriented. The technical basis of the strategies developed in the framework of SAMG comprises thermal hydraulic calculations and the full-scope, plant specific level 2 PSAs. The developed decision-making support tools were checked for their applicability (validation) by the participants in the emergency response organisation. Furthermore, the validation was performed by means of exercise scenarios, for which SAMG plays the major role in managing the accident (see Article 16). SAMG is updated by the licensee according to the state of the art. ENSI reviews the SAMG by inspections and as part of emergency exercises and of the periodic safety review (PSR).

All the plants have met the requirement to examine and take account of the behaviour of the instrumentation under severe accident conditions in the course of the introduction of SAMG. ENSI therefore regards the instrumentation as generally adequate. The availability of the instrumentation required for accident management measures is also included in the "Lessons Learned" report on the Fukushima accident (Checkpoint 5, see Annex 2) and will be followed up in the frame of ENSI's forthcoming oversight activities.

All NPPs have Accident Management (AM) procedures on a variety of measures to deal with scenarios beyond the design basis of the plant. The AM procedures (on these measures outlined next) are elements of the EOP package, the SAMG or both. Generally, the AM equipment (e.g. mobile pumps) needed is available on site. As a back-up provision, AM equipment is also available from an external storage (see Article 16 for more details). The incorporation of the external storage in the AM procedures is in progress.

Concerning the prevention of fuel damage, the AM measures include, for example, venting of the steam generators (SG) without external power, venting of the RPV via alternative trains, the supply (by means of fire brigade pumps) of borated water from the Spent Fuel Pool (SFP) into the RPV, coolant supply via the fire extinguishing system and cross-switching of power supply systems. Inspections (carried out for all NPPs in 2012) of the strategies to deal with a prolonged total loss of AC power (Station Blackout, SBO) generally indicate that sufficient AM measures for core damage prevention are available. Nevertheless, the review of the SBO issues is an undergoing an oversight activity.

As part of the Severe Accident Management with emphasis on the mitigation of the consequences of fuel damage, the measures include filtered venting of the containment before or after an RPV failure and flooding of the containment.

Concerning the prevention and mitigation of accidents taking place in the SFP, the provided measures include re-injection of water into the SFP, thereby compensating the evaporation and/or vaporisation volume and the isolation of the openings of as well as the control of the ventilation in the SFP building. Due to post-Fukushima back-fitting completed so far, all NPPs have connection points allowing AM measures on SFP cooling without entering the SFP building.

Clause 5: Each Contracting Party shall take the appropriate steps to ensure that necessary engineering and technical support in all safety related fields is available throughout the lifetime of a nuclear installation.

NPPs have developed their own on-site technical support covering the surveillance test programme, reactor engineering and fuel management, operational experience feedback, plant modifications and safety-related computer applications. These functions are the responsibility of the various technical departments in an NPP. In most cases, a department at the licensee's headquarters is responsible for core and cycle design and for fuel procurement. If additional expertise is required, each plant can obtain technical support from the reactor supplier by subcontracting work to them. Nevertheless, the licensee must have sufficient expertise within its own organisation to ensure the quality of any outsourced tasks.

With the deregulation of the electricity market and the current increase in economic pressures, retaining corporate knowledge has become an important issue. The Inspectorate is aware of this and the issue is discussed at the regular management meetings between the Inspectorate and NPPs. To ensure adequate technical support in Switzerland, the level of research has increased. In addition, a master's course in nuclear engineering at the Swiss Federal Institute of Technology has been established.

Clause 6: 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 relevant licence to the regulatory body.

The Nuclear Energy Act, the Nuclear Energy Ordinance and the Inspectorate's guidelines contain requirements on the notification of events and incidents:

- notification of events to allow early recognition of deviations and their correction;
- notification of incident/accident conditions to alert the Inspectorate's emergency organisation and other authorities;
- notification of events of public interest to allow the Inspectorate to make an independent assessment and inform the public quickly.

The Nuclear Energy Act obliges licensees to notify the supervisory authorities within a specified time of special activities or occurrences relating to the handling of nuclear materials and which might interfere with nuclear safety or security. The Nuclear Energy Ordinance specifies reporting requirements for nuclear safety, security and the transport of nuclear materials. The Inspectorate is required to regulate the detailed reporting procedures and the method of classifying events and findings in accordance with the Nuclear Energy Ordinance. As a result, the Inspectorate's Guideline B03 contains criteria defining the reporting obligation threshold for events. The licensee is responsible for giving a preliminary rating to each reportable event or finding on the basis of INES, whereas the Inspectorate is responsible for the final INES rating. The Nuclear Energy Ordinance specifies the time limits for initial notification, receipt of the event history report and the report on remedial action based on the INES rating. There is an additional class for events of public interest. For example, if ambulances, fire engines or police cars enter the precincts of a nuclear installation with sirens wailing, this requires immediate reporting, even if there is no event of significance to nuclear safety. The Inspectorate uses the written confirmation by the licensee of an event as the basis for its initial review of the classification and also any immediate action required should an event reveal unexpected barrier degradation. If an event is reported as INES Level 2 or higher or if there is a public interest, the Inspectorate's special emergency team meets as required by its own internal rules on emergency preparedness. The meeting will review the event and inform the media if necessary. Following a minor amendment to the Nuclear Energy Ordinance, the former national event rating scale has been abolished. The INES scale was being used in parallel and so the national scale provided no additional benefit.

To ensure that nuclear installations apply the Inspectorate's guidelines correctly, event classification is part of both the initial licence exams for shift supervisors and on-call engineers and their relicensing. During the periodic emergency exercises, event classification is an important objective for both NPP and regulatory staff.

As part of its quality management system (see Article 8, Clause 1), the Inspectorate has its own internal procedures for event investigation, which include the independent assessment and classification of all events reported nationally. It has set up a working group consisting of experts in engineering, human factors and radiation protection, which assesses events in cooperation with specialists from individual sections. If the final rating is INES 0, the decision on this final INES rating is taken by the Head of the Division responsible for the oversight of plant operation. If the rating is INES 1 or higher, the decision is taken by the Director General of the Inspectorate. The results are communicated to the licensee and entered in the systematic safety assessment database.

For several years, it has been the Inspectorate's practice to include a summary of reported events and their classification in the Inspectorate's annual regulatory oversight report. This report is publicly available.

Clause 7: Each Contracting Party shall take the appropriate steps to ensure that programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies.

An important process in Swiss NPPs is the process dealing with non-conformance control and remedial action. It is guided by procedures that form part of the management system. Any non-conformance is reported and discussed at the daily morning meeting held by each NPP and where necessary follow-up action (e.g. work authorisations) is initiated.

The safety impact of non-conformances is evaluated. If the event is of interest or significance to safety, the non-conformance must be reported to the Inspectorate. In addition, an internal investigation team in the plant is required to conduct a thorough analysis of the event. If the event is more complex, the NPP will use dedicated root-cause analysis methods. Based on these analyses, the event investigation team will suggest what action is required. These suggestions are reviewed by the plant's internal safety committee before implementation.

Low level non-conformance events (below the reporting obligation level), near misses and other types of failures or malfunctions are reported to the daily meeting of plant managers and representatives from the main technical divisions. Their significance is then evaluated. Depending on the safety relevance or operational impact of the non-conformance, remedial action is initiated immediately or the problem is transferred for further evaluation to the event investigation team or a technical division.

Having decided what remedies are appropriate, responsibility for implementation is assigned to a division. The final details must be reported to the safety review committee and the resultant operating experience is used to inform future plant improvement programmes.

The CEOs of all NPPs monitor the exchange of operating experience between Swiss NPPs. This CEO group is supported by several working groups who deal with issues such as training, nuclear safety performance, ageing surveillance, management systems, radiological and chemical plant performance, fire services and industrial safety.

Each NPP has a process for dealing with external operating experience, which screens and evaluates information on external events. Depending on their significance and applicability to an individual plant, the information is evaluated in detail and modifications are implemented as necessary. The Inspectorate periodically inspects this process. Furthermore, plants must provide a monthly report to the Inspectorate with information on external events evaluated in detail. Important sources of external information are the World Association of Nuclear Operators (WANO), the Plant Owners' Group, the Incident Reporting System (IRS) of IAEA and NEA and the Association of Power and Heat Generating Utilities in Germany. Specialist groups of experts from Swiss NPPs meet periodically to exchange operational experience, information from abroad and the exchange of detailed information on recent events in their own plants.

The Ordinance on the Methodology and Boundary Conditions for the Evaluation of the Criteria for the Provisional Taking-out-of-Service of Nuclear Power Plants ensures on the one hand plant specific analysis for all internal events rated INES 1 and above in Swiss NPPs and on the other hand surveys of reported events in NPPs from all over the world rated INES 2 and above.

Each NPP is required to carry out a Periodic Safety Review (PSR) every 10 years (see Article 14). As part of the PSR, each plant is required to assess in summary form its own operating experience and any important external event of relevance to the plant. This review is also assessed by the Inspectorate and its report is publicly available.

The Inspectorate has its own process for assessing events in nuclear installations in other countries. If the Inspectorate's assessment indicates potential for safety improvements at Swiss NPPs, the plants are required to analyse the situation in their own installation and take appropriate action. The IRS is the main source of information for the Inspectorate. The Inspectorate has been a member of IRS since it was founded in 1980. Members prepare reports on safety issues of relevance to the nuclear community and attend and organise meetings and workshops on important safety issues. The Inspectorate sends delegates from amongst its own staff to the OECD/NEA/CSNI "Working Group on Operational Experience" (WGOE) and to the "Working Group on Human and Organisational Factors" (WGHOF).

The Inspectorate obtains other important information from IRS reports, NRC information letters and bilateral contacts (e.g. safety commissions) with its neighbours France and Germany.

The following are some examples of Swiss events reported to the IRS:

- unintentional opening of the automatic depressurisation system (ADS) safety relief valves at Leibstadt NPP;
- non compliances with the technical specification during start-up near end of cycle at Leibstadt NPP;
- significant rise in core damage frequency due to unavailability of both the Beznau NPP Unit 1 emergency diesel generator and the offsite power source;
- exposure of two workers to doses in excess of the statutory annual limit at Beznau NPP Unit 2;
- exposure of a worker in excess of the statutory annual dose limits at Leibstadt NPP.
- The following are some examples of information on operational experience from abroad that resulted in major modifications at Swiss NPPs:
- Based on the Generic Letter 89-10 of the US-NRC, the Inspectorate required all Swiss licensees to re-evaluate the functional analysis of motor-operated valves in safety related systems. As a consequence, all Swiss NPPs modified certain gate valves.
- Following the incident at Barsebäck 2 (Sweden) on 28 July 1992 involving clogging of the suctionline strainers in the suppression pool, the Inspectorate initiated a programme of short-term measures designed to resolve the problem in all NPPs. The short-term measures included inspections, a detailed review of the types of thermal insulation in use, a clogging analysis of strainers and the preparation of accident management measures in BWR plants. This resulted in the replacement of all suction strainers in the emergency core cooling system of BWRs (Mühleberg and Leibstadt) during their outage

periods in 1993. In the new equipment, the strainer area was much larger. For the PWRs, backfitting was not considered necessary at the time and a reassessment of the issue in the light of recent results from French and NRC research showed that the design of PWR suction strainers is still appropriate. However, one licensee has installed new state-of-the-art cassette-type suction strainers in order to improve safety and allow greater flexibility in the type of thermal insulation material used in the containment.

- Two hydrogen explosions occurred in European and Japanese BWRs at the end of 2001, resulting in ruptured pipes. This is a known phenomenon and had been the subject of previous assessments; following those two events, the two BWRs in Switzerland were required to re-evaluate the earlier assessments. This resulted in immediate improvements to procedures (e.g. filling empty pipes with water). Minor hardware modifications (e.g. improved insulation, installation of thermocouples) were made during the annual outage. The investigations were then completed but because of differences in the BWR design in Switzerland, it was not considered necessary to undertake hardware modifications or consider a new design basis accident.
- The reactor vessel head corrosion event at the Davis Besse NPP (USA) in 2002 generated considerable attention in the nuclear community. In this event, a significant amount of boric acid corrosion was detected caused by leakage from cracks in the control-rod nozzles. Both Swiss operators and the Inspectorate had previous experience of this phenomenon and so were already vigilant. A small head corrosion event caused by leakage had occurred in Switzerland in the early 1970s, and 5 years before the above US event, cracks had been found and reported in the control nozzles of US plants. The Inspectorate had used this previous experience to strengthen the requirements for the periodic surveillance by plant operators of nozzle cracks and leakage control. Therefore, the Davis Besse event did not necessitate any additional action.
- The incident at Forsmark 1 NPP (Sweden) on 25 July 2006 also led to major investigations by the Inspectorate. The Inspectorate checked in detail aspects identified as being significant to the sequence of events. All Swiss NPPs carried out a comprehensive check of the technical and organisational measures used to deal with the consequences of a similar type of event. The investigation results were published in a separate report and this is available on the Inspectorate's website. The investigations did not identify any deficiencies in technical and organisational precautions by Swiss NPPs designed to protect plants from the effects of grid disturbances. Nevertheless, the Inspectorate recommended that NPPs intensify simulator training for scenarios involving loss of redundancy in safety or information systems and signals in the control room.
- The Fukushima accident triggered a series of actions taken by the Inspectorate with the goal of understanding the event sequence, its causes and to draw consequences for the safety of Swiss NPPs. The Swiss National Report for the CNS Second Extraordinary Meeting contains more details on lessons identified, analyses performed and measures adopted. The Inspectorate has chosen a stepwise response approach to the Fukushima accident, to allow the incorporation of possible new lessons as soon as they become available from further accident investigations, which are still in progress in Japan. In spite of insights gained from the national response approach and European approach (EU stress test), which confirmed a high safety standard for Swiss

NPPs, areas of further improvement were identified. Essential topics to be addressed by the licensees have been protection against earthquakes and flooding, the design of spent fuel pools, the availability of the ultimate heat sink and the availability of accident management equipment from offsite locations. Details are given in Articles 16 and 18. ENSI's target for the completion of the response programme is by the end of 2015.

The Annual Report of the Inspectorate includes information on selected events in Swiss NPPs and the use made of information from external operating experience. Special attention is given to analyses and plant modifications performed in response to the Fukushima accident.

Clause 8: Each Contracting Party shall take the appropriate steps to ensure that the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and that any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

The Nuclear Energy Act includes the principle that the generator of radioactive waste is responsible for its safe management until disposal. Before an NPP is licensed, it must demonstrate that the waste generated by the facility can be safely and permanently managed and disposed of. The Radiological Protection Act and the Radiological Protection Ordinance stipulate that the volume of radioactive waste produced must be kept to the minimum possible. Under the Nuclear Energy Act, radioactive waste originating in Switzerland must be disposed of in Switzerland.

To ensure compliance with legal requirements during the licensing phase, plans for nuclear installations are subject to a critical review by nuclear safety authorities. During the construction and the operation of such installations, the Inspectorate's supervisory activities ensure compliance.

Each NPP stores the spent fuel discharged from the reactor on site for several years. The Nuclear Energy Act prohibits the reprocessing of spent nuclear fuel for a period of ten years starting on 1 July 2006. In the past, NPP operators had signed contracts with foreign companies for the reprocessing of some 1,139 tonnes of spent fuel. All spent fuel covered by these contacts had been shipped abroad by June 2006 and has finally been reprocessed.

The return of waste from foreign reprocessing facilities to the Central Interim Storage Facility started in 2002 and is proceeding on schedule. By spring 2013, approximately 2/3 of the return-able reprocessing waste from La Hague (F) had been repatriated with the remaining transports to be finalized in 2015. Return of reprocessing waste from Sellafield (UK) is being prepared for the first shipment in early 2014 and the last one in 2018, possibly as early as 2016.

All separated Pu-products from reprocessing of Swiss fuel have also been repatriated in the form of MOX-fuel elements, all of which have already been reused in the PWRs at the Beznau and the Gösgen site. Even a part of the attributed U-products has already been reused in form of U(rep)oxide-fuel elements in Swiss reactors.

Since July 2006, any spent fuel from the Mühleberg NPP and Leibstadt is transported to the Central Interim Storage Facility and stored in dry transport and storage casks. The Beznau NPP operates its own dry storage facility on site, whereas the Gösgen NPP started on site operation of a separate wet storage facility for spent fuel in May 2008.

Any operational waste from the NPPs is collected and segregated. Waste with such low activity levels that it can be exempted from regulatory control is cleared for re-use or conventional disposal under the supervision of the Inspectorate. The conditions required for clearance are included in Annex 2 of the Radiological Protection Ordinance. The associated procedures are detailed in the regulatory guide ENSI-B04.

Radioactive waste in the form of resins, sludge or activated components is conditioned as soon as practicable on site at the NPPs. Incinerable waste, however, is conditioned externally at the Central Interim Storage Facility (ZZL), which successfully operates the world's first plasma incinerator for radwaste. This facility accepts any waste, which previously used to be super-compacted or otherwise treated in incinerators using "conventional" incineration techniques at the Paul Scherrer Institute, a facility now waiting for decommissioning. ZZL also provides services for decontamination, segregation, handling of bulky items and, quite recently, processing radwaste containing asbestos.

According to the Nuclear Energy Ordinance, any procedure for the conditioning of radioactive waste must be approved by the Inspectorate. Approval is only granted if waste products comply with accepted storage criteria, meet the requirements of NAGRA, the disposal planning organisation and can be transported in compliance with the regulations on the transport of hazardous goods. Detailed requirements for such waste type qualification are documented in the regulatory guide ENSI-B05.

Specific requirements for interim storage facilities and their operation are detailed in the new regulatory guide ENSI-G04, which replaced the previous HSK-R29. ENSI-G04 covers all safety reference levels (SRL) of the WENRA storage report which had been identified as "missing" in the Swiss regulations during the WENRA benchmarking exercise. In February 2013, the working group on waste and decommissioning of WENRA concluded that Switzerland had successfully carried out its national action plan on WENRA waste SRLs. Current inspections in interim storage facilities confirmed the compliance of operators with the new requirements, especially those asking for monitoring and inspection programmes for stored items to confirm the continuous compliance with acceptance criteria of interim and final storage.

OSART Mission to Switzerland

At request of the government of Switzerland, an IAEA Operational Safety Review Team (OSART) reviewed the following areas of Mühleberg NPP operation:

- management
- organisation and administration
- training and qualification
- operations
- maintenance
- technical support
- operating experience feedback
- radiation protection
- chemistry
- emergency planning and preparedness

In addition to this full scope OSART review programme, the areas

- long-term operation
- severe accident management

were covered on special request.

The OSART mission took place from 8 – 25 October 2012. International experts from Belgium, Czech Republic, Finland, Germany, Hungary, Slovakia, Sweden, United Kingdom, United States of America together with IAEA staff members visited the Mühleberg NPP. The OSART team studied plant specific information, reviewed programmes and procedures, observed work performed and held in-depth discussions with plant personnel counterparts. The findings were recorded in the mission report (NSNI/OSART/012/170). The report was derestricted in January 2013.

The OSART team found several areas of good performance, including the following:

- strategy to manage the core shroud cracking issue and allow long-term operation
- preserving and transferring of knowledge
- response to recent significant external operating experience (OE) events
- support for industry efforts to improve fuel design and monitoring practices

The team offered a number of proposals for improvements. Among the most significant proposals are the following:

- provision of all reasonable protection for persons on the site in an emergency with radioactive release to avoid any unjustified health risks
- use OE throughout the plant on day-to-day activities and ensure timely corrective actions
- reinforce the work-control and risk assessment system with the use of radiation work permits
- improvement of the means for an independent nuclear oversight with a continuous review of safety performance at the NPP

A follow up mission will be conducted by the IAEA to review the implementation of the proposed improvements.

Developments and Conclusion

Clause 8: The plasma incinerator operates very reliable at the ZZL facility, which further expanded its services to include treatment of radioactive waste containing asbestos.

Clause 8: The new regulatory guide ENSI-G04 replaced the old guideline R29 and now covers any type of spent fuel or waste storage facility. It implements WENRA's safety reference levels, which were not covered by the previous regulatory guide R29 in the Swiss regulatory system.

Outlook

The aftermath of the Fukushima accident has had a major impact on Switzerland. The Swiss government and parliament have decided to suspend the licensing process for the new builds and are committed to a nuclear phase-out. Within this framework, ENSI will continue to advocate an effective strengthening of the global nuclear safety regime by actively participating in the Working Group to strengthen the effectiveness and the transparency of the Convention on Nuclear Safety CNS, contributing to an improvement in the review process of the CNS and implementing the IAEA Action Plan on Nuclear Safety. ENSI supports the efforts to harmonise safety requirements within the Western European Nuclear Regulators Association WENRA. ENSI strives to provide regulatory guidelines compliant with IAEA Safety Standards and harmonised with the safety requirements of WENRA.

In the next reporting period, ENSI will have to address the following challenges:

First, a series of actions have been taken by ENSI to understand the event sequence in Fukushima and its causes so as to draw consequences for nuclear safety in Switzerland. Lessons have been identified, analyses performed and several measures taken. While the design reassessment for protection against flooding has been concluded, the reviews of the protective measures against earthquakes, based on a comprehensive reassessment of the seismic hazard, have still to be completed. A reassessment of further topics to be addressed and the follow-up is done on a yearly basis by ENSI. ENSI plans to take all the necessary actions identified to date and to enforce the derived measures by the end of 2015.

Secondly, the commitment by the Swiss government to a nuclear phase-out will create further challenges to ENSI's supervisory activities, as the schedule for the nuclear phase-out will depend on the outcome of various parliamentary decisions and maybe national referenda. As a result, ENSI will have to adapt its planned activities along with the outcome of these decisions. Accordingly, ENSI is currently drafting a guideline for the decommissioning activities.

Thirdly, the process to select a site for the disposal of radioactive waste in deep geological formations in Switzerland is continuing. Nagra (Switzerland's National Cooperative for the Disposal of Radioactive Waste) will carry out provisional quantitative safety analyses and a safety-based comparison of the siting areas that will allow the identification of at least two sites each for the HLW and L/ILW repository. In the next stage of the process, the remaining sites will be investigated in depth with a view to site selection and preparation of an application for a general licence. Parliament's decision on the government's approval of the general licence for deep geological repositories can be expected around 2020. That decision will be subject to an optional national referendum. A deep geological repository for low and intermediate level radioactive waste is expected to be ready for operation in 2035 at the earliest, and a repository for high-level waste in 2045.

Fourthly, the Swiss government decided in May 2011 to set up an official working group to review emergency preparedness measures in case of extreme events in Switzerland. As a result, ENSI is responsible for implementing measures related to assistance for persons with severe radiation exposure, the availability of measurement and forecasting systems for NPPs in extreme events, the reference scenarios for emergency preparedness and the review of the emergency planning zones around NPP sites.

Finally, ENSI is committed to improving its supervisory activities by implementing the recommendations arising from the Integrated Regulatory Review Service (IRRS) mission, which took place in 2011. A follow-up mission is planned for 2015.

As a result, ENSI will continue to refine its Integrated Oversight Strategy in response to the increase in tasks to be undertaken by the regulatory body and the complexity of the oversight required for the long-term operation of existing NPPs and the nuclear phase-out challenges.

Annex 1 – Swiss actions undertaken in implementing the IAEA Action Plan on Nuclear Safety

Safety assessments in the light of the accident at TEPCO's Fukushima Daiichi Nuclear Power Station	
Undertake assessment of the safety vulnerabilities of nuclear power plants in the light of lessons learned to date from the accident	
Member States to promptly undertake a national assessment of the design of nuclear power plants against site specific extreme natural hazards and to implement the necessary corrective actions in a timely manner.	See Article 14.
IAEA peer reviews	
Strengthen IAEA peer reviews in order to maximize the benefits to Member States	
Member States to be strongly encouraged to voluntarily host IAEA peer reviews, including follow-up reviews, on a regular basis; the IAEA Secretariat to respond in a timely manner to requests for such reviews.	See Articles 8 and 19.
Emergency preparedness and response	
Strengthen emergency preparedness and response	
Member States to conduct a prompt national review and thereafter regular reviews of their emergency preparedness and response arrangements and capabilities, with the IAEA Secretariat providing support and assistance through Emergency Preparedness Review (EPREV) missions, as requested.	See Article 16.
National regulatory bodies	
Strengthen the effectiveness of national regulatory bodies	
Member States to conduct a prompt national review and thereafter regular reviews of their regulatory bodies, including an assessment of their effective independence, adequacy of human and financial resources and the need for appropriate technical and scientific support, to fulfil their responsibilities.	See Article 8.
Each Member State with nuclear power plants to voluntarily host, on a regular basis, an IAEA IRRS mission to assess its national regulatory framework. In addition, a follow-up mission to be conducted within three years of the main IRRS mission.	See Article 8.

Operating organizations	
Strengthen the effectiveness of operating organizations with respect to nuclear safety	
Member States to ensure improvement, as necessary, of management systems, safety culture, human resources management, and scientific and technical capacity in operating organizations; the IAEA Secretariat to provide assistance to Member States upon request.	See Articles 8 and 12.
Each Member State with nuclear power plants to voluntarily host at least one IAEA Operational Safety Review Team (OSART) mission during the coming three years, with the initial focus on older nuclear power plants. Thereafter, OSART missions to be voluntarily hosted on a regular basis.	See Articles 8, 10 and 19.
IAEA Safety Standards	
Review and strengthen IAEA Safety Standards and improve their implementation	
Member States to utilize as broadly and effectively as possible the IAEA Safety Standards in an open, timely and transparent manner.	See Article 7.

International legal framework	
Improve the effectiveness of the international legal framework	
States parties to explore mechanisms to enhance the effective implementation of the Convention on Nuclear Safety, the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, the Convention on the Early Notification of a Nuclear Accident and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency, and to consider proposals made to amend the Convention on Nuclear Safety and the Convention on the Early Notification of a Nuclear Accident.	Switzerland supports efforts to strengthen the global system for nuclear safety. The background for this position is the call for mandatory IAEA review missions to all countries with NPPs to assess their regulatory framework and activities as well as their NPP's siting, design and operation. Switzerland aims for more transparency in the reporting on the CNS meetings and the review missions by calling for mandatory publication of the review results. The IAEA Action Plan on Nuclear Safety includes these elements on a non-mandatory basis and is considered to be a necessary step towards the effective strengthening of the global nuclear safety regime. At the Second Extraordinary Meeting of the Convention on Nuclear Safety held in August 2012, Switzerland proposed various amendments to the Convention. To accommodate those, a working group entrusted with the task of strengthening the Convention was established. Switzerland will actively participate in this working group. Switzerland also actively participates in the Working Group on Practices in the Management of the Review Process under the Convention on Nuclear Safety and the Joint Convention. ENSI reaffirmed this position during the Fukushima Ministerial Conference on Nuclear Safety in December 2012. See also subsection of Summary and Conclusions-Actions taken in Switzerland in the light of the Fukushima Daiichi accident – 2012, International supervision and cooperation.

Capacity Building	
Strengthen and maintain capacity building	
Member States with nuclear power programmes and those planning to embark on such a programme to strengthen, develop, maintain and implement their capacity building programs, including education, training and exercises at the national, regional and international levels; to continuously ensure sufficient and competent human resources necessary to assume their responsibility for safe, responsible and sustainable use of nuclear technologies; the IAEA Secretariat to assist as requested. Such programmes to cover all the nuclear safety related areas, including safe operation, emergency preparedness and response and regulatory effectiveness and to build upon existing capacity building infrastructures.	See Articles 10, 11 and 12.
Member States with nuclear power programmes and those planning to embark on such a programme, to incorporate lessons learned from the accident into their nuclear power programme infrastructure; the IAEA Secretariat to assist as requested.	See sub-section in the Summary and Conclusions, entitled Actions taken in Switzerland in the light of the Fukushima Daiichi accident
Protection of people and the environment from ionizing radiation	
Ensure the on-going protection of people and the environment from ionizing radiation following a nuclear emergency	
Member States, the IAEA Secretariat and other relevant stakeholders to share information regarding the assessment of radiation doses and any associated impacts on people and the environment.	See Article 16.
Communication and information dissemination	
Enhance transparency and effectiveness of communication and improve dissemination of information	
Member States, with the assistance of the IAEA Secretariat, to strengthen the emergency notification system, and reporting and information sharing arrangements and capabilities.	See Article 16.

Member States, with the assistance of the IAEA Secretariat, to enhance the transparency and effectiveness of communication among operators, regulators and various international organizations, and strengthen the IAEA's coordinating role in this regard, underlining that the freest possible flow and wide dissemination of safety related technical and technological information enhances nuclear safety.	See Article 12.
Research and development	
Effectively utilize research and development	
Relevant stakeholders, with assistance provided by the IAEA Secretariat as appropriate, to conduct necessary research and development in nuclear safety, technology and engineering, including that related to existing and new design-specific aspects.	ENSI supports and coordinates safety research within its regulatory powers. The results of that research directly influence its Guidelines, individual decisions and resources. Research projects serve training purposes and thereby maintain competence within ENSI and its experts. ENSI's research programme contributes to international projects which Switzerland would be unable to conduct on its own. International exchange of expertise is thereby encouraged.
Relevant stakeholders and the IAEA Secretariat to utilize the results of research and development and to share them, as appropriate, to the benefit of all Member States.	See answer above.

Annex 2 – List of identified checkpoints after the analysis of the Fukushima accident

No	Description of Checkpoint
1	The hazard assumptions for earthquake and external flooding, and also for extreme weather conditions, must be re-evaluated to take account of the latest knowledge.
2	The control strategies for a long-lasting total power failure must be re-evaluated on the basis of knowledge gained from Fukushima.
3	A review must be carried out to determine whether the coolant supply for the safety systems and the associated auxiliary systems is guaranteed from a diverse source which is safe against earthquakes, flooding and contamination.
4	A review must be carried out to determine whether the requisite tightness of buildings containing important safety equipment is guaranteed in case of flooding of the site.
5	On the basis of experience gained from the Fukushima accident, another review must be undertaken to determine whether the availability of the instrumentation required to assess the condition of the plants is guaranteed adequately even in extreme situations.
6	A review must be carried out to determine whether control of leaks and long-term cooling of the spent fuel pools are guaranteed in case of severe accidents.
7	A review must be carried out to determine whether tests and inspections regarding the prevention of hydrogen explosions should be extended to additional areas of the plants beyond the primary containment.
8	The design and operation of the systems for filtered venting of the containment must be reviewed again.
9	It is necessary to carry out a new review of the earthquake and flood design of the monitoring network for automatic dose rate measurement in the vicinity of NPPs (MADUK), in relation to experience gained from the Fukushima accident.
10	A review must be carried out to determine whether the emergency rooms (ER) and the substitute emergency rooms (SER) at the Swiss NPPs still meet the requirements, based on the experience gained from the Fukushima accident.
11	The access control system for NPPs and the associated arrangements must be reviewed to determine the accessibility of rooms where intervention is required in case of severe accidents, while maintaining appropriate plant safety and security. Monitoring of radiation protection must continue to be guaranteed in this context.
12	The emergency measures for heat dissipation in case of a complete failure of the cooling water supply must be reviewed and verified under conditions resulting from the disruption of the infrastructure and the power supply.

No	Description of Checkpoint
13	It is necessary to review how the alternative supply of water and power for emergencies is ensured.
14	It is necessary to examine the water resources that can be made available to supply the reactor pressure vessel, the spent fuel pools and the containment.
15	Emergency management must be reviewed to determine further potential for improvement.
16	ENSI has identified the following issues as checkpoints for improving emergency planning and emergency exercises: a) The decision-making aids for emergency management in case of severe accidents (SAMG) at NPPs, including the newly planned checkpoints to deal with severe accidents, must be reviewed on the basis of knowledge gained from the Fukushima accident. In this regard, it is particularly necessary to check: - whether adequate consideration is given to a Station Blackout (SBO) of long duration and the simultaneous occurrence of events in multiple-unit plants; - whether there is any need for measures, auxiliary resources and equipment that must be available to ensure that critical levels are not attained over the long term in case of severe accidents. b) Consideration given to incidents involving an SBO of long duration in the planning of emergency exercises. c) Examination of whether the procedures are trained often enough during emergency exercises. Particular attention should be focused here on a functioning inter-organisation chain of communication across the various organisations.
17	A review must determine whether and to what extent the communication facilities are designed with adequate redundancy and diversity.
18	It must be ensured that adequate staff is available at all times to accomplish all necessary emergency management activities.
19	Measures that increase the organisation's ability to react to unexpected events must be reviewed again on the basis of experience gained from Fukushima.
20	Transmission of plant parameter data must be re-evaluated with respect to an alternative, independent means of data transmission.
21	The evacuation concepts must be reviewed, taking account of knowledge gained from the Fukushima accident.
22	Coordination with other international partners is required to determine whether and how an international network for central international emergency support can be set up.
23	A review must be carried out to determine whether the necessary information regarding forecasts of releases and radiation exposure is provided in a timely and continuous manner in case of damage.

No	Description of Checkpoint
24	The following improvement measures were identified regarding information provided to the public: a) It must be ensured not only that the requisite infrastructure and the necessary individuals and/or organisations and equipment are available for crisis communication, but also that the necessary means of communication are in place. The relevant precautions must be taken. Regular training must be provided on the associated procedures. This point also includes a functioning network of experts who are available to the media to supply neutral and objective information. b) Review to determine whether the organisational responsibilities for informing the public as well as the local authorities and support staff are clearly stipulated, and are uniformly understood by all involved parties. c) A review should be carried out to determine whether the timely communication of radiological effects, including calculated forecasts, is also ensured beyond Switzerland's borders.
25	It is necessary to examine the extent to which the release of non-nuclear hazardous substances in case of events beyond the design basis could exert an additional influence on the events related to an accident, and which counter-measures are required.
26	The process of evaluating and examining the applicability of national and international operating experience must be optimised on the basis of knowledge gained from the Fukushima accident.
27	It must be guaranteed that the knowledge gained from national and international operating experience (the procedure for processing events) in the licensees' organisations reaches all the relevant individuals and units (including those at group level).
28	It must be ensured that internationally harmonised assessment scales for nuclear safety are established at the highest level of safety.
29	Greater importance should also be accorded in the international sphere to the recommendations resulting from international reviews (IRRS, OSART (Operational Safety Review Team)) and from the regular Periodic Safety Reviews (PSR). The transparency of ENSI's supervision and of the operators' safety-related activities must be increased.
30	ENSI is reviewing the significance of the lessons learned from the Fukushima accident for its supervisory activities.
31	Additional operational resources must be kept in readiness for radiation protection in case of severe accidents.

No	Description of Checkpoint
32	It is necessary to examine whether the emission and immission measurements in place on the power plant sites in order to determine the activity releases are guaranteed in case of loss of offsite power (LOOP) or in case of an emergency.
33	It is necessary to examine the extent to which the availability of the meteorological data required for dispersion calculations is guaranteed in case of extreme natural events.
34	It is necessary to stipulate arrangements for dealing with contamination in the area surrounding nuclear plants following severe accidents.
35	It is necessary to examine how to deal with large volumes of contaminated water, radioactive waste or environmentally hazardous substances in case of severe accidents.
36	As part of the emergency planning for severe accidents, it must be ensured that sufficient radiation protection staff are available on site.
37	The knowledge gained from the Fukushima accident must be taken into account in the programmes to foster and develop the safety culture in Swiss NPPs.

Annex 3 – List of open points from the EU Stress Test

No	Point designation	Status / action plan	Description	Implementation text
38	OP2-1	2013	ENSI will follow up the question as to whether automatic scrams in the Swiss NPPs should be triggered upstream by the seismic instrumentation.	An upstream automatic scram by means of seismic instrumentation has not yet been implemented in Swiss nuclear power plants. A working group at ENSI will draft a concept in 2013 regarding the advantages and drawbacks of an upstream automatic scram by means of seismic instrumentation.
39	OP2-2	2013	In respect of seismic proof that has still to be supplied, ENSI will follow up, for all Swiss nuclear NPPs, with a more detailed examination of the seismic robustness of the isolation of the containment and the primary circuit.	Proof was submitted by the licensees in 2012 and the cursory review by ENSI was completed. Further processing will take place in 2013.
40	OP2-3	2013	For KKG and KKL, ENSI will continue to follow up measures to improve the seismic resistance of systems for containment venting in case of events beyond the design basis.	Proof was submitted by the licensees in 2012 and the cursory review by ENSI was completed. Further processing will take place in 2013.
41	OP3-1	LA	ENSI will follow up on the impacts of a total debris blockage of hydraulic engineering installations at KKG and KKM.	Proof was submitted by the licensees (KKB, KKG and KKM) in 2012. For KKB and KKM, ENSI determines that no cliffedge effects from debris blockage are to be expected. Further processing will take place in 2013.
42	OP4-1	2013	ENSI will follow up on more detailed proof of protection against extreme weather conditions, including combinations thereof.	Requirements were defined by ENSI in 2012. Proof of adequate protection against extreme weather conditions is to be furnished by the licensees in 2013.

No	Point designation	Status / action plan	Description	Implementation text
43	OP5-1	LA	ENSI will follow up on the development of a comprehensive strategy for the targeted deployment of the mobile accident management emergency diesels in order to secure selected direct current or alternating current consumers in the long term under total SBO (or SBO) conditions.	Inspections of this aspect were carried out by ENSI in the fourth quarter of 2012. The results will be assessed in the first quarter of 2013. Any follow-up measures will be implemented by ENSI in the course of its ongoing supervisory activities.
44	OP6-1	2013	For the purpose of risk minimisation, ENSI will follow up on the extent to which the current deployment strategies for the containment venting systems in severe accidents should be retained.	The issue of containment integrity is a key point in 2013.
45	OP6-2	NI	ENSI will follow up on whether restoring containment integrity during shutdown in the case of a total SBO represents a time-critical measure.	-
46	PRT-1	2013	The peer review team recommends considering the assessment of margins with respect to extreme weather conditions exceeding the design bases, e.g. by extending the scope of future PSRs.	ENSI specified detailed requirements for the probabilistic hazard analyses and the proof of adequate protection of plants against extreme weather conditions in 2012. In 2013, the licensees will submit proof (including statements of the safety margins) to ENSI.
47	PRT-2	2013	It is recommended that the regulator assesses the opportunity of requiring more reliance on passive systems for hydrogen management for severe accident conditions. It is also recommended that the regulator considers further studies on hydrogen management for the venting systems.	In 2013, ENSI requires a reconsideration of various aspects of the hydrogen hazard in case of severe accidents in the reactor. The topics are: analyses of the hydrogen hazard including the propagation of hydrogen from the containment into other buildings of the nuclear power plant, robustness and scope of the measuring equipment, measures and instructions in place, and review of the containment venting path.

Annex 4 – List of abbreviations used in the present report

AC	Alternate Current
ADAM	Accident Diagnostics, Analysis and Management system
ADPIC	Atmospheric Diffusion Particle-In-Cell Model
ADS	Automatic Depressurisation System
ALARA	As Low As Reasonably Achievable
AM	Accident Management
ANPA	Data system for plant parameters (Anlageparameter)
ASME	American Society of Mechanical Engineers
ASP	Ageing Surveillance Programme
AUTANOVE	Autarkic Emergency Power Supply (Autarke Notstromversorgung, Project at the Beznau NPP)
BBC	Brown, Boveri & Cie
BDBA	Beyond Design Basis Accidents
BKW	Licensee of the Mühleberg NPP (Bernische Kraftwerke BKW)
BWR	Boiling Water Reactor
BWROG	Boiling Water Reactor Owners Group
CDF	Core Damage Frequency
CEO	Chief Executive Officer
CET	Core Exit Temperature
CHF	Swiss Francs
CNS	Convention on Nuclear Safety
CSNI	Committee on the Safety of Nuclear Installations (OECD-NEA)
DBA	Design Basis Accidents
DBE	Design Basis Earthquake
DBF	Design Basis Flood
DC	Direct Current
DEC	Design Extension Conditions
DETEC (UVEK)	Department of Environment, Transport, Energy and Communication (Eidgenössisches Departement für Umwelt, Verkehr, Energie und Kommunikation)
DIWANAS	Diversitäre Wärmesenke und Nachwärmeabfuhr-System (Project at the Mühleberg NPP)
DSSA	Deterministic Safety Status Analysis
ECCS	Emergency Core Cooling System
ECURIE	European Community Urgent Radiological Information Exchange
EMERCON	A descriptor referring to the official system for issuing and receiving notifications, information exchange and assistance provision through the IAEA's Incident and Emergency Centre in the event of a nuclear or radiological incident or emergency.
ENEF	European Nuclear Energy Forum
ENSI	Swiss Federal Nuclear Safety Inspectorate ENSI (Eidgenössisches Nuklearsicherheitsinspektorat ENSI)

ENSREG	European Nuclear Safety Regulatory Group
EOP	Emergency Operating Procedures
EOR	Emergency Organisation Radioactivity
EPD	Electronic Personal Dosimeter
EPO	Emergency Protection Ordinance
ERO	Emergency Response Organisation
ERT	Emergency Response Team
EU	European Union
EURATOM	European Atomic Energy Community
FA	Fuel Assembly
FCVS	Filtered Containment Venting System
FMB NBCN (BST ABCN)	Federal Nuclear, Biological, Chemical and Natural Crisis Management Board
FN (AN)	File Note (Aktennotiz)
GDC	General Design Criteria
GE	General Electric
GLA	General Licence Application
HCLPF	High Confidence of Low Probability of Failure
HEPA	High Efficiency Particle Arrestor
HERCA	Heads of European Radiological Protection Competent Authorities Association
HLW	High-Level Waste
HOF	Human and Organisational Factors
HPP	Hydro(electric) Power Plant
HSK	Hauptabteilung für die Sicherheit der Kernanlagen (precursor of ENSI)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ICS	Intercommunication System
IDA-NOMEX	Interdepartmental Working Group to Review Emergency Protection Measures in case of Extreme Events in Switzerland (Interdepartementale Arbeitsgruppe zur Überprüfung der Notfallschutzmassnahmen bei Extremereignissen in der Schweiz)
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IFTS	Inclined Fuel Transfer System
INES	International Nuclear and Radiological Event Scale
INEX	International Emergency Exercise
IRRS	Integrated Regulatory Review Service
IRRT	Integrated Regulatory Review Team (precursor of IRRS)
IRS	International Reporting System for Operating Experience
ISO	International Standards Organisation
ISOE	Information System on Occupational Exposure
JRODOS	Java-based Real-time Online Decision Support system

KKB	Beznau Nuclear Power Plant (Kernkraftwerk Beznau)
KKG	Gösgen Nuclear Power Plant (Kernkraftwerk Gösgen)
KKL	Leibstadt Nuclear Power Plant (Kernkraftwerk Leibstadt)
KKM	Mühleberg Nuclear Power Plant (Kernkraftwerk Mühleberg)
KPMG	Klynveld, Peat, Marwick und Goerdeler (Swiss auditor)
KWU	Kraftwerk Union AG
L/ILW	Low-Level and Intermediate-Level Waste
LASAT	Lagrangian Simulation of Aerosol-Transport
LBB	Leak Before Break
LCO	Limiting Conditions for Operation
LOCA	Loss Of Cooling Accident
LTO	Long-Term Operation
LPCI	Low-Pressure Coolant Injection
LOOP	Loss Of Offsite Power
LWR	Light Water Reactor
MADUK	Measurement network in the vicinity of NPPs (Messnetz zur automatischen Dosisleistungsüberwachung in der Umgebung der Kernkraftwerke)
MCR	Main Control Room
MOX	Mixed OXide
MTO	Man Technology Organisation
Nagra	National Cooperative for the Disposal of Radioactive Waste (Nationale Genossenschaft für die Lagerung radioaktiver Abfälle)
NBC	Nuclear, Biological and Chemical
NBCN	Nuclear, Biological, Chemical and Natural
NDE	Non-Destructive Evaluation Methods
NEA	Nuclear Energy Agency of the OECD
NEO	Nuclear Energy Ordinance
NEOC	National Emergency Operations Centre (Nationale Alarmzentrale NAZ)
NERS	Network of Regulators of Countries with Small Nuclear Programmes
NEWS	Nuclear Events Web-based System
NGO	Non-Governmental Organisation
NPO	Non-Power Operation
NPP	Nuclear Power Plant
NRC	U.S. Nuclear Regulatory Commission
NSC (KNS)	Nuclear Safety Commission
OBE	Operating Basis Earthquake
OECD	Organisation for Economic Cooperation and Development
OHSAS	Occupational Health and Safety Assessment Series
OLNC	OnLine Noble Chemistry primary water operation mode

OSART	Operational Safety Review Teams (IAEA)
PC	Primary Circuit
PEGASOS	Probabilistic Earthquake Hazard Analysis for the Locations of the Nuclear Power Plants in Switzerland (Probabilistische Erdbebengefährdungsanalyse für die KKW-Standorte in der Schweiz)
PGA	Peak Ground Acceleration
PRP	PEGASOS Refinement Project
PSA	Probabilistic Safety Analysis
PSI	Paul Scherrer Institute
PSR	Periodic Safety Review
PWR	Pressurised Water Reactor
QM	Quality Management
RADUK	Radiological dispersion calculations in the vicinity of nuclear facilities (Radiologische Ausbreitungsrechnungen in der Umgebung von Kernanlagen)
RANET	IAEA Response and Assistance Network
RB	Reactor Building
RCIC	Reactor Core Isolation Cooling
REMPAN	WHO Radiation Emergency Medical Preparedness and Assistance Network
RHR	Residual Heat Removal
RPO	Radiological Protection Ordinance
RPRC	Federal Commission for Radiological Protection and Monitoring of Radioactivity
RPV	Reactor Pressure Vessel
SAMG	Severe Accident Management Guidance
SAR	Safety Analysis Report
SBO	Station Blackout
SER	Safety Evaluation Report
SFOE (BFE)	Swiss Federal Office of Energy
SFP	Spent Fuel Pool
SG	Steam Generator
SIA	Swiss Association of Engineers and Architects (Schweizerischer Ingenieur- und Architektenverein)
SP	Suppression Pool
SQS	Swiss certification company (Schweizerische Vereinigung für Qualitäts- und Management-Systeme)
SRL	Safety Reference Levels (WENRA)
SSC	Structures, Systems, and Components
SSE	Safe Shutdown Earthquake
SSHAC	Senior Seismic Hazard Analysis Committee
SUSAN	Special emergency system of KKM (Selbstständiges, Unabhängiges System zur Abfuhr der Nachzerfallswärme)
Sv	Sievert
TB	Turbine Building

TLAA	Time-Limited Ageing Analysis
TLD	Thermoluminescent Dosimeter
Total-SBO	Total Station Blackout
TS	Technical Specification
TSC	Technical Support Centre
UPS	Uninterruptible Power Supply
U.S. NRC	U.S. Nuclear Regulatory Commission
USIE	Unified System for Information Exchange in Incidents and Emergencies
W	Westinghouse
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association
WGHOF	NEA Working Group on Human and Organisational Factors
WGIP	NEA Working Group on Inspection Practices
WGOE	NEA Working Group on Operating Experience
WOG	Westinghouse Owners Group
ZWILAG	Swiss Central Interim Storage Facility (Zwischenlager Würenlingen AG)
ZZL	Swiss Central Interim Storage Facility (Zentrales Zwischenlager)

Annex 5 – List of the Inspectorate's guidelines currently in force

Status: August 2013

Languages:

- All 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:

- All guidelines are available on the ENSI website (www.ensi.ch).
- 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 of operations. With 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.
- The security guidelines are not listed.

Guideline	Title of Guideline	Date of current issue
G01	Safety classification for existing nuclear power plants	2011/1
G03/e	Specific design principles for deep geological repositories and requirements for the safety case	2009/4
G04	Design and operation of storage facilities for radioactive waste and spent fuel assemblies	2012/3
G05	Transport and storage casks for interim storage	2008/4
G07/f	Organisation of nuclear Installations	2013/7
G11	Vessels and piping classified as important to safety: Engineering, manufacture and installation	2013/6
G13/f	Radiation protection measuring devices in nuclear installations: Concepts, requirements and testing	2008/2

Guideline	Title of Guideline	Date of current issue
G14/f	Calculation of radiation exposure in the vicinity due to emission of radioactive substances from nuclear installations	2009/12
G15/f	Radiation protection objectives for nuclear installations	2010/11
A01	Requirements for deterministic accident analysis for nuclear installations: Scope, methodology and boundary conditions of the technical accident analysis	2009/7
A04	Application documents for modifications to nuclear installations requiring a permit	2009/9
A05/e	Probabilistic Safety Analysis (PSA): Quality and Scope	2009/1
A06/e	Probabilistic Safety Analysis (PSA): Applications	2008/5
A08	Analysis of source terms: Extent, methodology and boundary conditions	2010/2
B01	Ageing management	2011/8
B02	Periodical reporting for nuclear installations	2012/3
B03	Reports for nuclear installations	2012/3
B04/f	Clearance of materials and areas from controlled zones	2009/8
B05	Requirements for the conditioning of radioactive waste	2007/2
B06	Vessels and piping classified as important to safety: Maintenance	2013/6
B07	Vessels and piping classified as important to safety: Qualification of non-destructive testing	2008/9
B09/f	Collecting and reporting of doses of persons exposed to radiation	2011/7
B10	Initial training, recurrent training and continuing education of personnel	2010/10
B11/f	Emergency exercises	2012/12
B12/f	Emergency preparedness in nuclear installations	2009/4

Guideline	Title of Guideline	Date of current issue
B13/f	Training and continuing education of the radiation protection personnel	2010/11
B14	Maintenance of electrical and instrumentation and control equipment classified as important to safety	2010/12
R-4	Supervisory procedures for the construction of nuclear power plants, project engineering of structures	1990/12
R-6	Safety classification, class limits and procedures for construction of equipment in nuclear power plants with light-water reactors	1985/5
R-7	Guideline for the radiological monitored area of the nuclear installations and the Paul Scherrer Institute	1995/6
R-8	Structural safety for nuclear power plants, Swiss Federal supervising procedures for construction work	1976/5
R-16	Seismic plant instrumentation	1980/2
R-30	Supervisory procedures for construction and operation of nuclear installations	1992/7
R-31	Supervisory procedures for construction and backfitting of nuclear power plants, 1E classified electrical equipments	2003/10
R-35	Supervisory procedures for construction and modification of nuclear power plants, systems engineering	1996/5
R-40	Filtered containment venting of light-water reactors, design requirements	1993/3
R-46	Requirements for the application of computer-based instrumentation and control important to safety in nuclear power plants	2005/4
R-48	Periodic safety review of nuclear power plants	2001/11

Guideline	Title of Guideline	Date of current issue
R-49	Requirements important to safety for security of nuclear installations	2003/12
R-50	Requirements important to safety for fire protection in nuclear installations	2003/3
R-60	Inspection of fuel element production	2003/3
R-61	Supervisory procedures when using nuclear fuel and control rods in light-water reactors	2004/6
R-101	Design criteria for safety systems of nuclear power plants with light-water reactors	1987/5
R-102	Design criteria for the protection of safety equipment in nuclear power stations against the consequences of airplane crash	1986/12
R-103	On-site measures against the consequences of severe accidents	1989/11

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