SECTORAL PLAN FOR DEEP GEOLOGICAL REPOSITORIES

SAFE DISPOSAL OF RADIOACTIVE WASTE
WHAT DO WE DO WITH RADIOACTIVE WASTE?

Switzerland has been utilising nuclear energy for electricity production for almost 50 years, but so far there is still no permanent and safe solution for the disposal of the resulting radioactive waste. Most of the radioactive waste in Switzerland comes from the country’s five nuclear reactors, though a certain amount is also produced in the medical, industrial and research sectors. A distinction is made between high-level and low- and intermediate-level radioactive waste. The combined total volume is around 100,000 cubic metres of material, around 90 percent of which is low- and intermediate-level radioactive waste.
LEGAL BASIS

The management (handling and storage) of radioactive waste is governed by the provisions of the Nuclear Energy Act and the Nuclear Energy Ordinance, both of which entered into force on 1 February 2005. The Nuclear Energy Act stipulates that radioactive waste produced in Switzerland must be disposed of in Switzerland. The principle of «user pays» applies. In other words, those who produce radioactive waste are also responsible for its safe disposal. The federal government is responsible for waste from the medical, industrial and research sectors, while waste resulting from the use of nuclear energy is the responsibility of the operators of the nuclear power plants. Consequently, the operators of Switzerland’s nuclear power plants established the National Cooperative for the Disposal of Radioactive Waste (Nagra) in 1972. Its mandate is to find and implement solutions for the sustainable disposal of radioactive waste in Switzerland.

The Federal Nuclear Energy Act also regulates the financing of the decommissioning of nuclear facilities and the disposal of the resulting radioactive waste. The owners of the nuclear power plants are required to pay contributions into the Decommissioning Fund and the Waste Disposal Fund. The Act also specifies the safety-specific requirements relating to the disposal of radioactive waste in deep geological repositories. A deep geological repository must guarantee long-term safety. General, construction and operating licences can only be granted if it can be demonstrated that the legally specified safety objectives for a deep geological repository can be fully complied with. The Swiss Federal Nuclear Safety Inspectorate is responsible for specifying the safety guidelines and monitoring the safety of deep geological repositories.

TEMPORARY SOLUTION: INTERIM STORAGE SITES

Radioactive waste is currently being stored in secure, above-ground buildings located in the canton of Aargau and on the premises of the nuclear power plants. However, this form of storage cannot guarantee safety over lengthy periods of time. What is required is a long-term solution: a deep geological repository.

Radioactive waste stored in a deep geological repository is protected by both natural and technical barriers.
LONG-TERM SOLUTION: DEEP GEOLOGICAL REPOSITORY

Radioactive waste is dangerous because of its radiation. It has to be disposed of in such a manner as to ensure that as little radioactivity as possible is released into the environment. Throughout the world, scientists agree that storing radioactive waste in deep geological repositories is the safest solution. High-level and low- and intermediate-level radioactive waste has to be stored for periods lasting from several tens of thousands of years up to a million years (depending on the waste category) until the process of radioactive decay has reduced the level of radiation enough so that it no longer poses a threat for human beings and the environment. The objective is to safely dispose of high-level radioactive waste in deep geological repositories with a combination of technical and natural barriers.

INFRASTRUKTUREN UND AUSWIRKUNGEN AN DER OBERFLÄCHE

A deep geological repository comprises various facilities on the surface, depending on its stage of development (see below). The largest and most important of these is the surface facility to which the radioactive waste is initially delivered and where it is prepared for storage. The appropriate transport infrastructure to the repository has to be provided. The surface facility is also the «gateway» via which the filled end-storage containers are transported to the underground storage area. In addition to this «gateway», at least two other access shafts or tunnels (auxiliary access facilities) to the storage area are required: one for the supply of fresh air and another for construction and operational purposes. The latter is used for moving excavated material out and construction materials in, transporting personnel and supplying the deep geological repository with power and water.

1. Main facility (spent fuel elements / HLW)
2. ILW repository (long-lived LILW)
3. Pilot facility
4. Test zone
5. Access tunnel
6. Ventilation and construction shaft

A deep geological repository also requires surface facilities for the transport and storage of waste.
TWO REPOSITORIES

Both high-level and low- and intermediate-level radioactive waste are produced in Switzerland. Based on the Sectoral Plan for Deep Geological Repositories, the two types of waste have to be stored either in separate repositories or in «combined repositories». The repositories may be constructed at a single site or at two different sites.

Search for suitable sites for low- and intermediate-level waste

The largest quantity of low- and intermediate-level waste results from the dismantling of nuclear power plants and from nuclear research facilities. Nagra conducted numerous studies to identify the safest types of host rock for the storage of low- and intermediate-level waste and ultimately selected the marl rock near Wellenberg (in the canton of Nidwalden) as the most suitable site. In 1993, Nagra submitted an application for a general licence for a repository for low- and intermediate-level waste, but the local population voted against the proposed project and stalled. For the site selection procedure, the Swiss Federal Nuclear Safety Inspectorate specified criteria for assessing the host rock properties. Based on these criteria and depending on the type and location of the repository, the most suitable host rock formations for low- and intermediate-level waste were determined to be «Brauner Dogge», «Effinger Member», Helvetic marls and opalinus clay. This marked the end of stage 1 in the process. At the end of stage 2, the regions that could potentially accommodate a repository site were identified, which allowed the options for the host rock formations to also be narrowed down.

Search for suitable sites for high-level waste

High-level radioactive waste includes spent fuel elements from nuclear power plants and vitrified fission products resulting from reprocessing. Due to their geological instability, the Alps and the Folded Jura cannot be considered as potential sites for deep geological repositories. Nagra's studies therefore focused on the central plateau and northern Switzerland. After conducting numerous studies, opalinus clay was identified as the safest host rock for the storage of high-level radioactive waste. This demonstration of feasibility was accepted by the Federal Council in June 2006.
HOW DOES A DEEP GEOLOGICAL REPOSITORY FUNCTION? FROM CONSTRUCTION THROUGH TO CLOSURE

CONSTRUCTION
The first step is to set up a rock laboratory where the safety-related and structural properties of the host rock can be studied on site. If the expectations are confirmed, a licence for the construction of the deep geological repository can be issued and the construction of the repository can then commence.

OPERATION
A deep geological repository is put into operation in a series of steps. The facility encompasses a test area (rock laboratory), a pilot facility and a main repository. The purpose of the test area is to study the construction and operation of the deep geological repository. In the pilot facility, the behaviour of the barrier system is monitored in order to detect any unfavourable developments at an early stage and take the necessary remedial measures. In the main repository, the radioactive waste will be stored.

MONITORING PERIOD
After the waste has been deposited in the repository, the applicable legislation calls for a lengthy monitoring period during which it must be possible to retrieve the waste if necessary without undue effort.

CLOSURE
If, at the end of the monitoring period, it is ascertained that no further measures are required in order to guarantee long-term safety, the sections of the facility that are still open can be filled and sealed so that the entire deep geological repository can be permanently closed. The remaining facilities on the surface are then dismantled. At that point, the permanent protection of human beings and the environment is secured solely through passive barriers requiring no human intervention. In principle, it would still be possible to retrieve the radioactive waste from the repository, at least as long as the storage containers remain intact. However, this would entail enormous financial and operational cost.
SEARCH FOR SUITABLE SITES FOR DEEP GEOLOGICAL REPOSITORIES

Although the storage of radioactive waste in deep geological repositories is widely regarded as the safest solution, the choice of location for these facilities is a subject of contention. It is, therefore, essential to determine suitable sites on the basis of a transparent, broadly accepted site selection procedure. The Sectoral Plan for Deep Geological Repositories provides a comprehensive, step-by-step selection procedure which is being implemented under the leadership of the Swiss Federal Office of Energy.

SECTORAL PLAN FOR DEEP GEOLOGICAL REPOSITORIES

The Federal Council adopted the Conceptual Part of the Sectoral Plan for Deep Geological Repositories in 2008. This plan specifies the objectives, procedures and criteria for the selection of suitable sites for deep geological repositories. The top priority is to ensure the long-term protection of human beings and the environment. The procedure comprises three stages, in each of which comprehensive studies are carried out to obtain further geological information.

The search for suitable sites for deep geological repositories was initiated with the six geological siting areas proposed by Nagra: Jura Ost, Jura-Süd-Süffuss, Nördlich Lägern, Südranden, Wellenberg and Zürich Nordost.

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At the end of each stage, the Federal Council can thus decide on the steps to be taken next based on the latest scientific and technical findings.

**Stage 1 (2008–2011):**
In stage 1, the main focus was on identifying suitable geological siting areas based on safety-related and geological criteria. Nagra proposed six geological siting areas based on the current status of geological knowledge (Jura Ost, Jura-Südfuss, Nördlich Lägern, Südranden, Wellenberg and Zürich Nordost) to be examined in greater detail in stage 2. The Federal Council confirmed this proposal, allowing the further examination of the six geological siting areas in stage 2. Regional participation was also established during this stage, enabling communes, organised interest groups and the local population of all six proposed siting regions to address regional issues and concerns.

The proposal submitted to the Federal Council is that Jura Ost, Nördlich Lägern and Zürich Nordost be examined in greater detail in stage 3.
Stage 2 (2011–2018):
At the beginning of 2015, Nagra proposed that two geological siting areas (Jura Ost and Zürich Nordost) be examined in greater detail in stage 2 and backed up its proposal with comprehensive reports. The Swiss Federal Nuclear Safety Inspectorate studied these reports and, at the end of 2016, decided that Nördlich Lägern should be further examined in stage 3 as well, stating that the existing data did not suffice to identify any clear disadvantages. In stage 2, in addition to focusing the selection of potential geological siting areas, Nagra worked closely together with the proposed siting regions to identify possible locations for the placement of the surface facilities. At the end of 2018, the Federal Council will decide which geological siting areas are to be examined more closely in stage 3 and whether the proposed locations for the placement of the surface facilities can be accepted.

Stage 3 (2018–2030):
In the geological siting areas proposed in stage 3, the findings relating to the site-specific geological conditions will be supplemented by geological studies. The repository projects will be finalised in cooperation with the proposed siting regions and the socio-economic and ecological impacts of the repositories will be examined in greater detail. Then, approximately in 2024, the National Cooperative for the Disposal of Radioactive Waste (Nagra) will submit general licence applications for the construction of the deep geological repositories. These applications will have to be reviewed by the relevant authorities. Towards the end of the 2020s, the Federal Council will decide on the applications for general licences, and its decision will have to be approved by Parliament. The parliamentary resolution is subject to an optional national referendum. If a referendum should be initiated, the Swiss electorate would decide on the award of the general licence, most likely in the early 2030s. Only once this entire process is concluded will the sites for the deep geological repositories be definitive.

Rules governing the site selection procedure
In the search for suitable sites for deep geological repositories, the long-term protection of human beings and the environment is the top priority. Potential sites must therefore meet the high requirements placed on safety. Spatial planning and socio-economic and ecological aspects must be taken into account in the site selection procedure. These include exploration, protection of nature and landscapes, and the economic development of the region concerned. For this purpose, a study of the socio-economic and ecological impacts for the proposed siting regions (Jura Ost, Nördlich Lägern and Zürich Nordost) was carried out during stage 2.
## TIMETABLE

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<th><strong>Search for suitable sites for deep geological repositories</strong></th>
<th><strong>Duration</strong></th>
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<td>Development of the conceptual section of the Deep Geological Repositories sectoral plan with broad participation</td>
<td>December 2004 to April 2008</td>
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<tr>
<td><strong>Stage 1</strong> (proposal and official examination of six potential geological siting areas, establishment of regional participation procedure)</td>
<td>April 2008 to December 2011</td>
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<td><strong>Stage 2</strong> (location of surface infrastructure, involvement of regional conferences, narrow focus to three geological siting areas)</td>
<td>December 2011 to the end of 2018</td>
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<tr>
<td><strong>Stage 3</strong> (deep boreholes, preparation of application for general licence, specification of sites, issue of general licence)</td>
<td>Beginning of 2019 to the end of 2029</td>
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<td>Adoption by Parliament of the Federal Council’s decision concerning the general licence, possibly followed by referendum</td>
<td>Beginning 2030 to the end of 2031</td>
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<th><strong>Construction of deep geological repositories</strong></th>
<th><strong>Repository for low- and intermediate-level radioactive waste</strong></th>
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<td>Geological studies («rock laboratory»)</td>
<td>2032 – 2044</td>
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<td>Monitoring period</td>
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<td>Closure of complete repository</td>
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<td>Long-term Monitoring</td>
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COOPERATION

REGIONAL PARTICIPATION
Close cooperation with the communes and the population in the proposed siting regions is necessary. For this purpose, regional participation was established at the end of stage 1. The objectives of this process are the integration of a deep geological repository project into the region, drafting of proposals for the layout of the surface facilities and the development of measures and projects aimed at mitigating any potential negative socio-economic or ecological impacts. In addition, regional conferences were set up in each of the six siting regions proposed in stage 1.

TRANSPARENCY
In order for this cooperation to function smoothly, the exchange of information among the involved stakeholders and the population is an important aspect of the site selection procedure. The key steps in the process and the decisions taken have to be communicated so they are understandable, clear and plausible. In cooperation with the cantons, information and communication activities are carried out via various channels (including special events, forums, newsletters etc.).

INTEGRATION OF NEIGHBOURING COUNTRIES
The Commission of Cantons was established for the purpose of securing cooperation with neighbouring countries. The Commission is responsible for securing the required cooperation between official representatives of siting cantons, neighbouring cantons and neighbouring countries, and it supports the federal government with the implementation of the site selection procedure and submits recommendations to the federal government.

Who is taking which decision?
The division of duties between Nagra and the federal government is clearly defined. The Swiss Federal Office of Energy (SFOE) bears overall responsibility for the site selection procedure. Its duty is to manage and coordinate the procedure. It conducts the public consultation and organises the regional participation. It is also responsible for providing the public with information about the site selection procedure and its current status. Nagra is responsible for providing the geological fundamentals in the search for suitable sites and for proposing potential solutions. The cantons support the SFOE in its organisation of the regional participation process and provide their expertise. They are also responsible for making necessary adjustments to cantonal structure plan. The relevant federal authorities are responsible for reviewing every stage of the site selection procedure. The Federal Council decides on each stage of the procedure. Upon completion of the site selection procedure, it is also responsible for awarding the general licence for deep geological repositories. The Federal Council’s decision regarding the general licence has to be submitted to Parliament for approval. The electorate has the final say in a national referendum.
The concept of deep geological repositories raises numerous questions, several of which are addressed below. You will find more questions on our website under the heading, «Questions and answers».

**Does radioactive waste have to be disposed of now? Would it not be better to wait until the problem of disposal can be solved with the aid of new technologies (e.g. transmutation)?**

Those who utilise nuclear energy also have to accept responsibility for the safe disposal of radioactive waste. It is our duty towards future generations to tackle the problem of waste disposal without delay. In 1999, the «Expert group for disposal concepts for radioactive waste», which was established by the Federal Department of the Environment, Transport, Energy and Communications (DETEC), came to the conclusion that the storage of radioactive waste in deep geological repositories is the only disposal solution that meets the requirements for long-term safety (safety ensured for at least 100,000 years). This storage concept is based on the principle that the permanent protection of human beings and the environment must be assured (Articles 3c and 30, Federal Nuclear Energy Act). The expert group therefore developed the concept of «controlled long-term geological storage», which combines end-storage with the option of recovery of the waste, and thus reversibility. Site selection, construction, operation, monitoring and closure of a deep geological repository are a step-by-step process that requires several decades. During this time, knowledge is constantly being acquired and new findings can be incorporated into the process. The decision to definitively seal the facility after a lengthy observation period is deliberately left to future generations.

**Is it possible for radioactivity to escape from a deep geological repository and reach the surface?**

The long-term protection of human beings and the environment is the top priority. Radioactive waste must be disposed of in such a manner as to ensure that little or no radioactivity can be released into the environment. To this end, radioactive waste is to be stored deep underground in sealed repositories that meet extremely stringent safety criteria. For example, the annual additional radiation exposure must not exceed 0.1 millisieverts. This level is well below that of the natural radiation to which the population of Switzerland is exposed, namely an average of 3 millisieverts per annum.
**What impacts would a deep geological repository have on a region?**

Safety is the highest priority in the search for suitable sites for deep geological repositories. It takes precedence over considerations regarding land use and socio-economic implications. A study carried out on behalf of the Swiss Federal Office of Energy examined how a deep geological repository could affect the quality of life and prosperity of a region. A team of experts compared the effects of five storage projects in Switzerland and abroad, ranging from the interim storage facility in Würenlingen to an end storage project for high-level radioactive waste in Finland. The study found that the effects of a storage facility were positive rather than negative, with the construction industry benefiting the most. At the locations concerned, neither land nor real estate prices showed a negative trend, and there were no negative impacts on population growth. However, industries such as tourism and organic farming could suffer from a negative image. A study on radioactive waste disposal in Switzerland, including an analysis of the socio-economic impacts of storage facilities, is available on the Internet at www.radioaktive-abfalle.ch.

**What options do residents have for participating in the site selection procedure?**

Realising a deep geological repository will only be possible if there is sufficiently broad acceptance of it, and for this reason the involvement of the cantons and communes is an essential factor in all three stages of the site selection procedure. In the initial stage, the federal government formed a «Commission of Cantons» comprising the cantons concerned and neighbouring countries. In stages 2 and 3, the communes in the siting regions are responsible for regional participation, in which local residents can become involved. In all three stages, citizens who wish to do so can also put forward their views during the public consultation. At the end of stage 3, a national referendum against the parliamentary decision concerning the award of a general licence can be launched.
DEFINITIONS AND ABBREVIATIONS

SFOE
Swiss Federal Office of Energy

FNSI
Swiss Federal Nuclear Safety Inspectorate

Responsibility for the disposal of radioactive waste
Anyone who operates or decommissions a nuclear facility is obliged to dispose of all radioactive waste produced at that facility, at their own cost (Article 31, Federal Nuclear Energy Act). The federal government is responsible for the disposal of radioactive waste produced from the medical, industrial and research sectors (Article 33, paragraph 1a, Federal Nuclear Energy Act). In 1972, the federal government and the operators of Switzerland’s five nuclear power plants formed Nagra, a cooperative with the aim of finding a solution to the problem of permanently and safely disposing of nuclear waste.

Geological siting area
A geological siting area is determined by the rock mass underground that is suitable for the storage of radioactive waste.

High-level radioactive waste
Spent fuel elements that can no longer be used are classified as high-level radioactive waste. This category also includes vitrified fission products resulting from reprocessing. High-level radioactive waste exclusively results from the operation of nuclear power plants.

Jura Ost
Geological siting area proposed by Nagra that is to be examined in greater detail in stage 3.

Jura-Südfuss
Geological siting area is to be kept as a reserve in stage 3.

Nuclear Energy Act
The Nuclear Energy Act regulates the peaceful use of nuclear energy in Switzerland. It entered into force in 2005. It had to be revised following the decision taken in 2011 to phase-out nuclear energy.

Federal Nuclear Energy Ordinance
This Ordinance is based on the Federal Nuclear Energy Act (Article 101, paragraph 1).

NSC
Federal Nuclear Safety Commission

Sectoral Plan for Deep Geological Repositories: Conceptual Part
The Federal Council adopted the Conceptual of the Sectoral Part for Deep Geological Repositories on 2 April 2008, in which the objectives of the federal government are defined, together with the various procedures and criteria according to which the site selection procedure for all waste categories is to be carried out in Switzerland.

Waste from medical, industrial and research sectors
The medical, industrial and research sectors only produce low- and intermediate-level radioactive waste. The federal government is responsible for the disposal of this waste category.
Neighbouring countries
In the Deep Geological Repositories sectoral plan the term «neighbouring countries» refers to Austria and Germany, which are represented in various committees.

Nagra
The operators of the five nuclear power plants are responsible for the disposal of the radioactive waste they produce. In 1972, they established the National Cooperative for the Disposal of Radioactive Waste (Nagra), the responsibilities of which include the planning of deep geological repositories for both categories of radioactive waste and the preparation of proposals for suitable sites for deep geological repositories based on geological studies.

Nördlich Lägern
Geological siting area which, according to the Swiss Federal Nuclear Safety Inspectorate, is to be examined in greater detail in stage 3.

Planningperimeter
The geographic zone in which the surface facility for a deep geological repository can be placed.

Low- and intermediate-level radioactive waste
This category of waste primarily contains short-lived radioactive material with a short half-life. This waste results from the operation and later dismantling of nuclear power plants, and from the medical, industrial and research sectors.

Siting Commune
According to the conceptual section of the Sectoral Plan for Deep Geological Repositories, a commune beneath the boundaries of which a geological siting region partially or fully lies.

Siting canton
A canton with one or more communes in a siting region. In stage 1, the siting cantons were Aargau, Nidwalden, Obwalden, Schaffhausen, Solothurn, Thurgau and Zurich.

Siting region
In stage 2, siting regions comprise the siting communes plus other communes located partially or entirely within the defined planning perimeter. In certain justified cases, other communes may also be included in a siting region. In stage 3, a siting region will comprise the infrastructure communes and other communes. Infrastructure communes include siting communes and other communes where an infrastructure system could be constructed on or below the surface of their territory. Other communes to be included are those communes involved in stage 2 that are not already designated as infrastructure communes and those bordering on siting regions and thus with an interest based on regional solidarity, topographic proximity to the surface infrastructure or potential socio-economic or ecological impacts.

Südranden
Geological siting area that is to be kept as a reserve in stage 3.

Wellenberg
A proposed geological siting area that is to be kept as a reserve in stage 3.

Zürich Nordost
A proposed geological siting area that is to be kept as a reserve in greater detail in stage 3.
WEBSITES

Federal Department of the Environment, Transport, Energy and Communications (DETEC)
www.detec.admin.ch

Swiss Federal Office of Energy (SFOE), radioactive waste disposal
www.radioaktiveabfaelle.ch

Swiss Federal Office of Energy (SFOE), financing of waste disposal
www.entsorgungsfonds.ch, www.stilllegungsfonds.ch

Swiss Federal Office of Energy (SFOE)
www.sfoe.admin.ch

Federal Office for Spatial Development
www.are.admin.ch

Swiss Federal Nuclear Safety Inspectorate
www.ensi.ch

Federal Nuclear Safety Commission
www.kns.admin.ch

Federal Geoinformation Centre
www.swisstopo.admin.ch

National Cooperative for the Disposal of Radioactive Waste (Nagra)
www.nagra.ch

Where can I obtain more detailed information?
This brochure provides an introduction to the site selection procedure for deep geological repositories. We will be pleased to supply you with additional documentation. Please do not hesitate to call us, order other reports or visit the website listed below.

Additional documentation that is available from the Swiss Federal Office of Energy (SFOE):

«Focus Entsorgung», an SFOE newsletter dealing with the Sectoral Plan for Deep Geological Repositories


IMPRESSUM
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ILLUSTRATIONS