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The Swiss waste management program

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ABSTRACT

In Switzerland, legislation and regulatory guidance are in place to ensure the implementation of deep geological repositories for all types of radioactive waste. A site selection process based on safety criteria, defined in the "Sectoral plan for deep geological repositories", will be followed by a step-by-step licensing process under the responsibility of the Federal Government. Stage 1 of the Sectoral Plan has been successfully completed and geological siting regions identified. Stage 2, currently underway, has included the participation of a wide range of stakeholder to identify sites for the surface facilities. It will lead to the narrowing down of the number of geological siting regions by means of a safety-based comparison. Key factors for successful site selection include: (i) A clearly defined stepwise approach with the criteria defined before starting site selection with first priority given to safety; (ii) a process in which all stakeholders are prepared to commit themselves and work together, and are ready to accept the basic rules defined beforehand; (iii) for this purpose, it is important to have a strong process owner who keeps the process on track.

1. Background information on the Swiss waste management program

Switzerland is a relatively small industrialized country. It has no significant fossil resources but favourable conditions for hydroelectric power production. Today, hydroelectric power accounts for about 60% of the total amount of electricity produced, with five nuclear power units contributing to around 40%.

Around 2007, the construction of new nuclear power plants (NPPs) was under discussion, also in view of replacing the older reactors. License applications were submitted in 2008, but the process was suspended following the Fukushima Dai-ichi accident in March 2011. A fundamental change in energy policy was decided by the Federal Government in May and approved by Parliament in June 2011. It foresees a gradual phase-out; no new nuclear plants will be built and additional renewable energy sources should be developed. The corresponding draft legislation has recently been submitted to parliament for debate.

However, independently of the future of nuclear energy in Switzerland, there is a need for the safe disposal of the radioactive waste produced. The current legal framework for nuclear energy requires disposal of all types of radioactive waste in geological repositories. Current planning foresees a repository for spent fuel (SF), vitrified high-level waste (HLW) and long-lived intermediate waste (LL-ILW) and a repository for low- and intermediate-level waste (L/ILW); the possibility of a "combined" repository is also considered: SF/HLW/LL-ILW and L/ILW would be disposed at the same site but with the disposal rooms spatially separated, taking advantage of the same surface infrastructure.

The programme related to the development of geological repositories started in the seventies. The waste disposal programme has in the meantime reached a significant level of maturity; the scientific-technological basis is available to start implementation of the required repositories. A new site selection process was started in 2008.[1]

Implementation of the repositories takes place in a step-by-step licensing process under the responsibility of the Federal Government and starts with general licences for the sites selected. The general licence needs to be ratified by Parliament and is subject to a facultative national referendum. The general licence is followed by licences for repository construction, operation and closure. Furthermore, licences are needed for geological investigations at potential disposal sites, e.g. drilling or an in-situ underground research facility. Those licences are issued by the responsible ministry.

[1] For the L/ILW repository, site selection was already started in the eighties and in 1993 the site of Wellenberg was chosen for the development of the repository and in 1994 a general licence application was submitted. At that time the canton had the right to vote on a concession for the use of the underground and the application was turned down in 1995 in a public vote by a very narrow margin. Subsequently, the project was modified taking some of the public concerns into account (e.g. the possibility for easy retrieval) and in 2002 again a public vote took place on the Wellenberg project which was again turned down. Consequently, the project was abandoned.

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Site selection as a preparatory step towards a general licence application is based on a process defined in detail in the so-called "Sectoral Plan Deep Geological Repositories"[2] and takes place under the leadership of the Federal Government.

One important characteristic of the "Sectoral Plan Deep Geological Repositories" is the broad involvement of stakeholders. Besides the licencing body (for important decisions the Federal Government), the implementer and the regulatory authorities, the formally established entities affected by the potential repository sites (cantons, municipalities and neighbouring countries), but also loosely formed entities (regions, organizations and the public at large) are also formally involved in this process and have clear roles and responsibilities.

2. The site selection process

The so-called "Conceptual part" of the Sectoral Plan (BFE/SFOE 2008) defines the site selection criteria, the role and responsibilities of the various stakeholders as well as the three stages of the process used to identify suitable sites. The Sectoral Plan also defines in detail the input needed for decision-making in each of the three stages. It should be emphasized that throughout the site selection process, highest priority is given to safety.

Stage 1 of the site selection process starts with a "white map of Switzerland" (which means that a priori no area is excluded) resulting in the selection of several geological siting regions for each repository type. Stage 2 will lead to the identification of at least two potential siting regions for each repository type, each of them including a site for the surface facilities. In Stage 3 the remaining geological siting regions will be investigated in more depth. This will lead to a further safety-oriented narrowing down to one site for each repository type for which the general licence applications will have to be prepared.

At the end of each stage, the proposals have to be approved by the Federal Government based on the results of a detailed review by the authorities and on the outcome of a broad consultation phase involving all stakeholders. The three stages of the process are described in more detail below.

2.1. Stage 1 of the Sectoral Plan

The focus of stage 1 was on a scientific screening process leading to the identification of potential siting regions, giving first priority to safety while ensuring technical feasibility. Societal aspects were not part of this evaluation. To assess safety and technical feasibility, the Sectoral Plan defines 13 criteria, grouped into four broad areas, namely "properties of host rock", "long-term stability", "reliability of geological information" and "suitability for construction". These 13 criteria are supported by 49 indicators (derived by Nagra in step two of stage 1, see below). The identification of suitable geological siting regions was conducted in five steps. In a first step, the waste inventory was defined (including reserves for future developments) and the different waste types (approx. 120) were allocated to either the HLW or to the L/ILW repository. In a second step the barrier and safety concepts for the two repositories were defined and – in view of the evaluation of the geological siting possibilities – quantitative and qualitative requirements on geology were derived. These related to geometrical requirements of the host rocks (e.g. lateral extent and depth of intact rock blocks), the barrier properties of the host rock (e.g. thickness, hydraulic conductivity), long-term stability (uplift/erosion, differential movements, etc. for the timescales of concern), the reliability of geological findings (spatial explorability and temporal predictability) and engineering feasibility (e.g. rock strength).

Steps three to five covered the evaluation of the geological siting options. The geological information basis available in Switzerland is rather extensive and includes data and information from investigations performed by Nagra over a period of 30 years as part of its geological disposal programme, as well as on the analysis and interpretation of data gathered by other parties. The latter include, for example, deep boreholes and seismic campaigns for oil and gas prospection and for geothermal energy, shallower boreholes, surface geological and tunnel mapping, high-level precision geodetic monitoring, etc.

In step three, the large-scale geological-tectonic situation was assessed and potentially suitable large-scale areas were identified from the viewpoint of long-term stability (uplift and erosion, differential movements) and spatial conditions (size of not significantly disturbed blocks of rock, explorability of spatial conditions). The evaluation showed that all large-scale geological-tectonic areas in Switzerland could in principle be considered for the L/ILW repository, whereas for the HLW repository, the Alps, the Folded Jura, the western Tabular Jura and a small part of the Molasse Basin (western sub-Jurassic zone) had to be excluded.

Step four involved selecting the preferred host rock formations within the large-scale areas still under consideration. This was done in several sub-steps and led to the following results: for the L/ILW repository the Opalinus Clay with its confining units, the claystone sequence 'Brauner Dogger' with its confining units, the Effingen Beds and the marl formations of the Helveticum were proposed. For the HLW repository, the Opalinus Clay with its confining units was proposed as the preferred host formation.

The configurations of the preferred host rocks within the large-scale areas under consideration were evaluated in step five. Taking into account the presence of regional geological features (regional fault zones, over-deepened valleys resulting from glacial erosion, zones with indications of small-scale tectonic dissection, other zones to be avoided for reasons of neotectonics), preferred areas were identified within which the preferred host rocks could be found at suitable depth and with sufficient thickness and lateral extent. The preferred areas were used as the basis for delimiting the geological siting regions. Some siting regions contain several preferred areas and for L/ILW sometimes more than one host rock type.

This systematic approach was developed to ensure that the identification and selection of the proposals for the geological siting regions are performed in a fully transparent manner; the detailed documentation was elaborated to deliver a clear answer to the question *"why here and not there?"* from the point of view of safety. This is also considered to be of importance in view of gaining acceptance and support.

In October 2008 Nagra (2008) proposed three geological siting regions for the HLW repository and six for the L/ILW repository (Fig. 1). Note that three of the siting regions for the latter are almost identical with the ones for the HLW repository, but include in two of them, besides Opalinus Clay, also other formations as host rock, lying above the HLW host rock (Opalinus Clay).

Besides the voluminous detailed technical documentation, some booklets and folders were published and a range of presentations were made by the authorities and Nagra in the siting regions to inform the general public on the proposed geological siting regions and the broad arguments that led to these proposals.

While Nagra's proposals were being reviewed by the authorities, under the auspices of the Swiss Federal Office of Energy (SFOE) the regions potentially affected by each of the geological siting regions

[2] The Sectoral Plan is a widely established land-use planning tool in Switzerland.