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Identifying remaining socio-technical challenges at the national level: Switzerland

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This report was written within the EU-project InSOTEC (www.insotec.eu) which aims to generate a better understanding of the complex interplay between the technical and the social in radioactive waste management and, in particular, in the design and implementation of geological disposal. In a first step 13 countries have been analysed in order to identify prevailing socio-technical challenges. This report aims to describe the current state of affair in Switzerland (chapter 1) and intent to identify the prevailing socio-technical challenges in Switzerland (chapter2). In a further step of the project it will be analysed in more detail how such socio-technical challenges can be considered and recommendations will be formulated. This will be done based on several case studies summarizing the experiences of all country reports.

1 State of affair

1.1 General Overview and key developments in nuclear policy in Switzerland

The Swiss nuclear power program started with the parliament's decision to support nuclear power in 1946 and the implementation of the relevant laws between 1957 and 1959 e.g. the Atomic Energy Act which was revised several times. The first commercial nuclear power plant began operation in 1969. At the beginning of 2011 there were 5 nuclear power plants at 4 sites in operation producing around 39 percent of electrical power in Switzerland with a total capacity of 3.2 GW:

- BKW FMB Energie AG, Bern (Mühleberg NPP)
- Kernkraftwerk Gösgen-Däniken AG, Däniken (Gösgen NPP)
- Kernkraftwerk Leibstadt AG, Leibstadt (Leibstadt NPP)
- Axpo AG, Baden (Beznau I and II NPPs)

In the 1978 revision the "polluter pays principle" was included in the Atomic Energy Act. Furthermore it was fixed that a safe management and disposal of radioactive waste has to be proven before new nuclear power plants can be licensed (so called "Entsorgungsnachweis"). The responsible ministry further asked for such a proof by the end of 1985 for all nuclear power plants in operation.

Based on a project which the National Cooperative for the Disposal of Radioactive Waste (Nagra), the waste management organisation in Switzerland, presented in 1985, the Federal Council decided that the disposal of low and intermediate radioactive waste in marl, a sedimentary rock composed of clay and calcium carbonate, is demonstrated adequately. But the presented approach of disposal of high radioactive waste in crystalline rocks was not seen as an adequate proof of safe disposal by the Swiss Federal Nuclear Safety Inspectorate (HSK) (HSK 1986) and further investigations for non-crystalline rocks were requested by the Federal Council. The required proof of safe management and disposal of high level radioactive waste was then given with Nagra's new Project "Opalinus Clay" which analysed the disposal in the sedimentary rock opalinus clay. It was approved by the Federal Council in June 2006.

In 2008 the operators of several nuclear power plants applied for a "decision in principle" ("Rahmenbewilligung") to build new nuclear power plants which should replace the old plants. In May 2011 following the nuclear accident in Fukushima the Federal Council announced to abandon plans to build new nuclear reactors. The existing reactors would be allowed to continue operating, but would not be replaced at the end of their life span. The Federal Council assumes a life span of 50 years (JC 2011).

As per law reprocessing is considered as part of spent fuel management in Switzerland. With the revision of the Nuclear Energy Act in 2003 the parliament decided to introduce a ten year moratorium on the export of spent fuel for reprocessing. This moratorium entered into force in July 2006. Therefore shipment of spent fuel for reprocessing abroad is stopped till 2016. By the end of 2007 a total of 1,139 t of spent fuel had been shipped to the reprocessing plants in UK and France (JC 2011).

In Switzerland, radioactive waste is categorised in high-level radioactive waste and low and intermediate level. The high-level radioactive waste consists of fission products from nuclear power plants. Fuel elements containing uranium needs to be disposed of after a service life of 4 to 6 years. Low and intermediate level waste products consist of other material used in operating the nuclear power plants (e.g., protective clothing, machinery, water for washing), material arising during

decommissioning of nuclear power plants and waste arising from uses in healthcare, industry and research (including dismantling and decommissioning research facilities) (BFE 2012). The total volume of radioactive waste in Switzerland will be about 100,000 m³ of which 90 % is low and intermediate level waste and 10 % high level waste.

Currently, the waste is stored in interim storage either in decentralised facilities available at the individual nuclear power plants or in two central interim facilities: for high level waste in ZWILAG and for the low and intermediate level waste from healthcare sector, industry and research in a facility operated by the Federal State-Swiss Confederation.

All radioactive waste is to undergo final disposal in repositories situated in suitable geological formations; surface and near-surface disposal is not allowed (JC 2011).

1.2 Main actors

- **Swiss Federal Office of Energy (BFE)** has the lead in the Sectoral Plan for Deep Geological Repositories and the general license process and is responsible for the organization of the regional participation. It keeps the public informed on the status of work.
- **National Cooperative for the Disposal of Radioactive Waste (Nagra)** acts as implementer for radioactive waste disposal. The Nagra cooperative was created from the waste producers and the Swiss Confederation in 1972. In the process of the Sectoral Plan for deep geological repositories Nagra's role is to elaborate the necessary geological information required for the search for sites and to propose the potential siting regions and later the specific sites. Nagra has to apply for the decision-in-principles, but has no decision power in the siting process. Nagra is organized as a cooperative with members from of the Swiss Confederation (represented by the Department of Home Affairs) and the owners of the nuclear power plants.
- **Swiss Federal Nuclear Safety Inspectorate (ENSI)** is the national regulatory body who reviews the license application of the deep geological repository before the Federal Council and the Parliament make their final decision. It is responsible for evaluating the proposals of the Nagra in terms of safety aspects.
- **Federal Department of the Environment, Energy and Communications (UVEK)** is responsible to steer and control the implementation of the Sectoral Plan.
- **Commission for Nuclear Waste Disposal (KNE)** is an expert commission set up by the Federal Department of the Environment, Energy and Communications (UVEK) and the Federal Department of Defence, Civil Protection and Sport. (VBS) which provides expert advice to ENSI in questions related to geo-scientific, long term safety and construction issues. The commission comments the specific reports of Nagra and further provides advice to public bodies on the appointment of experts. It is responsible to review location and carries out its own studies about specific safety and construction issues.
- **Swiss Federal Nuclear Safety Commission (KNS)** is an advisory body of the Federal Council, the UVEK and ENSI which works on fundamental issues related to nuclear safety.
- **Waste Management Advisory Council** acts as an independent national advisory board which was created by the UVEK. Its responsibility is to identify conflicts and risks at an early stage and propose solution. It advises UVEK and promotes the dialogue among all actors.
- The responsibility for the final decision on the license of the geological repository lies in the hands of the **Federal Council**. The Federal Council is also responsible for the approval of different steps in the Sectoral Plan.

- According to the Sectoral Plan for Deep geological repositories the **cantons** play a central role in the siting process. They accompany the whole process professionally and politically. They coordinate the collaboration with the affected communities and give statements to the Federal Government. To organize the work several committees have been installed e.g. the **Cantonal Commission (Ausschuss der Kantone)** which works at the political level and the working groups which focus on “Information and Communication” as well as “Spatial Planning”. Furthermore a **Technical Forum Safety** has been established. The Technical Forum on Safety discusses and answers technical and scientific questions posed by the population, communes, 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 (Swiss Federal Nuclear Safety Inspectorate, ENSI, Swiss Federal Office of Topography [swisstopo]), from commissions (Federal Nuclear Safety Commission [NSC], Federal Commission for Radioactive Waste Disposal [KNE]), from the National Co-operative for the Disposal of Radioactive Waste [Nagra], from the cantons, and includes one representative from each of the siting regions.
- **Regional conferences** are committees built of different regional stakeholders e.g. representatives of communities, NGOs in the potentially affected siting areas with the mandate to represent the regional interest. They comment on Nagra’s reports and develop a strategy for regional development.
- The **Swiss voters** have the possibility to call for a national referendum on the general license for the repository.
- **Swiss Federal Office of Spatial Development (ARE)** examines and assesses spatial planning aspects and supports the Swiss Federal office of Energy
- **Swiss Federal Office for Environment (BAFU)** examines and assesses environmental aspects and supports the Swiss Federal office of Energy.
- Other Federal Offices like e.g. **Federal Office of Public Health (BAG) or the Paul Scherrer Institute (PSI)** support the BFE in specific questions.
- The **Schweizerische Energie-Stiftung (SES)** is an independent non-profit critical anti-nuclear organisation.

1.3 The legislative and regulatory system

The safety of spent fuel and radioactive waste management is governed by the federal legislation on nuclear energy and on radiation protection. The most important laws and ordinances are:

- Nuclear Energy Act of 21 March 2003 (Commencement date: 1 February 2005)
- Radiological Protection Act of 22 March 1991 (Commencement date: 1 October 1994)
- Swiss Federal Nuclear Safety Inspectorate Act of 22 June 2007 (Commencement date: 1 January 2008)
- Nuclear Energy Ordinance of 10 December 2004 (Commencement date: 1 February 2005)
- Radiological Protection Ordinance of 22 June 1994 (Commencement date: 1 October 1994)
- Ordinance on the Decommissioning and Waste Management Funds for Nuclear Installations of 7 December 2007 (Commencement date: 1 February 2008)
- Ordinance on the Collection of Radioactive Waste of 3 September 2002 (Commencement Date: 1 January 2003)
- Ordinance on the Swiss Federal Nuclear Safety Inspectorate ENSI of 12 November 2008 (Commencement date: 1 January 2009)

The requirements of the legislation are detailed in regulatory guidelines issued by the Swiss Federal Nuclear Safety Inspectorate (ENSI).
For further details refer to e.g. to the Joint Convention Report (JC 2011).

1.4 Timeline aid

1946: Start of the nuclear power program
1969 first commercial nuclear power plant started operation
1969-1983: Swiss radioactive waste dumped in the North Atlantic
1972: Foundation of the waste management organisation Nagra
1977: first concept for the nuclear management in the Switzerland presented
1978: polluter pays principle included in Atomic Energy Act, for all radioactive waste a safe management and disposal needs to be proved (Entsorgungsnachweis)
1979-84: Focus on crystalline rocks as an option for final disposal of high-level waste, application for license to construct a rock laboratory in crystalline formation at the Grimsel region.
1980: Nagra submitted applications to perform reflection seismic measurements and twelve deep boreholes in the crystalline basement of northern Switzerland.
1981: Nagra proposed five potential host rock types: anhydrite, alpine marls / claystones, Opalinus Clay, crystalline basement and shielded formations, i.e. formations that are protected from water infiltration by a «roof» of impermeable rock layers for low level waste, then Nagra selected 100 potential suitable sites for low level waste in different host rocks, after in depth investigation narrowed down to 20 potential sites for low level waste, out of the evaluated host rocks, Nagra later selected three types of suitable host rocks and identified for each a promising site: anhydrite (Bois de la Glaive), crystalline (Piz Pian Grand), alpine marls / claystones (Oberbauenstock) for low level waste
1982 – 1985: Nagra drilled exploratory boreholes at Böttstein, Weiach, Riniken, Schafisheim, Kaisten and Leuggern under the supervision of the responsible authorities.
1988 – 1989: Drilling of the borehole in Siblingen
1984: Underground laboratory Grimsel (crystalline rocks) started operation
1985: feasibility study Project “Gewähr”: prove for a safe management and disposal for low and high level waste
1986: the Wellenberg site (marl) was added to the list of potential sites for low level waste due to its comparatively better potential for exploration.
1988: Federal council accepted the prove for a safe management and disposal (Entsorgungsnachweis) for low level waste in marl, but not for high-level waste in crystalline rocks, further analysis requested for sedimentary rocks.
1990: Nagra submitted an application for a borehole in Benken
1993: Nagra selected Wellenberg as a potential site for low level waste
1994: GNW, a daughter company of Nagra, applied for a general license for constructing a deep geological disposal in the region Wellenberg
1995: cantonal veto: the canton Nidwalden refused to grant the concession for use of underground space required under cantonal law and rejected the recommendation of the cantonal government to grant the general licence. The licence procedure was then put on hold.
1996: Federal Council granted the application for a borehole in Benken
1998: Nagra stopped investigation in the crystalline rocks. Mont Terri rock laboratory in opalinus clay started official operation
1999: Establishment of EKRA (Expertengruppe Entsorgungskonzept für radioaktive Abfälle)
2000: EKRA report published, suggestion a controlled deep geological disposal

2001: After the blocked Wellenberg project was changed, the GNW submitted an application for a concession for the exploratory drift, this was approved by the cantonal government

2002: second cantonal veto: the Canton rejected the license for the construction of an exploratory drift in Wellenberg, after that Nagra abandoned all activities at the Wellenberg site.

2002: Project Opalinus Clay (Entsorgungsnachweis): prove for a safe management and disposal of high-level waste in opalinus clay for exemplary site Benken

2006: Federal Council accepted the Project Opalinus Clay (Entsorgungsnachweis)

2005-2006: Draft concept of the Sectoral Plan

2007: public hearing with regard to the concept of the Sectoral Plan for deep geological repositories

2007: Concept of the Sectoral Plan for Deep Geological Repositories approved by the Federal Council

2008: Start of phase 1 of the Sectoral Plan: Nagra suggested 6 potential sites for the deep geological disposal

2010: Nagra's site suggestions approved by ENSI, KNE

2011: start of seismic campaign, end of stage 1 of the Sectoral Plan: Federal Council approved Nagra's proposed sites

2012: Start of phase 2 of the Sectoral Plan: Nagra suggested areas for the surface facilities in the candidate sites, start of several public involvement activities

1.5 Early siting process at Wellenberg

Research on geological disposal started in the 1970ies. From 1979 to 2002 Nagra planned and implemented several activities for choosing a site for low and intermediate radioactive waste. In 1994 GNW, a daughter company of Nagra, applied for a license to construct an exploration drift and for a decision in principle to build a repository in the region Wellenberg. Despite the positive statement of the cantonal Government the population of the canton Nidwalden refused both applications in a cantonal veto.

This setback was followed by a period of discussion on basic questions on nuclear waste management. This was initiated by the minister for the Environment, Transport, Energy and Communications (UVEK), Bundesrat Moritz Leuenberger, who established in 1998 the working group "Energy-Dialogue Waste Management" that discussed the waste management question in a broader societal context reflecting different positions of industry and environmental organisations. During these discussions the concept of "controlled and retrievable geological disposal" was developed. For more detailed elaboration of this concept Bundesrat Leuenberger established the expert group EKRA (Expertengruppe Entsorgungskonzept für radioaktive Abfälle) in 1999. The EKRA consisted of several experts in the field of radioactive waste management. Its mandate was to develop the basics for a comparison of different management ways for radioactive waste and to give recommendation for the further procedure. The EKRA developed the concept of "controlled geological disposal" (EKRA 2000). This means that besides the main repository a pilot repository will be built and the latter will be monitored for a certain period. Later, this concept then referred to as deep geological repository (geologische Tiefenlager) was fixed in the Nuclear Energy Act.

In spite of the amendments of the disposal concept the Wellenberg kept being the preferred site for disposal of low and intermediate level waste. The canton Nidwalden established in June 2000 the Cantonal Professional Group KFW (Kantonale Fachgruppe Wellenberg) as advisory body of the canton. It was assigned to accompany the further planning and implementation of site explorations for the planned repository in the Wellenberg region. Four of the eight members of the KFW had also been members of the EKRA and therefore had the possibility of continuously developing further the EKRA concept under more concrete conditions of a specific site. In the following two years the KFW published several reports dealing e.g. with the site selection procedure that lead to the

determination of Wellenberg, with the waste inventory and with the adaption of a potential repository at the Wellenberg site to the EKRA concept of “controlled geological disposal”. In their report on the site selection procedure (KFW 2002a) as well as in the report on the waste inventory (KFW 2002b) the KFW affirmed their earlier position in favour of investing the Wellenberg site by drilling an exploration drift although the analysis of the selection procedure revealed some deficiencies in the early phase of the process.

However, even after comprehensive changes of the “Wellenberg” concept and in spite of the KFW’s recommendations, the canton refused the mining license for the construction of an exploration drift in 2002. In the light of these developments Nagra abandoned all activities at the Wellenberg site. Thus the first attempt for siting a radioactive waste repository had failed due to public protest and political intervention.

Up to now neither a site for disposal of low and intermediate nor for spent fuel and high level waste has been determined, but since 2002 a new approach of siting according to the “Sectoral Plan for deep geological repositories” is in place.

1.6 Participatory approaches for designing a siting process – Sectoral Plan for deep geological repositories

With the revision of the Nuclear Energy Act in 2003 which entered into force in 2005 the concept of deep geological repositories was established in Switzerland. Furthermore the licensing steps and the responsible authorities were fixed in the law e.g. license for geological investigations, decision-in-principle, construction license, operation license. In this context the cantonal veto right was replaced by a facultative referendum at federal level.

It was agreed that the process of siting will take place according to a Sectoral Plan. Sectoral Plans are well established instruments in the context of spatial planning in Switzerland for projects of national relevance. They support the federal government in fulfilling their duties in spatial planning and coordinating their plans with the competent parties especially on the cantonal level (BRP 1997). It was decided that this instrument will also be used in the context of the siting process. First of all a conceptual part of the Sectoral Plan for deep geological repositories was prepared and presented in January 2007. During the development of the Sectoral Plan stakeholders and public were involved e.g. through focus groups and workshops. This phase of development was followed by a consultation phase in which the cantons, interested organizations and the public could submit their opinions on the proposals. In 2008 the Federal Council adopted the Sectoral Plan for deep geological repositories. The aims of the Sectoral Plan are:

- To define the criteria and other requirements for the siting process and the choice of potential host regions and sites
- To specify the process that will lead to the approval of a candidate site

The Sectoral Plan defines the roles of the different actors and maps several measures for regional participation. The measures are described in detail in the conceptual part of the Sectoral Plan (BFE 2008) and several other reports e.g. (BFE 2011a). The regional public participation is clearly limited to questions concerning surface infrastructure, spatial planning and regional development. The concept of deep geological disposal and the underground construction are not to be discussed. But all citizens have the chance to pose questions on technical and scientific issues to the Technical Forum on Safety which discusses the questions and provides answers. The Sectoral Plan also ensures the involvement of neighbouring countries as far as they are concerned due to the location of potential sites. In praxis

Germany is closely involved through the foreseen participation activities e.g. in the Cantonal Commission (Ausschuss der Kantone). The possibilities how neighbouring countries are involved in the Sectoral Plan are described in detail in Appendix V and VI of the Sectoral Plan (BFE 2008).

In Switzerland it is not foreseen to include a volunteering approach in the site selection procedure, but the implementation of the Sectoral Plan shall lead to a candidate site within ten years through the following three stages:

Within stage 1 in 2008 Nagra identified six potentially suitable siting areas on the basis of predefined geological and safety criteria stated in the Sectoral Plan. All six areas are recommended for low and intermediate level waste while only three of them are also evaluated as being potentially suitable for high active waste.

The suitability of the proposed siting areas was judged by the Nuclear Safety Inspectorate (ENSI), the Commission for Nuclear Waste Disposal (KNE), the German interdisciplinary expert group ESchT set up by the German Ministry of Environment and other experts. All these experts confirmed the potential suitability of the proposed six areas.

Furthermore the methodology for the planned study of the economic, ecological and social effects of a geological repository in stage 2 has been developed and approved by the federal government.

According to the Sectoral Plan it is planned to involve the stakeholders at each stage at different levels. In stage 1 the public has been involved e.g. in the Cantonal Commission (Ausschuss der Kantone). Additionally the BFE finances an independent expert group which supports the cantons.

Nagra's and ENSI's findings in stage 1 of the siting process were given to public consultation at the end of 2010. The consultation process is documented in a report by BFE (BFE 2011b) and comments that have been provided during this consultation have been considered in BFE's concluding report on stage 1 (BFE 2011c).

The formal approval of BFE's concluding report by the Federal Council on 30 November 2011 marks the end of stage 1 of the Sectoral Plan. The Federal Council endorsed all sites areas which had been proposed by Nagra for further investigations in stage 2.

Within the approx. 2.5 year lasting stage 2 a spatial planning assessment is carried out for the proposed siting areas. At the same time socioeconomic studies are carried out at all proposed areas. In stage 3 Nagra has to propose and decide how the layout and design of the surface infrastructure and the arrangement of the underground components may look like at each site.

For stakeholder involvement in stage 2 of the siting procedure, so called "Regional Conferences" have been established in each of the potential host regions (see e.g. the Jura Ost Regional conference under <http://www.jura-ost.ch/>). The 50 to 150 members of the regional conferences represent local and regional politics, economics, special interest organisations and non-organised citizens. The operational business is taken over by an executive committee that consist e.g. in the "Jura-Ost Regional conference of 5 conference members. The mandate of the regional conferences is to represent the regional interests. They develop reports and statements for the attention of the BFE or other competent authorities who should answer questions and consider the positions throughout the further siting procedure. For in-depth treatment of specific issues the regional conferences can establish respective working groups. Among others each regional conference has established an expert group "Safety".

After carrying out preliminary safety assessments and safety comparisons, Nagra has to propose at least two sites for each low and intermediate level and for high level radioactive waste. At the end of this stage the Federal Council will decide which two sites will be further investigated.

In stage 3 which is expected to last between 2.5 to 4.5 years the proposed sites will be investigated in greater detail. If required further geological studies will be carried out to extend the knowledge

about the geological conditions of the sites. The socio-economic studies will be amended. The siting regions will provide input in those steps. They have to propose projects for regional development and define principles of any required compensation measures as well as for monitoring the socioeconomic and ecological impacts. At the end of this stage it is foreseen that Nagra submits applications for a high radioactive waste and a low and intermediate waste repository. It is not yet decided whether there will be one site hosting both the high and the low and intermediate level waste or two separate sites. The Federal Council is responsible to submit a decision-in-principle for the specific site, which has to be approved by the Federal Assembly.

Nagra has to apply for a general licence before construction of the deep geological repository. According to the Nuclear Energy Act this requires the preparation of a Safety Case.

2 Identification of significant socio-technical challenges

The identification of prevailing socio-technical challenges in Switzerland is based on a review of relevant literature and publications, the revision of research programs of relevant authorities and institutions, the exchange with key actors through interviews and on the experience of the authors of this report gained within the years in different projects, committees etc. Detailed results of the empirical analysis of the relevant literature and publications and research programs as well as results of the interviews are presented in section 3.

Based on the review of literature and on the interviews the following socio-technical challenges have been identified:

- Retrieval and pilot facility
- Marking geological repositories / Knowledge transfer
- Siting of surface facilities / Safety versus participation
- Evolving knowledge during siting process
 - Different levels of knowledge at different sites
 - Necessary level of knowledge at different stages of siting

In the following chapters each of these socio-technical challenges is described in more detail.

2.1 Retrieval and pilot facility

After the investigation plans at Wellenberg were stopped a second time by a cantonal veto, the EKRA was commissioned to analyse the status of the management of radioactive waste in Switzerland. The EKRA has evaluated different options and concluded that the deep geological disposal is the only way for managing all radioactive waste in a long term safe manner (EKRA 2000). The EKRA further stated that the society demands retrievability of the waste. In 2000 the EKRA therefore developed the concept of controlled deep geological long term storage which is now referred to as deep geological repository for low level as well as high level waste. In the concept it is foreseen to create a pilot facility next to the main disposal facility. The pilot facility is monitored for a certain period to observe whether the radioactive waste is disposed safely and the system reacts in the expected way. If any problems occur, the waste can be retrieved. That means that the waste has to be disposed in such a

way that it can easily be retrieved during the operation period of the facility. After the closure the retrieval of the waste would only be possible with more elaborated mining activities. The concept of the deep geological disposal with the possibility of retrieval and the installation of a pilot facility was then finally fixed in the Nuclear Energy Act (KEG) which entered into force in 2005. The Sectoral Plan for deep geological repositories is based on these legal conditions. It seems that Switzerland found a widely accepted way to meet both the societal demand of a retrievable disposal and the challenges of long term safety. In so far this socio-technical challenge could be solved on the conceptual level. But as the practical feasibility of this concept has still to be proved, some discussions are still on-going. In the consultation process at the end of stage 1 several objectors e.g. communities, environmental organisations and NGOs demanded a longer period of retrievability and extended monitoring for the whole facility (BFE 2011b). One interview partner said that an open question is how the retrievability of the waste can be technically assured. The issues of monitoring and retrievability also comprise the question on the appropriate point of time for the closure of the repository as it influences the technical options for monitoring as well as the accessibility of the wastes for potential retrieval.

2.2 Marking geological repositories / Knowledge preservation and transfer

The permanent marking of a geological repository is a requirement which is fixed in the Swiss Nuclear Energy Act (KEG 2003. Article 40).

In 2000, the EKRA identified marking, availability of information and transfer as important elements of a comprehensive coherent planning for the realization of geological disposal (EKRA 2000). In 2002, the EKRA again indicated a need for more research related to the documentation and marking of geological repositories (EKRA 2002).

Thus, the marking of geological repositories is one of the topics of the research plan of the BFE (BFE 2006). So far a literature study from Marcos Buser has been done summarizing the past developments and knowledge in that field (BFE 2010). The outcomes of this literature review will be used e.g. in the on-going international OECD-project with the title "Preservation of RK&M across Generations" in which the BFE is involved (OECD 2011).

According to a lot of interview partners the marking of the geological repository is an important socio-technical challenge, but which is at the moment discussed mostly on the international level. Within Switzerland the discussion has just started and is less to some extent in the public and the media. But solutions have not been found yet. The Schweizerische Energie-Stiftung highlight it as one of the most important unsolved questions in the field of geological disposal (SES 2011).

The challenge is that it is unknown how future generations will live, how the state will be organized and what techniques will be available etc. This outlines that while doing research in that field one has to consider the strong connection between societal and technical aspects.

It is expected that the discussion of this socio-technical challenge will be intensified at a later stage when the Sectoral Plan will proceed.

2.3 Siting of surface facilities / Safety versus participation

In stage 2 of the Sectoral Plan it is foreseen to identify potential areas for surface infrastructure in each of the 6 potential suitable regions approved in stage 1. The selection of these areas is done orientated on the following overarching aims:

- Safety and technical feasibility
- Compatibility with spatial planning and environment aspects
- Local integration of the facility in the region

Based on that the Nagra defined criteria and indicators which were used while selecting the areas for the surface infrastructure (Nagra 2011).

On 20th of January 2012, the BFE announced that Nagra has proposed 20 potential areas in which the surface facilities could be sited. According to the Sectoral Plan the regions are involved in the decision where the surface facilities would be located. Within the next weeks several information meetings were held in the respective communities in order to inform the general public. According to the Sectoral Plan the regional conferences will discuss the proposals and will provide their statements and proposals by autumn 2012.

According to impressions on how the media is reporting on this issue, the first reactions of the affected communities have been very different. Some were not surprised that one of the potential areas lay in their territory, others criticized the proposal of the Nagra strongly saying that they are very surprised and cannot trace the decision of the Nagra. Some cantons e.g. Aargau stated that they are in principal against a geological repository within their territory while others want to discuss the proposal in detail.

This outlines that the results of participation will be considered in the decision on the potential sites for surface facilities besides the technical criteria that laid the basis of Nagra's choice of potential areas. The siting of the surface infrastructure is therefore a socio-technical issue, because in the selection process both socio-political and technical criteria need to be considered.

The Schweizerische Energie-Stiftung (SES) and some of the interviewees criticised that the sites for surface facilities will be fixed before the underground site for the deep geological repository is chosen. According to them this order of site selection hinders to have the safest access to the underground facility. The SES claimed that an access shaft is safer than a ramp but fear that an access via a shaft is very improbable while siting the surface facilities prior to the siting of the underground repository (SES 2011).

Such questions are discussed e.g. in the technical forum which was set up during phase 1 of the Sectoral Plan. In the forum both representatives from the public and technicians work together allowing the discussion of societal as well as technical issues. Within the Sectoral Plan other such committees have also been established e.g. the Expert group "Safety" which aims to support the relevant regional conferences. This can be acknowledged as an approach to handle the socio-technical challenges.

In this context another more general issues was brought up in the academic research scene as well as by Swiss stakeholders. The ETH Zürich summarised it in the question "Technical safety vs. public involvement?" (Krütli 2009). Other stakeholders talked about the tension between safety aspects on the one hand and outcomes of participation on the other hand. While safety should have the uppermost priority in the selection process public involvement generates results that need to be considered in the decision-making. The reasons for that "safety first- principle" may be that public participation is understood mainly as an instrument for gaining acceptance and that it is feared that when the results of the public participation will be considered with the higher priority, not the safest but the site with the highest acceptance will be chosen. But in this argumentation it is not considered that the early involvement of the public might also increase the safety of a facility because e.g. critical issues are brought up at an early stage.

The clear distinction between technical issues and social issues is also reflected in the research programs: When it was decided to establish an independent research programme the roles were

distributed as such that the BFE is responsible for the socio-scientific issues including the design of the process, the ENSI is responsible for regulatory issues whereas Nagra will continue to concentrate on the technical issues (see section 3.1.). The ETH Study of 2009 (ETH 2009) also concluded that there is a broad consensus between all stakeholders that “site selection should not be purely based on technical criteria but socio-economic criteria should also be considered”, but that the principle of “safety first” is broadly accepted (ETH 2009).

The Swiss way of excepting the underground facilities from public discussions might be interpreted as a way to deal with that dilemma. However, discussions are still on-going if the public is excluded from decisions on issues which are relevant for long-term safety and if decision making is influenced by the level of public acceptance in a way that jeopardises safety.

In so far public participation may be defined as a socio-technical challenge itself. This includes the compatibility of the safety first principle with the results of public participation and the influence of different levels of public acceptance. It is expected that potential solutions for this dilemma have to consider the respective stage of the planning, siting or implementation process.

2.4 Evolving knowledge during siting process

The issue of evolving knowledge during the siting process has two socio-technical aspects:

- Different levels of knowledge at different sites and
- The level of knowledge on certain issues that is necessary at a respective stage.

Within stage 1 of the Sectoral Plan it was criticized that the knowledge base of the different areas under investigation is very inhomogeneous e.g. the region of Zürich North-East is well investigated due to earlier siting approaches and the efforts related to the “Entsorgungsnachweis”. This raises the question how far the comparison of sites is influenced by different levels of knowledge and if lesser knowledge supports an early exclusion of a site from the selection process.

Due to the Sectoral Plan additional geological investigations of the sites will only start in phase 3 of the siting procedure. But SES and KNS demand that additional geological investigations need to be started as soon as possible to guarantee a comparable level of knowledge at all regions. In their statement on stage 1 (KNS 2010) KNS pointed out that additional geological investigations e.g. like 3D seismic or deep boreholes are required. They indicate that such investigations need time and that they will probably delay the whole process if they are started too late. KNS recommends strongly checking the necessity of additional investigations with the highest priority. This opinion is also shared by the cantons which claim the start of investigations in their statement to stage 1 as well (AdK 2010).

In October 2010 the Nagra presented a report (Nagra 2010) in which they described their plan for further investigations and evaluated the necessity of additional geological investigations. With reference to the additional analyses which are foreseen in stage2 anyway Nagra came to the conclusion that these are sufficient to fill most of the knowledge gaps. They furthermore explained that if required additional investigations could be conducted in stage 3.

The ENSI has confirmed in its statement of March 2011 that the existing geological information is sufficient for the foreseen work (ENSI 2011).

But this opinion is not shared by KNS which is still sceptical whether the foreseen investigations will lead to a comparable level of knowledge at the different regions (KNS 2011).

The Working group Safety and the supporting cantonal expert group for Safety prosed to have a stop in the process after the investigations in stage 2 have been conducted to evaluate the geological information existing at that time (AG SiKa/KES 2011).

As one consequence of discussions about the existing geological database Nagra agreed to conduct additional 2D-seismic investigation which was recommended by the KNS in some of the areas. The 2 D measurements started on 24.10.2011 (see <http://www.seismik-news.ch/?p=60>)

The question of the different levels of knowledge is directly linked to the preliminary safety assessments, because they need to be based on sound geological models.

The discussion on equality of knowledge has a high technical component, but touches also the societal demand of finding the safest site in a transparent and legitimate process and can therefore be seen as a socio-technical challenge.

The second aspect of evolving knowledge touches the level of knowledge on certain issues that is necessary at a respective stage.

Swiss stakeholders mentioned e.g. the question at which stage the material of the canisters has to be chosen. The current approach of leaving issue open for clarification at a later stage is not shared by all stakeholders. Some think that too many issues relevant to safety are still open and need clarification before proceeding with the site selection.

Others stress that taking decision on technical solutions at the time they are really needed allows for considering latest research outcomes and find a state-of-the-art solution.

One social challenge in this context is the communication of a stepwise process that implies an evolutionary approach for the development of the technical concept and components. This concerns societal demands for clarification of open issues in order to have confidence in the system. But also a common understanding among waste management experts on the timing of technical developments and the flexibility that is necessary to react on new results and findings.

3 Results of emprical analysis

In order to identify prevailing socio-technical challenges in the Switzerland a review of relevant literature and publications, the revision of research programs of relevant authorities and institutions were conducted. Additionally key actors were interviewed. The analyses of research programs and of results from interviews performed are presented in the following.

3.1 Developments in social sciences research on nuclear waste management, especially deep geological disposal, in Switzerland

Within this chapter the status of socio-scientific research in the field of nuclear waste management and especially geological disposal is analysed. The aim is to trace potential developments towards an increased awareness and consideration of such aspects. Publications dealing with the consideration

of socio-scientific aspects in the field of geological disposal as well as research programs have been reviewed for this analysis.

On behalf of the BFE, Basler and Hofmann studied “the status and perspectives of radioactive waste management research and development”. In their report which was published in 2004 (BFE 2004), they concluded that socio-economic questions firstly came up during the process of the “Entsorgungsnachweis” (waste management proof). According to their study it became obvious in the context of the “Entsorgungsnachweis” that the public does not accept anymore a purely natural-scientific technical proof of safety of a repository, but also wants to discuss various socio-economical questions. Basler and Hofmann concluded that the technical researchers accept the relevance of social sciences in the waste management area but are also critical with regard to the “soft” results. They further stated, that both socio-scientific and natural-scientific research needs to outline the societal, political and psychological reasons which could hinder the realization of a repository and to propose solutions. But according to them this can not only be done by social scientists. However, before 2006 social sciences was only conducted in single projects mostly either within the EKRA or from the ETH Zurich.

The EKRA was established after the second failure of starting investigations at the Wellenberg site (see section 1.5). EKRA has published two reports (EKRA 2000; EKRA 2002) in which they gave recommendations for disposal concepts for radioactive waste considering both societal demands and technical possibilities.

At the ETH Zurich the working group “Natural and Social Science Interface (NSSI)” works on the interfaces of human and environment systems, research and practice and natural and social sciences. First socio-scientific studies in the field of radioactive waste management were conducted e.g. by Flueeler in 2001 on the topic “Options in radioactive waste management revisited: A framework for robust decision-making”. According to the publication list¹ work on social sciences got more intensive after 2006 e.g. a study by Kruetli et al (2010) working on “Functional-dynamic public participation in technological decision making” based on the example of a site selection processes of nuclear waste repositories.

The developments of socio-scientific research in Switzerland were shortly outlined by Flueeler in his contribution to the publication of (Hocke and Grunwald 2006) which was published after a workshop dealing with perspectives on socio-scientific research in Germany on radioactive waste management (Flueeler 2006). He criticised that until 2005 there has been hardly any movement in that field in Switzerland. This has changed with the decision to create a site selection process according to a Sectoral Plan which regulates the involvement of the public.

The fact that the Sectoral Plan (BFE 2008) intends to involve the public at several stages and considers several societal aspects like e.g. socio-economic studies which are foreseen in stage 2 of the process shows that there is a rising awareness of the importance of socio-scientific aspects.

However, in the public hearing which was held during stage1 several objectors claimed that the questions related to deep geological disposal are not only technical ones, but also of ethical nature. According to them the today’s decisions on deep geological disposal have impacts on thousands of future generations. That’s why some objectors criticised the missing consideration of the ethical perspective in the discussion on nuclear waste management (BFE 2011b).

There are some few publications dealing explicitly with socio-technical issues. E.g. a book from Flueeler with the title “Decision Making for Complex Socio-Technical Systems - Robustness form Lessons Learned in Long-Term Radioactive Waste Governance (Flueeler 2006b) which includes a survey of international literature in that field. Flueeler characterised the long-term governance of

¹ see <http://www.uns.ethz.ch/res/irl/radGov>

radioactive waste as an unresolved major complex socio-technical issue. He examined in his study e.g. the risk perception of the public.

In 2008, the ETH conducted a survey in Switzerland and Sweden on the topic of interplay between technical expertise and societal input during siting processes for radioactive waste repositories (ETH 2009). According to the study “the construction of a deep geological repository for long-term disposal is complex and triggers many questions. Some of these questions are of a technical nature and can be tackled by engineers and geologists. [...] There are, however, also questions for which there is no technical-scientific answer because they involve values, beliefs, and norms [...]. These sorts of questions should be answered by society and necessitate the involvement of the directly affected population” (ETH 2009). In order to realize a deep geological repository it is according to the authors of the study important to bring together the different parties. The aim of the study was to better understand the expectations of stakeholders. According to the study stakeholders in both countries have high expectations on measures for public participation. Stakeholders claim for example the democratic involvement of the affected public and request high transparency of the public participation process. According to the study there is a broad consensus between all stakeholders that “site selection should not be purely based on technical criteria but socio-economic criteria should also be considered”. But the principle of “safety first” is broadly accepted (ETH 2009).

Looking at the research programmes it is obvious that until 2006 research in the field of geological disposal was mainly done by Nagra concentrating on technical issues. This was criticized by some stakeholders and also by the EKRA. One recommendation was to establish a research programme which was independent of Nagra’s research activities and covered both the technical-scientific and socio-scientific field (EKRA 2002).

When it was decided to establish an independent research programme the roles were distributed as such that the BFE is responsible for the socio-scientific issues including the design of the process, the ENSI is responsible for regulatory issues whereas Nagra will continue to concentrate on the technical issues.

In 2006 the BFE has started its first own research plan. Main topics are:

- Long term aspects (preservation of knowledge and marking)
- Sectoral Plan (Communication with the public)
- Perception, opinion making, acceptance
- Ethics and law

Within this research plan socio-scientific projects have been started dealing with the topics e.g. “Value and opinions” (Seidl 2011) or “communication with the society” and a literature survey on “Marking deep geological repositories” (BFE 2010).

The establishment of BFE’s research programme in 2006 indicates that there is an understanding, that socio-scientific research is required in the field of deep geological disposal. Anyway, the research has just started within the last years. The socio-scientific projects of BFE’s research plan will be worked off one by one. According to some interview partners there is still a big demand of further increasing the socio-scientific research in that field. One interview partner warned that the socio-scientific research is not only about gaining acceptance. The interview partner gave some ideas on other relevant topics (compare section 2.2.). An interview partner proposed an accompanying evaluation of the implementation of the Sectoral Plan as an important future project.

3.2 Analysis of interviews

In order to consider a broad spectrum of views on socio-technical challenges in Swiss waste management activities four interviews have been realized with representatives of the regulator, the implementer, an NGO and of academia.

The experts were asked by two colleagues of the Oeko-Institut via a one hour telephone interview with twelve semi-structured questions (see Annex 1). A short summary of the interview was provided and sent to the interview partners for corrections and amendments.

We want to thank all interview partners for their interest and support to the InSOTEC project and for taking the time to answer our questions in detail.

The interviews were structured in a way to lead from reflections on general topics of major interest in public, media, politics and the waste-management-scene to the interviewees' views on explicitly socio-political topics on the one hand and on natural-scientific/technical topics on the other hand. The following questions made the link to the combination of technical and social aspects: in which topics such socio-technical combinations are estimated as relevant and if / how discourses on nuclear waste management reflect such combinations adequately. A short review of the interviewees' opinions on the most relevant topics of research in the field geological disposal and the relevance of socio-sciences in research programmes concluded the talks.

A short overview of results is given in the following:

- *On topics in the field of geological disposal which are mainly discussed in the public, in the media, in politics and in the professional waste-management-scene*

The following issues were mentioned as topics of interest in the regional public:

- The Sectoral plan
- Site selection of surface facilities
- The need of a geological repository / the concept of geological disposal
- Impacts of a deep geological repository
- Host rocks especially opalinus clay
- Transports of radioactive waste
- Nuclear power in total, e.g. phase out of nuclear power

More general aspects of nationwide interests:

- Financial aspects
- Long term safety
- Marking
- The concept of geological disposal as such

One interviewee thought that the discussion in the public is highly influenced by the information given by BFE and Nagra.

It was mentioned that the public on the national level is not well informed about waste management whereas at the regional level issues related to deep geological disposal are discussed in more detail.

One interview partner raised the issue that the knowledge of the regional stakeholders in the selected regions is very different. Some regions especially those which were affected by the earlier siting approaches e.g. Zuerich North-East are well informed and have a strong mostly critical opinion.

As an option to improve knowledge on geological disposal BFE started trainings for interested stakeholders which comprise information about the Sectoral Plan as well as about technical and ethical issues.

The topics which are discussed in the media are according to one interview partner similar to the ones in the public. One interviewee said that the issues retrievability and safety are further topics of interest in the media. A lot of media reports are about the Sectoral Plan itself. In the reports the different steps of the process and the involved players are described in detail. Sometimes questions related to the geological underground or the timeframe are discussed. One interview partner acknowledged that the media reports are mainly objective and do not tend to spread opinions for or against disposal or specific sites.

The discussion in the *politics* is according to most interview partners concentrated on financial and safety aspects. According to one interviewee the budget that is being accumulated via the nuclear waste management and decommissioning funds may be insufficient as the calculations assumed an operational time of Swiss nuclear power plants of 60 years. In case of shorter operational times or higher dismantling costs - which have to be expected due to experience in Germany – the contributions to the funds had to be raised in order to cover future costs.

Other topics which are prevailing at the moment are the discussion which geological investigations are required at what stage of the process.

Asked about the topics which are discussed between *experts* the interviewees gave a wide spectrum:

- Feasibility of retrievability
- Access to the underground facility via shaft or ramp
- Communication in a stepwise process
- Canister material

Single interviewees added the following topics.

- Content of organic material in the waste (Experts claim that the waste needs to be thermally treated before packing.)
- Filling of open caverns especially the extended damage zone
- Gas formation
- Generation of heat

In the context of these issues it was also pointed out that not all of them are of relevance at the current stage of the site selection process.

Further aspects that were mentioned affect the implementation of the step-wise approach in practice: Agreements have to be reached on the appropriate level of knowledge that is necessary at the different stages to assure well-supported evaluations and decisions and to enable a well-founded comparison of the siting areas or sites.

- *On the main prevailing socio-political challenges*

According to the interviewees a big socio-political challenge is to guarantee a fair site selection process. According to one interview partner the public fears that the principle of safety first may to some extent be jeopardised by the level of public acceptance that can be reached in the different regions.

People will feel more and more affected when narrowing down the suitable sites. One interview partner pointed out the problem that most people are only willing to participate when they start feeling directly affected. But they are not interested to participate at the beginning when the process itself is tailored. That means that at the beginning of the process a discussion with the directly affected public is not possible, because they are not yet known. The discussion is done by representatives of the public.

According to one interviewee the proposal of suitable regions for the surface facilities has led to the so called NIMBY-syndrome. As one interviewee explained that most cantons are willing to participate in a productive way in the process, but some are sceptical to host the deep geological repository. Some argue that they already bear the risks of the nuclear power plants or most of the burden of big infrastructure facilities like airport, railways etc. Others claim that they do not have benefited from the nuclear power plants and therefore do not see the duty to host the deep geological repository. Such discussions in the stakeholder committees especially the regional conferences are considered to be very important.

Other important socio-political challenges are according to one respondent how deep geological disposal can be realised in a way which is fair for the current generation and future generations. This affects questions of retrievability and marking of geological repositories.

- *On open technical challenges*

The point of views of the interviewees on the open technical challenges differed. Some thought that only few technical questions are open According to them the recent knowledge is adequate for the present stage of the process. Open points concern in their view mainly the concept and layout of the underground facility e.g. the decision if the waste is disposed of in galleries or boreholes. Other questions which are discussed at the moment are which geological investigation is required at what stage.

Further technical challenges that were mentioned by one or another interviewee cover a wide spectrum:

- Monitoring of the repository during operation and the appropriate time for closure in the light of the demands for monitoring
- Gas formations
- Selfhealing of the opalinus clay
- Effects of construction work on the geological characteristics
- Natural events such as earth quakes, glacial erosion
- Technical feasibility of the concept

But there was no clear tendency traceable which of these issues constitute the major challenges from the point of view of most interviewees.

According to one interviewee there is a dilemma because the deeper the geological repository is built the safer it will be but it will be more difficult to monitor it.

- *On the connection of the existing socio-political and the technical issues*

One interviewee said that the connection of socio-political and technical issues is at present not considered adequately and no one does research in that field.

Some criticised that the public is only involved in less important questions like the siting of surface facilities but it has no right to discuss the important safety relevant issue. Issues like the underground facility which are related to long-term safety aspects are only discussed between experts without

involvement of the public. One thus might conclude that involvement mainly has the goal to gain acceptance.

Others saw a connection of socio-political and technical issues in the challenge to have an understandable communication. The language has to be easy and understandable for everyone without oversimplifying the content. One aspect for such a communication is to talk about what has to be known at what stage of the process. The different levels of knowledge are a big challenge for the site comparison.

One interviewee claimed that in the realization process of the deep geological repository both political aspects and technical aspects need to be combined. It was also mentioned as a problem that the BFE as the leader of the Sectoral Plan was more interested in political aspects and had little competence in technical questions. The competence for technical solutions on the other hand was with Nagra. This makes it difficult to combine both the technical and socio-political issues

The optimisation process of the project is also seen as an issue combining both technical and socio-political aspects.

Asking about the *main socio-technical issues* most interview partners outlined the following:

- Retrievability
- Marking
- Communication in a stepwise process/providing adequate information

Some added further issues like:

- Siting of surface facilities
- Closure of the deep geological repository
- Effects of public participation on the realisation of the “Safety first principle”: in this context the question of stakeholders was cited if a participatory approach may in future lead to an inadequate importance of regional acceptance that may impede the priority of safety in the site selection process.
- Requirement of long lasting decisions due to the big timeframe of the project
- Construction of a facility under consideration of intergenerational justice by constructing the facility in a way that avoids any undue burden for future generations.

Although there are significant differences between countries e.g. Switzerland has a direct democracy whereas Germany is a representative democracy most interview partner thought that the identified issues are not typical for Switzerland but are also relevant in the international context. But according to one interview partner participation issues can only be discussed in the national context. In Switzerland it is for example not foreseen to include a volunteering approach in the site selection procedure.

According to one interview partner there are various approaches of finding solutions to the socio-technical issues. For example there are different committees like the Technical Forum Safety in which both representatives of the society and technicians discuss such issues together.

Furthermore each regional conference has established an expert group “Safety”. Additionally the BFE finances an independent expert group which supports the cantons. Socio-technical issues have also been discussed in the process of building the regional conferences. In the trainings of the BFE ethical as well as technical aspects were addressed.

The interview partners had the following ideas for improvements:

One interviewee proposed to establish a committee similar to the former EKRA meaning an independent group highly motivated to work in a constructive process in which representatives of

the technical, the political and the ethical scene discuss together. According to him EKRA's work was very successful.

Some interview partners asked for an interdisciplinary research combining both socio and technical issues. One interview partner claims that socio-scientific research in the field of deep geological disposal has been insufficient so far. It could help to understand how big the challenges are.

Others explained that in order to establish an independent research, the research programme of the BFE was started. But BFE is responsible for socio-scientific projects whereas the Nagra is responsible for the technical projects. One interview partner claimed that an independent research in the technical field is required and proposed to establish a second independent research centre besides the Nagra with competence in technical questions as well. The advantage would be that there would be more dynamics and possible solution might be more creative. Another interviewee proposed to finance a free and open research for a period of at least 10 years to get an overview of relevant issues. This would allow the research also on more "exotic" topics which are recently not considered at all to be relevant, but which might change when gaining more knowledge.

One interview partner pointed out that there will be an increasing lack of professionals in the field of nuclear power and radioactive waste in the next years. This was fostered by the phase-out decision. The interviewee proposed to establish a new image of waste management by shifting it to the field of resource management and thus emphasising the creative aspect rather than the context of cleaning up the legacy of a phase-out technology.

Asked about the *important topics for the research in the field of radioactive waste* the interview partner named the following:

- Marking
- Canister material
- Evaluation of the process according to the Sectoral Plan during implementation

Some interview partners were of the opinion that socio-political research is currently focussed on acceptance aspects and that a shift of scope was necessary.

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ANNEX 1

List of questions for the interviews [Frageliste für semi-strukturierte Interviews, in German]

1. Was sind in Ihrem Land nach Ihrer Meinung die derzeit am meisten diskutierten Themen im Bereich der Endlagerung...?
 - In der Öffentlichkeit
 - In den Medien
 - In der Politik
 - Zwischen Fachexperten
2. Welche wichtigen gesellschaftlichen und politischen Herausforderungen bestehen derzeit?
3. Welche wichtigen technischen Herausforderungen sind derzeit offen?
4. Gibt es Verknüpfungen zwischen diesen gesellschaftlichen und politischen Herausforderungen und den technischen Anforderungen? Können Sie die Verknüpfungen/Auswirkungen beschreiben?
5. Was sind Ihrer Meinung nach die wichtigsten sozio-technischen Herausforderungen in Ihrem Land?
 - Aus der Literatur und der Verfolgung der aktuellen Ereignisse ergeben sich nach unserer Einschätzung auch folgende sozio-technischen Herausforderungen: Wie ist Ihre Meinung zu diesen Aspekten? Halten Sie diese auch für wichtige sozio-technische Herausforderungen?
 - Rückholbarkeit der Abfälle
 - Markierung
 - Verschluss
 - Ungleicher Kenntnisstand
 - Obertägige Infrastrukturanlagen
 - Wie ist Ihre Meinung zu diesen Aspekten? Halten Sie diese auch für wichtige sozio-technische Herausforderungen?
6. Sind dies auch international wichtige sozio-technische Herausforderungen oder handelt es sich um eine landestypische Herausforderungen? Wenn letzteres, warum hat dieses Thema in Ihrem Land eine so hohe Relevanz?

Mögliche Nachfragen:

 - Handelt es sich um kulturelle Gepflogenheiten? Liegt es am politischen Kontext? Basiert dies auf den ordnungspolitischen Zusammenhängen?
7. Welche Ansätze gibt es, sich mit solchen sozio-technischen Herausforderungen auseinander zu setzen? Gibt es positive Ansätze? Wo sehen Sie Verbesserungsbedarf?
8. Haben Sie Vorschläge, wie man mit diesen sozio-technischen Herausforderungen umgehen sollte?
9. Welche Auswirkungen hätte es Ihrer Meinung nach, wenn Ihre Vorschläge bei der Planung und Realisierung von Endlagern berücksichtigt würden?
10. Was sind Ihrer Meinung nach wichtige Themen in der Endlagerforschung?

11. Gibt es aus Ihrer Sicht Entwicklungen, sozialwissenschaftliche Aspekte in der Endlagerforschung verstärkt zu berücksichtigen?
12. Haben Sie weitere Anmerkungen?