



Who Decides What is Safe? Experiences from Radioactive Waste Governance in Switzerland

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7.1 Introduction

Switzerland is one of the countries that experienced failures in its original approach to identifying one or several sites for nuclear waste repositories. In consequence, the country initiated a new site selection procedure in 2008, based on a blank map. Since then, despite some delays, good progress has been made towards the goal of granting a general license for one or two deep geological repositories in 2031. So far, the different actors involved in the selection process have cooperated effectively and without major disruptions. Emerging conflicts can be solved in a way that does not threaten the implementation of the site selection procedure according to plan. Nevertheless, it is worth taking a critical look at some aspects of the process—especially with regard to future governance aspects.

In this contribution, we will show how the Swiss democratic model was modified for nuclear waste governance, how this affected the actors involved, and what role different actors play within the site selection process. This also includes a debate on how the participatory elements are integrated into decision-making,

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for example who is involved in what kinds of tasks and decisions, and how the borders are drawn between experts and the public, particularly with regard to the debate on safety. We will discuss how the actors communicate and interact along and across those borders. We draw conclusions about how successful the Swiss approach to decision making is in dealing with conflicts and moving towards safe disposal of nuclear waste. The results presented in this contribution are based on our research in several inter- and transdisciplinary research projects on nuclear waste governance. The focus lies on interactions and cooperation between the responsible collective actors.

7.2 Radioactive Waste Management in Switzerland

7.2.1 Origins of Waste and Interim Storage

Four nuclear power plants are currently in operation in Switzerland, Beznau I and II, Gösgen and Leibstadt. A fifth power reactor, Mühleberg, finally terminated its commercial operations in 2019 and is now being decommissioned. Today, the nuclear power plants produce around one third of the electricity generated in Switzerland (Swissnuclear, 2021). All nuclear power plants are predominantly owned by the public sector. This presumably promotes the perception of waste disposal as a collective task to be solved by Switzerland as a whole. After the severe Fukushima reactor accident in 2011, the Swiss government, the Federal Council (Bundesrat) and the Parliament decided that Switzerland should phase out the use of nuclear energy. However, the existing nuclear power plants may continue to be operated as long as they are safe.¹ New nuclear power plants can no longer be licensed, but this does not signify an absolute ban on nuclear technology.

The use of nuclear energy in Switzerland is controversial. In 2013, 57% of Swiss citizens were opposed to energy production by nuclear power plants (TNS opinion, 2013). However, about two thirds of the Swiss consider the nuclear power plants (NPPs) in their own country to be ‘safe’ or ‘rather safe’ (Swissnuclear, 2021). Various referendums calling for a phase-out or a faster phase-out of nuclear power have failed over the last twenty years, most recently the

¹A nuclear power plant is considered safe if the legal safety requirements are met. Demands on the implementation of the legal safety requirements are substantiated by the Swiss Federal Nuclear Safety Inspectorate (ENSI) in guidelines and, if necessary, in additional subordinate specifications.

“Atomausstiegsinitiative” (nuclear phase-out initiative). This wanted to ban the construction of new NPPs in Switzerland at the constitutional level and limit the operating lives of the five existing Swiss NPPs. In 2016, it was rejected by Swiss voters with 54.2% of the vote against it (DETEC, 2016).

The radioactive waste in Switzerland, especially the ca. 1500 m³ of high-level radioactive waste, originates mainly from the nuclear power plants. Medicine, industry and research account for about 30% of the total volume of low- and intermediate-level radioactive waste which amounts to 56,000 m³, including disposal containers (Nagra, 2022). Facilities for the conditioning and interim storage of the radioactive waste that is produced during operation are located at the nuclear power plants. A central interim storage facility, ZWILAG, accommodates all types of radioactive waste. Aside from storage buildings it encompasses a conditioning plant as well as an incineration and smelting plant. Waste originating from the medical, industrial and research sectors is stored temporarily in a federal interim storage facility. This facility is located at the site of the Paul Scherrer Institute (PSI), the largest research institute for natural and engineering sciences within Switzerland. PSI has also facilities for the treatment of its own radioactive waste and of radioactive waste from the medical, industrial and research sectors. The ZWILAG- and the PSI-sites are located in the immediate vicinity of each other in the canton of Aargau (ENSI, 2021b).

7.2.2 The Recent Evolution of Radioactive Waste Disposal

The Swiss governance ecosystem for the long-term management of radioactive waste has changed considerably over the past 20 years. The transformation started in 2000 with the societal and political agreement on the concept of deep geological repositories, as described in the final report of the Expert Commission on Disposal Concepts (Expertengruppe Entsorgungskonzepte für radioaktive Abfälle, EKRA) (EKRA, 2000).² This concept was novel at the time and contains specific features, like the so-called pilot repository, which are unique to Switzerland. Further, the original plan of the implementer, the National Cooperative for the

²Members of the EKRA discussed this concept with NGOs, industry and safety authorities and addressed their concerns before publication of the report. The report was widely acknowledged and the concept it described laid the basis for further planning activities in Switzerland.

Disposal of Radioactive Waste (Nagra), to start underground investigations for a repository for low- and intermediate-level waste at the Mount Wellenberg site had to be abandoned due to two cantonal vetoes against this endeavour. The agreement on geological repositories for high-level and low- and intermediate-level radioactive waste, together with the events at the Wellenberg site and other developments, paved the way for new nuclear energy legislation which went into force in 2005.

This legislation envisaged regulating the site selection procedure with a Sectoral Plan. A Sectoral Plan is an established spatial planning instrument of the Swiss Confederation (Kreusch et al., 2019; Jud, 2014), which is used for any activities affecting or altering space within federal responsibility. Other Sectoral Plans exist, for example, for transport infrastructure and transmission lines for electricity (ARE, 2021). Usually, they provide a framework and guidelines for the planning activities of the cantons and—in contrast to the Sectoral Plan for Deep Geological Repositories—do not entail additional participatory elements. At the same time, the lead management of the site selection procedure was transferred from the implementer, Nagra, to the Swiss Federal Office of Energy (SFOE) and thus to the public administration—a step that fostered confidence in the procedure among the Swiss population.

The conceptual part of the “Sectoral Plan for Deep Geological Repositories” (SFOE, 2008) entered into force in 2008. There, a step-wise site selection process is fixed, which aims at identifying one or several repository sites for radioactive waste produced in Switzerland in a transparent and comprehensible manner while ensuring safety and security (Hocke & Kuppler, 2015). Stage 1, the selection of suitable geological areas, was concluded on December, 1st 2011 when the Federal Council gave its consent to the result report issued by the SFOE. In stage 2, the public was invited to participate in the siting of the surface facilities. Further, the responsible actors had to select at least two sites that would be subject to extended exploration in order to identify suitable sites at the end of stage 3. Stage 2 was concluded in 2018. In September 2022, Nagra announced that a combined site in the siting area of Nördlich Lägern would be the safest option according to their current assessments (Nagra, 2022a). Stage 3 is expected to be concluded in 2031 with the approval of the Federal Council’s decision on the general licenses by Parliament and a possibly subsequent referendum (SFOE, 2008, see Fig. 3). After this, construction, operation and closure of the repository have to be decided upon and carried out.

7.3 A Federalist Governance Ecosystem

Switzerland has developed over centuries from a network of various alliances into a federal state whose national borders were internationally recognised in 1815. The political system dates back to the Federal Constitution of 1848. The federal state consists of 26 cantons. Each canton has its own cantonal constitution and its own legislative, executive and judicial authorities.

The federal structure of Switzerland is deeply rooted in the self-concept, the political culture and the legislation of the country (cf. for example Maissen, 2015). The cantons are responsible wherever the Federal Constitution does not explicitly delegate responsibilities to the Confederation. Therefore, the Confederation has a primarily coordinating effect in many policy areas. In the case of nuclear energy, the responsibility lies with the Confederation according to the Federal Constitution. Nevertheless, the cantons and regions are strong actors that clearly shape the process. Their influence on agenda setting, policy development and policy implementation is significant; in practice, the federal government cannot act without the cantons. In addition, direct democratic elements are implemented in Swiss political decision-making, which comprise for example the right to call for public votes on certain legislations.³ The Swiss governance ecosystem can only be understood if this specificity is taken into account. This characteristic is also referred to as multilevel governance, which implies that in governance in general the interaction between various levels of government—local, regional, national and international—may play an important role. For the analysis in this chapter, Switzerland's governance ecosystem therefore requires a subdivision of the political sphere into the level of the Confederation and the other two levels of government: the cantons and the municipalities (see Fig. 7.1). They are grouped together here for the sake of clarity (see also Fig. 7.2).

Over the course of time, the governance ecosystem established due to the enforcement of the Sectoral Plan has shown some dynamics that have helped to mitigate conflicts, but have also led to new conflicts emerging. In the following, we first give a short overview of the actors involved in the different societal domains, which form the governance ecosystem, to then analyse their interaction and dynamics.

³For detailed information on the Swiss democratic system see for example Linder and Mueller (2021).

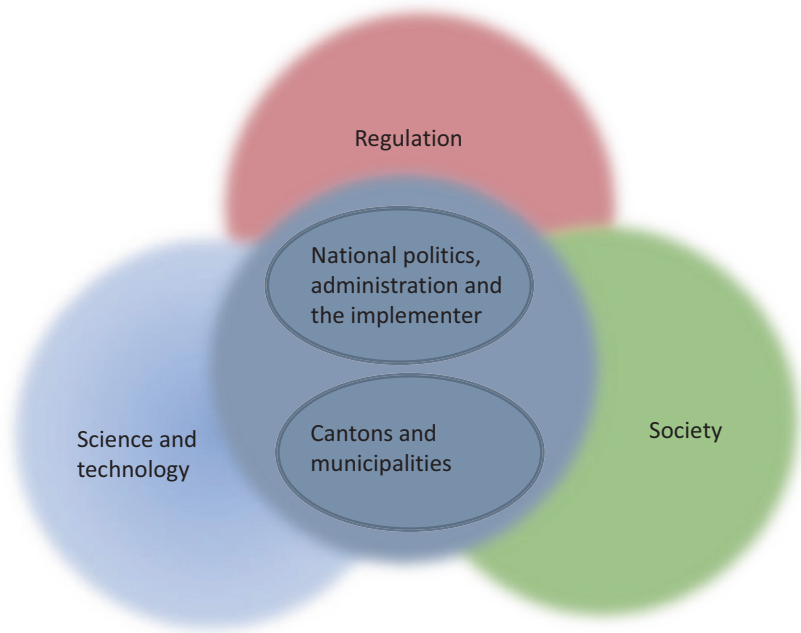


Fig. 7.1 The governance ecosystem framework for Switzerland. (Adapted from Kool et al., 2017)

7.3.1 Laws and Regulations

The main legal documents guiding nuclear waste governance in Switzerland are the Nuclear Energy Act (SNEA, 2021) and the Nuclear Energy Ordinance (SNEO, 2019), which entered into force in 2005. In the previously applicable Federal Act on the Peaceful Use of Atomic Energy (or Atomic Energy Act), radioactive waste, referred to there as residues, was mentioned only in passing (1959). In the present nuclear energy law three leading principles are stipulated (SNEA, 2021, Art. 30):

1. Radioactive substances shall be handled in such a manner as to ensure that as little radioactive waste as possible is produced.
2. All radioactive waste produced in Switzerland shall, as a general rule, be managed in Switzerland.
3. Radioactive waste shall be managed in such a manner as to ensure the permanent protection of humans and the environment.

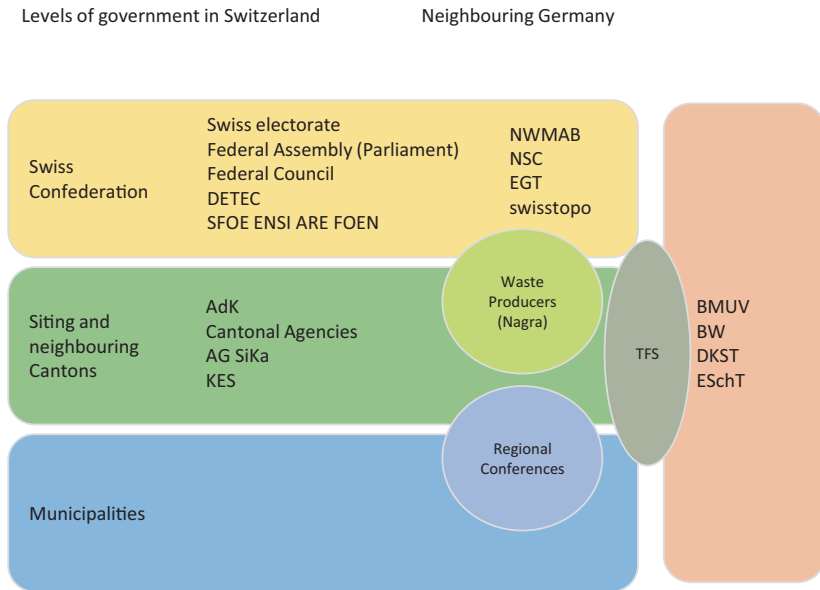


Fig. 7.2 Main institutions involved in the site selection procedure. (Adapted from SFOE, 2019)

AdK: Siting Cantons Coordination Committee

AGSiKa: Cantonal Safety Working Group

ARE: Federal Office for Spatial Development

BMUV: Federal Environment and Consumer Protection Ministry

BW: Federal State Baden-Wuerttemberg and its districts

DETEC: Federal Department of the Environment, Transport, Energy and Communications

DKST: German Coordination Office for Swiss Deep Geological Repositories

EGT: Expert Group on Deep Geological Disposal

ESchT: Expert Group Swiss Deep Geological Repositories

FOEN: Federal Office for the Environment

KES: Cantonal Expert Group on Safety

NSC: Nuclear Safety Commission

NWMAB: Nuclear Waste Management Advisory Board

SFOE: Swiss Federal Office of Energy

Swisstopo: Federal Office of Topography TFS: Technical Safety Forum

These principles do not differ substantially from the way the waste was handled before 2005. What is new is that they became legally binding. The implementation of the first principle can essentially be left to the waste producers, as it is in their own interest to keep the amount of radioactive waste that has to be disposed

of at high cost as low as possible. The second principle is sporadically challenged politically with ideas of disposing of radioactive waste abroad, but these ideas have so far never found significant resonance. The third principle is to be implemented sustainably with deep geological disposal. Further important principles are the ‘polluter pays’ principle, the prohibition of reprocessing spent fuel elements, and the explicit obligation to dispose of all types of radioactive waste in deep geological repositories.

The Federal Constitution of the Swiss Confederation states that the Confederation is responsible for legislation in the field of nuclear energy (Federal Constitution, 2021, Art. 90). This also includes the legislation on nuclear waste. In the Nuclear Energy Ordinance (SNEO), it is specified that the “federal government shall specify in a Sectoral Plan the objectives and criteria for the disposal of radioactive waste in deep geological repositories which are legally binding for the relevant authorities” (SNEO, 2019, Art. 5). The legal framework in Switzerland has remained stable since the new nuclear energy law came into force. The political hurdles for adjustments to the Nuclear Energy Act are high. There are currently no signs of changes in the coming years.

7.3.2 Population and Civil Society

In Europe, the Swiss case is often considered a special case from which it is not straightforward to draw lessons learned for other countries. The main reason for this is the Swiss model of democracy, which Linder (2004) classifies as “semi-direct”, and which is unique in Europe. Due to the direct-democratic elements in the political system, citizens entitled to vote play a particularly important role in political issues such as the disposal of radioactive waste. In common Swiss parlance, the community of those entitled to vote, is therefore also referred to as the sovereign («Souverän»).

When taking a closer look at the way decision-making processes take place in cooperation between the political and the public domains, it becomes clear that for example the Swiss electorate’s veto rights can fulfil a similar function as for example extra-parliamentary protests in representative democracies, such as Germany (Kuppler, 2016). At the same time, in view of the “participatory turn”, the Swiss political domain has the clear advantage of being familiar with consultations with a wide variety of actors in policy processes (cf. Linder, 2004; Sauruger, 2010; Linder & Mueller, 2017, 2021).

Representative surveys, for example based on the Eurobarometer studies, show that about half of the general population of Switzerland has a rather critical

and rejecting attitude towards the disposal of radioactive waste as it is planned today. The other half is more in favour of the disposal in deep geological repositories as it is planned currently. About 50% of Swiss citizens agree that deep geological disposal is the most appropriate solution for long-term management of high-level radioactive waste. At the same time, over 80% think that there is no safe way of getting rid of this waste (TNS opinion, 2013). The proportion of those who would take a negative view of a deep geological repository in the vicinity of their own place of residence declined from 2012 to 2018. In 2018, it was around 65% (SFOE, 2018b, p. 15).

There are several citizens' initiatives in Switzerland actively lobbying against the construction of a nuclear waste repository at specific sites or, more generally, advocating for modifications in the site selection process.⁴ The larger environmental NGOs, such as the Schweizerische Energie-Stiftung or Greenpeace, seem to not consider nuclear waste as one of their main fields of activity as no larger campaigns on this topic could be observed in Switzerland. One reason for this is that Switzerland is now phasing out nuclear energy. As the use of nuclear energy—due to the danger of a strong uncontrolled nuclear reaction—is associated with a far higher disaster potential than the disposal of radioactive waste, these NGOs have already reached their most important goal. Another reason might be that the path currently being followed for disposal can build on a broad consensus among the population and politicians (see below). Therefore, the opportunities to mobilise opponents are limited.

In the past, the citizens' initiatives have regularly organized protest activities. Several of their members also participate in the regional conferences ("Regionalkonferenzen"), which are the official participatory bodies in the potential siting regions. The motivations of the various NGOs have not been well studied. It is assumed that both the concern not to have a repository in one's own neighbourhood (NIMBY arguments, e.g. Kraft & Clary, 1991) and values that differ from those of other actors play a role.

⁴Those include for example KLAR! Schweiz ("for a life without atomic risks", <https://www.klar-schweiz.com/>), LIKE Weinland ("no repository in the Weinland", <http://www.likeweinland.ch/go/>), KAIB ("no nuclear waste in Bözberg"), NOE ("Niederamt without repository", <http://www.kaib.ch/>), LOTI ("Nördlich Lägern without repository", <https://loti2010.ch/>). All slogans in brackets were translated by the authors (see also Alpiger 2019: 191).

7.3.3 Politics and Administration I—Cantons, Municipalities and Regions

Socio-economic issues associated with a deep geological repository affect not only the siting municipality, but a specific region. This also applies to other issues, such as the transport of radioactive substances or the long-term safety of the repository.

Therefore, regional participation is a pivotal element of the Sectoral Plan. The core of regional participation is the regional conferences, founded in 2011. They consist of around 90 to 100 members from diverse backgrounds, such as local stakeholder representatives, civil society representatives and representatives from the German communities bordering the potential repository sites. In stage 2 of the Sectoral Plan, they expressed (among others) their views on where the facilities above ground of a deep geological repository should be built. In stage 3, they are involved in the optimisation of these infrastructures. The regional conferences also discuss compensation and measures that can support the desired development of the region (SFOE, 2023).

From the outset, the participatory elements in the Sectoral Plan process were understood as complementary to the democratic processes and instruments (Jordi, 2006). In the conception of the Sectoral Plan process however, the intertwining of democratic and participatory structures and processes elicited crucial questions, which had to be discussed and working compromises had to be found.

One adjustment was the formation of panels on safety issues within the regional conferences (“Fachgruppen Sicherheit”). The Sectoral Plan assigns tasks to regional participation primarily in the area of the design and placement of surface facilities and the socioeconomic impacts of deep geological repositories (SFOE, 2008, p. 34f). In addition, the regional conferences decided to also set up safety panels to examine safety issues (c.f. for example Standpunkt, 2012, p. 7). By installing these panels, members could allocate funds to invite experts of their choice and had the right to read and comment on technical reports. Before the installation of the panels, no public participation on safety issues was planned by the responsible authorities.

With the start of stage 3, some of the tasks of the regional conferences were concluded and new ones were added. As the level of concretisation increased, certain communities within the potential siting regions became more directly affected than others. The evaluation process of the application for the general license is work in progress and needs to be well prepared. This applies particularly to the

participation of the regional conferences and the involvement of the selected sites (Jordi, 2021).

Even though the regional conferences are contributing to the site selection process in a constructive manner, conflict lines between the local actors represented in the regional conferences can be observed. Indemnities (“Abgeltungen”) are payments that the siting region receives for performing a national task. Compensation (“Kompensationen”) is used to compensate for negative impacts that arise, for example, during the construction of a deep geological repository. There are various ideas on the use of the indemnities. Therefore, in future, a newly created organisation managed by the siting regions will decide on the use, distribution and management of the payments. Those communes that are designated as infrastructure communes in the Federal Council’s decision at the end of stage 3 should be able to use part of the compensation amounts freely (SFOE, 2021).

With the enforcement of the Nuclear Energy Act (SNEA, 2021), the role of the siting region in decision-making processes has changed fundamentally. The veto right, as it was established at cantonal level before the enforcement of the new nuclear energy legislation, can be considered an institutionalized link between the political sphere and the electorate in the Swiss democratic system, which fulfils the same function as public protests or law suits in other democratic systems (Kuppler, 2016). After the events at the Mount Wellenberg- site, political actors were concerned that with the cantonal veto right in place, no repository will ever be built in Switzerland (Kuppler 2017). If suitable sites for deep geological repositories were blocked by cantonal decisions, this could have serious consequences because the radioactive waste could not be disposed of in a sustainable manner (c.f. among others, Nuklearforum, 2002). Finally, the cantonal veto right on underground investigations was abandoned in favour of an optional national veto right on the general licence for a deep geological repository (Alpiger, 2019, esp. p. 53; Krütli et al., 2010). This political compromise has endured from 2005 to the present day, but has recurrently been the subject of criticism (cf. for instance SFOE 2018a; UREK-N, 2013). In the consultations that accompanied the development of the Sectoral Plan, concerns were expressed that the envisaged role of the regions in the selection process and their possibilities to raise issues of their interest was too limited. The reasons for this concern were the abandonment of the cantonal veto right and the transfer of responsibility for parts of the general licence application process to the national level. Before the enforcement of the Sectoral Plan, the cantonal authorities were responsible for water permits, for example. Those concerns resulted in the installation of a Committee of the Cantons (“Ausschuss der Kantone”) (Kuppler, 2017).

7.3.4 Politics and Administration II—National Politics, Administration and the Implementer

The general political consensus on the Sectoral Plan process in Switzerland has been strong since its inception in 2008. Political initiatives in both chambers of Parliament cover a wide range of specific issues, concerning among others safety, participation, governance and the financing of the disposal of radioactive waste. Since the start of the site selection process, only criticism of the lack of independence between the Swiss Federal Nuclear Safety Inspectorate (ENSI) and the National Cooperative for the Disposal of Radioactive Waste (Nagra), emerging in 2012 after the serious reactor accident at Fukushima, has elicited a significant political and media response (Curia Vista, 2021). Fundamental criticism of the way Switzerland is managing its radioactive waste is not voiced.

In Switzerland, the ‘polluter pays’ principle applies to the disposal of radioactive waste (SNEA, 2021 Art. 31). Therefore, Nagra, as an organisation founded by the waste producers, is responsible for the safe long-term disposal of the waste (Nagra, 2021a). Nagra proposes geological siting regions and sites, submits an application for a general license (SFOE, 2008, p. 77) and is later in charge of building and operating the deep geological repositories. Nagra can be understood as a boundary organization between the political-administrative and science and technology domains. On the one hand it is part of the public sector, acting as an implementer of radioactive waste policy. On the other hand, it is also part of the sphere of science and technology as it carries out applied research and is responsible for scientific and technical aspects of the site selection process and the following steps of disposal (as described in Sect. 3.4 on science and technology below).

The cost of disposing of Switzerland’s radioactive waste is estimated today at approx. CHF 22 billion (approx. EUR 22 billion). A waste disposal fund was created in 2000 to finance the disposal of radioactive waste. Together with the decommissioning fund, which was established in 1984, they constitute the Decommissioning Fund for Nuclear Installations and Disposal Fund for Nuclear Power Plants (STENFO). The bodies of STENFO are the administrative commission, the administrative office and the statutory auditors. The members of the administrative commission and the statutory auditors are appointed by the Federal Council for a term of office of four years (STENFO, 2021).

The political and administrative institutions involved in nuclear waste governance have remained more or less the same since the introduction of the Sectoral Plan in Switzerland, but their role has changed over time. As described in Jost (2012) and Hocke and Kuppler (2015), the central political and administrative

actors in Switzerland on the national level are the Swiss Federal Office of Energy (SFOE) and the Swiss Federal Nuclear Safety Inspectorate (ENSI), the Federal Council, and Federal Department of the Environment, Transport, Energy and Communications (DETEC). Several other public institutions bear responsibility for specific topics in the site selection process, supporting the central actors with their expertise. Examples for such institutions are the Federal Office for Spatial Development (ARE) or the Federal Office for Environment (FOEN). In addition, there is a broad network of actors who help to shape the process. They have different responsibilities and different degrees of influence (see Fig. 7.2).

The SFOE has the important role of ensuring that the Sectoral Plan is put into practice in a high-quality manner. The SFOE takes the lead in the site selection procedure and is responsible for centralised operational and administrative activities (SFOE, 2008). Next to overall coordination, this includes the setup of the regional participatory processes. Other federal actors, such as ENSI and ARE remain fully responsible for their specific tasks within the site selection process. ENSI reviews and assesses safety aspects. This includes evaluating applications and reports issued by Nagra as part of the site selection procedure regarding safety issues.

A special aspect of the SFOE's task fulfilment is that a number of active politicians from the Social Democratic Party took and still take leading roles in the site selection process. These individuals bring political experience to the site selection procedure and—due to their specific political orientation—also a particularly good understanding of the concerns of individuals and organisations critical of nuclear energy. The fact that the political orientation of representatives of the SFOE has never played a significant role in public discourse is probably due to the fact that the Swiss political system is generally very consensus-oriented, and most politicians, even the members of both chambers of the Swiss parliament, exercise their mandates in part-time.

In the international context, the Nuclear Safety Commission (NSC) has an exceptional function. This commission consists of seven part-time members who are experts in areas of science and technology that are relevant for nuclear safety. In the field of radioactive waste management, the NSC examines fundamental questions of nuclear safety and issues statements to the licensing authorities. Politically, this commission plays an important role in Switzerland as a second-opinion body, which ensures an independent quality control for the supervisory authorities.

In the Sectoral Plan process, it became apparent early on that many of the potentially suitable sites are located close to the German border for geological reasons. Therefore, German administrative units, municipalities, NGOs and citizens were involved in the Sectoral Plan at an early stage. Communication

between representatives of both countries proved challenging at times but has improved over time (cf. for example Besmer, 2021). Challenges are mainly encountered in the areas of political participation, legislation, competences of the authorities and at the political-cultural level. For example, it became clear that participation processes must be embedded in the respective structurally pre-determined political processes in both Switzerland and Germany. Parallel structures must not be created that compete with the established political structures. Because the disposal issue has a different status in Germany and a greater potential for conflict than in Switzerland, the Swiss authorities must adapt their conflict management accordingly (El Mohib, 2010).

7.3.5 Science and Technology

Nagra carries the main responsibility for conducting the research, investigations and development needed for ensuring and assessing the safety and feasibility of the deep geological repositories. In addition, ENSI and SFOE conduct their own regulatory research. While ENSI invests in research concerning the safety of radioactive waste management—sometimes embedded in international co-operations (ENSI, 2021a)—SFOE commissions research in the social sciences and occasionally also in the humanities, although to a very limited extent (AGNEB, 2019). This applied research is directly related to the supervisory tasks of both institutions.

Fundamental research on radioactive waste management is conducted at several universities and university-related institutions. The PSI, with its competences in natural and engineering sciences, plays a major role in this. Generally, there is a strong emphasis on natural science research in Switzerland. Fundamental or applied fundamental research on societal aspects of the management of radioactive waste is currently rather marginalized (for one of the rare exceptions see Alpiger, 2019). One explanation for this is that problems related to the management of radioactive waste in Switzerland are solved pragmatically, so far successfully, and—following an internalised and lived principle of subsidiarity—at the lowest possible societal level.⁵ The perceived need for social science reflection, articulated e.g. in the context of the Sectoral Plan, is correspondingly low. Social

⁵For example, the decisions for a repository in clay in the deep underground and for a site close to the German border in the upper Rhine valley find general acceptance. Other concepts, such as the “Guarding Concept” (“Hüte-Konzept”) or maintenance free final disposal are currently not debated.

science studies seem to be noted by implementer and regulator, but exert little (visible) influence on disposal structures and processes.

Further, a number of consultants and consultancy agencies are involved in the site selection process. They usually answer to tenders on specific topics like studies on the socioeconomic consequences of disposal facilities, or carrying out and evaluating deep drillings.

7.3.6 Interactions Between the Spheres

Nuclear waste governance in Switzerland is highly influenced by interactions between the different spheres. The site selection process as described in the Sectoral Plan as a whole can be interpreted as a result of such interactions. As is customary in Switzerland, in the preparations for the Sectoral Plan, a variety of actors were consulted in different ways. Among others, the SFOE conducted focus groups with interested citizens (ISOPUBLIC, 2006). A hearing was organized, in the course of which public actors could hand in their statements and members of the SFOE exchanged views in person with representatives of central stakeholder groups, such as local mayors. These activities led to important adjustments in the Sectoral Plan as described above, which increased its acceptability to a variety of actors (Kuppler, 2017).

A central platform for actors and stakeholders is the Technical Safety Forum (TSF), chaired by the Swiss Federal Nuclear Safety Inspectorate (ENSI). The TSF receives, discusses and answers questions from the public about technical safety aspects. The questions and answers are posted on the Internet after replies have been given. In the TSF, representatives of the federal administration, cantons, communes, communities in neighbouring countries, NGOs, the interested public and others are gathered (TSF, 2021).

The implementer and regulator in Switzerland collaborate intensely with scientific institutions. Every five years, according to Art. 52 of the Nuclear Energy Ordinance, Nagra has to submit its waste management programme. This waste management programme is associated with a research, development and demonstration plan (Nagra, 2016). Both programmes are reviewed by ENSI and SFOE, which also monitor compliance. The review makes it possible to better coordinate the research programmes of implementer and regulator. It also gives the authorities, mainly ENSI and SFOE, the opportunity to bring up their research requirements at an early stage.

With the progress of the Sectoral Plan, new questions move into focus. If Switzerland wants to continue the transparent and inclusive pathway it entered

with the Sectoral Plan, discussing and finding an answer to those questions well before they become acute would be key. None of the questions can be classified as belonging in one sphere only. Rather, they need to be answered in close cooperation between the spheres (cf. Fig. 7.1). A particularly important question is what requirements must be imposed on the general license for a repository. This question touches the legal sphere, as laws and regulations have to be adhered to, especially with regard to safety and security of the planned repository. It is also a political question, insofar as the Federal Council and the Parliament decide whether the general license is granted. This means that those political bodies—with the support of the federal administration—have to decide whether in their view one or two safe and secure repositories can be built at the suggested site or sites. It is also a question that touches the public sphere, as an optional referendum can be held on the Parliament's decision if sufficient persons or cantons demand it. It concerns the regional, cantonal and community levels because these levels are most directly affected by the impact of granting a general license. And it is of course also a scientific question, as issues of safety, security, feasibility etc. require scientific assessments.

7.4 Current Topics in Nuclear Waste Governance

The existing governance ecosystem in Switzerland is influenced by further progress on the path of disposal and challenged by current debates that can affect nuclear waste management.

7.4.1 Sectoral Plan—and What Next?

Current issues in radioactive waste management in Switzerland are primarily determined by the status of the site selection procedure. As mentioned above, Nagra has submitted a site proposal in September 2022 (Nagra, 2022a). The sites not included in this proposal are put on hold, i.e. no further investigations are undertaken at these sites for the moment. If the site proposed by Nagra should for some reason prove unsuitable, they can re-enter the process. The evaluation process of the following application for a general license needs to be well prepared. This applies particularly to the participation of the regional conferences and the involvement of the communities where those selected sites are located (Jordi, 2021). Presently pertinent questions are

1. How will Nagra's siting proposal be received in the affected region—and in the regions that have been put on hold in the long-term?
2. How will the mode of governance change in the period between 2022 and the 2030s when the final decision on a general licence application is made? Adaptations can become necessary, for example, because new issues that already refer to the construction and operation of a repository require the inclusion of new competences and responsibilities.
3. The general licence application and the application for determination of a site in the Sectoral Plan are reviewed by the federal authorities. Will they and will the Federal Council and Parliament approve the site and the general licence application? Will the optional referendum that comes at the end of the Sectoral Plan process result in the site being accepted and a general licence being granted to Nagra? What happens if the general licence application is rejected by the electorate?
4. How to continue with public participation after a general license has been granted to Nagra?

Nagra expects to be able to start construction of a repository for low- and intermediate-level waste in 2045 and its operation in 2050. From 2053, the part of the combined repository for high-level radioactive waste will be built and should be in operation from 2060. The entire repository is to be closed at the end of an observation phase, the duration of which is open and which will be terminated by a political decision. Nagra supposes that the repository will be closed around 2125. Then it can be released from nuclear energy legislation. Nagra will have fulfilled its task and can be dissolved (Fig. 7.3).

During this process, the governance ecosystem will have to adapt to additional requirements and new developments. Switzerland benefits from its experience in handling major projects that take decades to complete, such as the New Railway Link through the Alps (NRLA), the planning for which began in 1986 and whose implementation is still in progress. Parts of the NRLA, such as the Gotthard Base Tunnel, took 17 years to build. It can be assumed that over time other pressing political challenges, such as climate change, will bind more resources and take up more space in the political and public debate. At the same time, once a siting decision has been taken and if construction and operation of the repository do not cause any major accidents, the population and politicians will increasingly perceive the nuclear waste disposal project as a “normal” large-scale project that requires negotiations and participation, but does not give rise to fundamental or fierce societal controversy.

Time plan for the combined repository

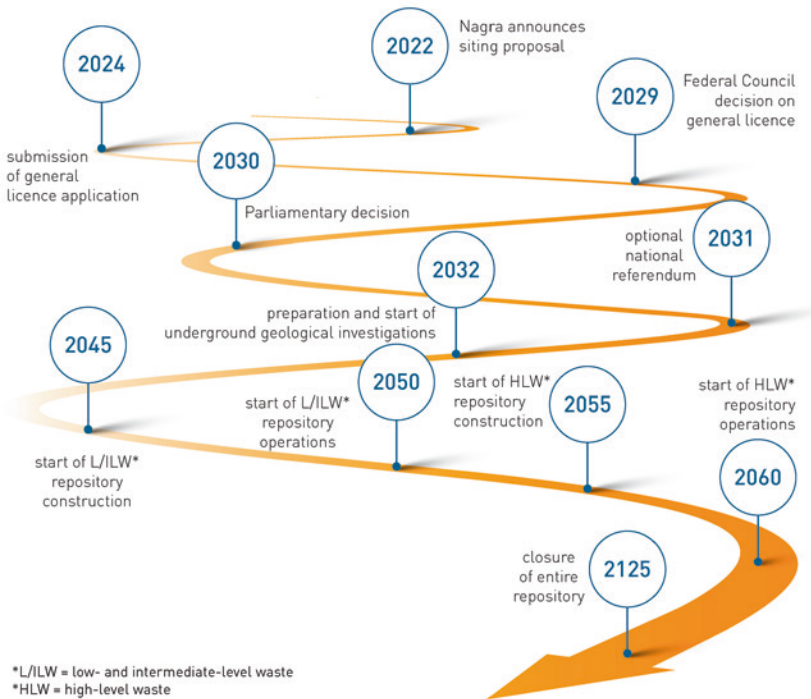


Fig. 7.3 Time plan for a combined repository in Switzerland (Nagra, 2021b, date for start of HLW repository corrected by Nagra June 2022)

However, the further procedure is accompanied by some interesting questions that must be answered by collective actors, such as the communication with future generations: The Nuclear Energy Ordinance (SNEO) obliges the owner of a deep geological repository to “compile documentation that is suitable for securing information about the repository over the long term” (SNEO, 2019, Art. 71). This documentation has to be handed over ultimately to the Federal Department of the Environment, Transport, Energy and Communications (DETEC) (SNEO, 2019, Art. 71). The SNEO also states that the owner must ensure a permanent marking of the repository (SNEO, 2019, Art. 69). Representatives of Nagra and the SFOE participate in international bodies on both issues, for example in the

OECD's Nuclear Energy Agency (NEA). However, no concrete ideas have been presented yet. Following the guideline of the Swiss Federal Nuclear Safety Inspectorate (ENSI), "a concept for permanent marking of the deep geological repository has to be submitted with the construction license application. The permanent marking concept has to be specified in concrete terms in subsequent licensing steps" (ENSI, 2020, p. 7).

7.4.2 Looming Debates

Debates that are already looming could intensify in the future and affect the disposal of radioactive waste. They address for example the following topics:

Dealing with insights from nuclear waste disposal in neighbouring countries

So far, Switzerland is one of the countries worldwide whose disposal programme for high-level radioactive waste is most advanced. Nagra and the Swiss authorities have become accustomed to receiving international visitors interested in the "Swiss model" and to presenting their solutions as exemplary at international conferences. Against this background, the disposal programme in France, which is also at an advanced stage, and the site selection procedure underway in Germany, present entirely new challenges. The larger neighbouring countries maintain programmes of research and development that exceed those of Switzerland. Moreover, France and Germany are currently also gaining experience with participation processes. This means that Switzerland can no longer sell itself as a role model in the long run, but must face the challenges that come with the fact that different, or even better, solutions may be found elsewhere and fuel the discussion on the "right disposal solution" in its own country.

The resurgent use of nuclear technologies

Currently the Nuclear Energy Act stipulates that "The granting of general licences for the construction of nuclear power plants is prohibited" (SNEA, 2021, Art. 12a). However, the Swiss government and Parliament stated that this prescription does not imply a ban on nuclear technology (Swissnuclear, 2019, p. 3). The debate at the World Climate Summits (2021 in Glasgow and 2022 in Sharm el-Sheik) on whether the European Commission should classify nuclear power as a sustainable source of energy and thus encourage future investment in this area, as well as global investment in new small modular reactors, put the rejection of nuclear power in Switzerland into perspective. Extensions of the operating lives of the newer nuclear power plants are already being examined (Meier, 2021), and Swiss media

are taking up the debate on the climate friendliness of nuclear power plants. The current broad social consensus on the disposal of high-level radioactive waste in Switzerland is closely linked to the decision to phase out the use of nuclear energy. Extensions of operating lives or even decisions to build new nuclear power plants could threaten this consensus. The fact that Switzerland, with the European Organization for Nuclear Research (CERN), PSI and École polytechnique fédérale de Lausanne (EPFL), is home to nuclear research facilities gives a particular boost to ideas for new nuclear applications (cf. for example, Transmutex, 2021).

International solutions for the disposal of radioactive waste

Joining an international project or an already existing solution for the disposal of radioactive waste abroad, is a recurrent topic in the political debate in Switzerland (Curia Vista, 2021). If a convincing solution for a joint disposal facility were to emerge in Europe or outside, this would certainly lead to substantial discussions on whether Switzerland should and could join such a solution.

7.5 Conclusions on the Future Governance Ecosystem

7.5.1 Consensus Through Complexity

The governance ecosystem for radioactive waste disposal in Switzerland is complex. The site selection procedure, following the Sectoral Plan, brings together actors with various scopes of responsibility and at different levels of government, institutions with decision-making powers and advisory bodies, science and technology, and a population that is used to having a political say. Prima facie this system raises questions including:

What happens if the Swiss Federal Nuclear Safety Inspectorate (ENSI) and the Nuclear Safety Commission (KNS) disagree in their technical assessment of the proposed repository site for the Federal Department of the Environment, Transport, Energy and Communications (DETEC)? Who is to take on the role of arbitrator here? DETEC does not have the scientific and technical expertise to fulfil this task (IRRS, 2012). Nagra, the implementing body, is largely owned by the cantons. At the same time, the potential siting cantons are following the site selection procedure with a critical eye.

A second look, though, shows that this governance ecosystem is very well adapted to the specific political and cultural environment of Switzerland. The Swiss Federal Chancellor put it this way: “What makes Switzerland special is how

we deal with political power. We are world champions in fragmenting power. In restraining and keeping a check on power” (Thurnherr, 2018). In a political culture that is geared towards consensus and consultation with all potentially affected parties, the interaction of many partners with different interests is well-rehearsed. At the same time, the established political culture of consensus and consultation ensures that the Sectoral Plan process functions so far successfully despite the large number of actors involved, and their complicated and not always clearly regulated interactions. Therefore, a general lesson that can be drawn from the Swiss case is that good integration into the specific political culture of a country with a functioning system of checks and balances is both necessary and rewarding.

However, the so far favourable site selection process in Switzerland does not guarantee a smooth and successful continuation in the future. The interaction of all participants must be permanently supported and promoted with great effort, so far especially by the leading SFOE. And ultimately, it is the Swiss electorate that has the say. In the 2030s, Swiss citizens could reject the results of an elaborate site selection procedure that took more than twenty years. Only then will it become clear whether the site selection procedure was ultimately successful. Whether the optional referendum has an enabling effect on the current process is an open question, due to the fact that on the one hand it will be a national referendum that does not give the communities at the selected site any particular veto rights, but on the other hand the national public could sympathize with the host community if they feel that it was not fairly treated. The further steps on the path to deep disposal involve other actors and require new participation procedures. Hence, sustained efforts and significant resources are required over a long time period.

7.5.2 Pragmatism as a Virtue and a Limitation

The relaunch of the search for sites for deep geological repositories in Switzerland at the beginning of the 2000s started with a pragmatic compromise. The newly developed concept of controlled long-term geological disposal combined the final disposal of radioactive waste with control and reversibility. Thereby it met the demands of both advocates of permanent surface disposal and proponents of a final repository. Another example of pragmatism is the Sectoral Plan. For deep geological repositories no specific political instrument for site selection was developed, but it was adapted from an already established instrument in spatial planning. Pragmatism can also be seen in the composition of the regional conferences: The majority of delegates to the regional conferences are members

of already existing institutions such as municipalities, regional planning authorities and stakeholder organizations. In addition, representatives of the population can apply to the regional conferences for membership (SFOE 2018c, p. 17). Stakeholders include, for example, regional businesses, agriculture and environmental organisations.

Throughout the Sectoral Plan process, numerous compromises were reached at various levels on topics such as the specific composition of the regional conferences (Planval, 2014, p. 38), the selection of possible siting areas (SFOE, 2018d, p. 9) or even the weighting of flight paths for the safety of surface facilities (Regionalkonferenz Nördlich Lägern, 2013, p. 20). In several cases, however, conflicts emerging within the governance ecosystem have not been resolved in a way that resulted in agreement among all actors involved. Rather, a working compromise has been found that made it possible to proceed with site selection even if the conflict has not been resolved. One example is the debate on whether the abandonment of the veto right at cantonal level was compatible with the Swiss democratic tradition. While no agreement was found, the Sectoral Plan—with its promise of a high degree of transparency and cooperation between the responsible actors at national level, the regional and local authorities as well as the general public—serves as a working compromise in this case.

A downside of pragmatism is a lack of independent applied fundamental research on disposal, especially in the field of social sciences. What has not been addressed so far is, for example, a sketching of the societal resources required to carry through technically demanding monitoring activities, interpret the data collected and take appropriate decisions based on the interpretation. Monitoring and retrievability are socio-technical concepts that require knowledge, skills, financial resources and appropriate decision-making structures—possibly over a long period of time (Hocke & Kuppler, 2019). A forward-looking evaluation and discussion of needs and requirements therefore seems appropriate.

Limits of pragmatism are also revealed by the superficially purely technical question of what kind of repository should be built: a single repository for high, low- and medium-level radioactive waste, or two separate repositories, one for high-level waste and one for low- and medium-level waste. A combined repository would be an efficient solution in terms of the effort required for licenses, compensations, construction and operation, monitoring during the observation phase, marking of the repository, closure etc. On the other hand, a combined repository poses higher safety requirements, for example with regard to potential interactions between the different types of waste or to operation during storage of the wastes. In this context, the questions, “What does the safety, we strive for, look like?”, and “How safe is safe enough?”, become highly relevant. The

central Swiss guiding principle, “Safety First”, does not answer how conflicting goals regarding safety should be handled. This also applies to the question of the extent to which compromises in the operational and long-term safety of the repository may be accepted in favour of monitoring in the observation phase, which reduces uncertainties about the development of the deep geological repository. There remains a lack of concrete guidance regarding research needs on, e.g. environmental protection associated with a repository, economic costs of different solutions, and assessment tools regarding safety and side effects.

It is possible that more fundamental reflections on this topic in other countries could reflect back on the Swiss procedure and call into question what has already been achieved. However, due to path dependencies, the hurdles for adjustments in later phases of disposal are very high. It remains to be seen whether accompanying research will play a greater role in the future of the Swiss governance ecosystem than it has to date. In our view, accompanying research is an essential element of any well-functioning governance of radioactive waste management.

7.5.3 Safety as a Socio-Technical Concept

Among the issues affecting several or all of the five spheres, safety plays a pivotal role. The Sectoral Plan sets the focus on safety, “with land use and socio-economic aspects playing a secondary role” (SFOE, 2008, p. 5). What does this mean in practice? Basic requirements for the safety of deep geological repositories are laid down in the nuclear energy legislation. These requirements are specified by ENSI in guidelines (especially ENSI, 2020) and other documents (e.g. ENSI, 2010). However, since Nagra, the implementer, bears the main responsibility for the safety of the deep geological repositories, the requirements of the supervisory authority are generally limited to concise, basic specifications. The Sectoral Plan stipulates that Nagra (“the waste producers”) evaluates the proposed geological siting regions and sites, particularly with respect to safety in accordance with the requirements of the Sectoral Plan and the relevant legal provisions (SFOE, 2008, p. 78). The safety authority ENSI (Swiss Federal Nuclear Safety Inspectorate) “reviews and evaluates the siting proposals of the waste producers from a safety viewpoint and advises the SFOE on safety issues” (SFOE, 2008, p. 27). Is it, therefore, Nagra that has to prove the safety of their repository plans and ENSI that has to evaluate this proof of safety?

In the Swiss process, the main responsibility for defining what is safe lies with the scientific and technical experts. Once they have demonstrated and assessed

the safety aspects in the application for a general license, the question of what is safe is handed over to the political sphere: The Federal Council and the Parliament decide upon this question as part of their decision on the granting of the general license. However, experience shows that the political institutions rely significantly on the judgement of scientific and technical experts when deciding on topics that touch the safety and security of nuclear installations. But: Safety and security are socio-technical constructs. This implies that public institutions and authorities together with the political and juridical spheres cannot define safety independently of the public debate.⁶ Civil society and stakeholders in Switzerland are part, or are actively demanding and working towards becoming a part, of the process of developing a shared interpretation of safety and security—a process that could be characterized as co-creation in decision-making. Should not responsible authorities and scientists therefore put questions of safety and security more actively forward for debate by the public? The sphere of public administration deals with such boundary questions by realizing a high degree of transparency and demanding the same from the other actors involved in the Sectoral Plan, such as Nagra and the regional conferences.

Currently, cantons, municipalities and regions, the Swiss population and civil society have a certain but limited influence on safety-related decisions. The cantons maintain their own working group on safety and an expert group on safety. These groups assess application documents which are submitted by Nagra, as well as other important information for the attention of the Committee of the Cantons. The regions enforced the implementation of safety panels of the regional conferences during the course of the Sectoral Plan. The regional conferences were granted their own budgets for inviting experts of their choice and paying them to write reports about topics they found relevant. If conflicts arise, the Technical Safety Forum (TSF) provides a platform to raise questions about safety and put them up for discussion in a wider circle of experts from different stakeholders. While debates in the TSF are often successfully closed, the question remains open how the results are disseminated and accepted in society—particularly, since the TSF has no officially granted influence on the implementer, i.e. Nagra, to optimize safety standards. No empirical research on the workings and effects of the TSF has been published. However, all of these provisions are so far

⁶Sociotechnical constructs of technological safety and security are meaningful interpretations which are well-known and shared by the interested public (for the conceptual framing of sociotechnical processes see Lösch, 2021).

predominantly oriented towards the technical aspects of safety. The socio-technical aspects of safety and security—like providing a strong safety culture, dealing with human failure, intensifying the exchange with related subjects in order to gain new perspectives, ensuring intergenerational justice, dealing with trade-offs between risks and uncertainties or future societal and technological developments—are hardly ever addressed (Hocke, 2015; Kuppler, 2017; Eckhardt, 2021).

In principle, the Safety Case—a methodology developed by the International Atomic Energy Agency (IAEA) to evaluate the long-term safety of a geological radioactive waste disposal facility—could create a link between the different spheres and facilitate discussion. However, in the discourse and perceptions of deep repository projects, there is currently a great deal of scepticism about it—if the Safety Case plays a role in the discourse at all. Therefore, the Safety Case should be better adapted to the needs of stakeholders, and to a certain amount to civil society's expectations. Such an adaptation requires transdisciplinary research on questions like: Which aspects of the safety case (paradigms, objects and results) shape public perceptions of for instance a site selection process? To what extent is it sensible and possible to involve a wide range of stakeholders in the preparation of the Safety Case (Röhlig & Eckhardt, 2017)? This question is currently being investigated in more detail in a research project in neighbouring Germany (Transens, 2021). The research focuses on expectations of civil society members and lay people regarding arguments relevant for safety case studies in nuclear waste governance.

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