Master thesis

Uncharted Territories: A Swiss Media Exploration of the Underground, with Emphasis on Deep Geothermal Energy, Cargo sous Terrain, and Carbon Capture and Storage

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Management Summary

The underground is an unknown territory, gloomy and often addressed by fairy tales. However, not only fairy tales, but also the federal government's Energy Strategy 2050 deal with the underground. Emerging technologies such as deep geothermal energy or carbon capture and storage aim to fight the climate change. There are other technologies like the freight transport system ‘cargo sous terrain’ that will be built underground. These forms of use put the underground increasingly in the focus of politics. Society will also have to form an opinion as further regulations and laws are required to govern the use of the underground. This thesis aims to shed light on Swiss society’s attitude towards the different uses of the underground and show how media coverage might have changed over time.

While the use of the underground is of high relevance in Switzerland, a country nearly hollowed out by tunnels and bunkers, little research on the society’s attitude towards the use of its underground has been conducted. To assess the thematization of the underground and its use in Swiss media, a quantitative media analysis is executed. This thesis analyses Swiss media articles in German and English language over the period starting from 2011, the year of the nuclear catastrophe in Fukushima, till 2023. To evaluate the society’s attitude towards future forms of use, an in-depth exploration is undertaken involving three emerging technologies. Articles focusing on cargo sous terrain, deep geothermal energy and carbon capture and storage are analysed qualitatively.

The results of this thesis indicate that media coverage of the use of the underground has increased since the nuclear disaster in Fukushima. However, the event and the resulting energy debate were not the only reasons for the increased media attention. In particular, the search for a potential site for a long-term nuclear waste repository has attracted interest. Additionally, deep geothermal energy has taken on a prominent role in media. The reporting can be considered generally to be neutral. Cargo sous terrain and carbon capture and storage have collected only little media attention. They are usually presented in a favourable light and thus enjoy support of the Swiss media. Furthermore, the underground ecosystem and other themes related to the underground are hardly discussed in Swiss media. Thus, the focus of the media discourse lays on the utilisation of the underground.

While media coverage has increased over the analysed period, the underground and the society’s attitude towards its use are a vastly unexplored field. This knowledge gap demands for more research which might also spark heightened media attention. If sustainable technologies are increasingly reliant on the underground, the society must be able to form an opinion about the use of the underground and what technologies should be used. Herby, the media takes on an important role in the formation of opinions.

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List of Abbreviations

CCS	Carbon capture and storage
CCU	Carbon capture and utilisation
CCUS	Carbon capture, utilisation and storage
CST	Cargo sous terrain
DGE	Deep geothermal energy
EGS	Enhanced geothermal system
ETH	Swiss Federal Institute of Technology Zurich
FGC	Federal Geological Comission
IPCC	Intergovernmental Panel on Climate Change
Nagra	National Cooperative for the Disposal of Radioactive Waste
NET	Net emission technologies
NIMBY	Not-in-my-back-yard
NZZ	Neue Zürcher Zeitung
ppmv	Parts per million by volume
UGüTG	Federal law on the underground transport of goods
WC	Word count

1 Introduction

In this introductory chapter, the content of this thesis is explained. The research questions and objectives as well as the procedure of the study are presented. Finally, a thematic delimitation is made.

1.1 Initial situation and problem

Space in Switzerland and globally is becoming increasingly scarce. The global population is growing exponentially, and as a result, there is a greater need for additional space for infrastructure (Federal Statistical Office, 2022a; United Nations, 2022). Consequently, there is a constantly increasing number of projects utilising the underground. There is significant potential in future forms of use of the underground space. The underground is no longer just seen as resource for material extraction. Underground projects go in a variety of directions, such as infrastructure use (e.g. storage), commercial use (e.g. malls, car parks), use for traffic and energy production (Broere, 2016; Durmisevic, 1999; Wang et al., 2023). However, the technological research rarely considers the interests of society. There are several characteristics that distinguish underground from above-ground space. For this reason, it is important to conduct targeted research for underground utilisation (Wang et al., 2023).

Often, the society does not have enough information about new technologies and there is no interest in acquiring this knowledge (Dermont, 2019; Huijts et al., 2007). Even if there is a lack of technical knowledge, society still form an opinion about future-oriented projects (Devine-Wright, 2007). Therefore, it is of high importance to understand the current opinion of the society to be able to assess possible impacts on future projects, as it has been shown in different renewable energy projects (Blumer et al., 2018; Dermont, 2019). In Switzerland, the government and research has recognised that public support will be crucial to achieve the Renewable Energy Strategy 2050 which also includes underground projects (e.g. deep geothermal energy) (Swiss Federal Office of Energy, 2013; Wüstenhagen et al., 2007). The federal government has also published a strategy for underground utilisation, aiming to use the underground more extensively to achieve the Energy Strategy 2050 (Federal Geological Commission, 2022). In Switzerland in particular, the underground projects will also lead to conflicts of us and prioritisation is unavoidable as the space is limited (Ruiz, 2018). In a direct-democratic country it is crucial that policies correlate with the stakeholders' and publics' will (Kammermann & Ingold, 2019). The political system allows the population to vote on certain legislations or to hold a subsequent referendum against legislative decisions. That is why the opinion and support of the society is of high importance (Hessami, 2016). At this moment, there is a lack of research addressing social aspects of the underground and its use.

The underground has a special status in Switzerland. The tunnel and shelter building expertise has been raising international attention. Air raid and military shelters are part of the country's identity (Ziauddin, 2017). At the same time, the underground is also unknown, mostly invisible and shrouded in fairy tales, where the space beneath the surface is often portrayed as gloomy (Ulmi, 2018). The question arises to what extent the underground, due to its invisibility in everyday life, is a topic of discussion among the society. Furthermore, it is interesting to know what the society is thinking about the future use of the underground. Despite the high relevance of the public opinion, relatively little research has been conducted in this area. This work aims to fill this gap and investigates the occurrence of discourse on the underground and its use in Swiss media. With a media analysis, the opinion of the society can be assessed. Furthermore, this thesis contains a deep dive into carbon capture and storage (CCS), cargos sous terrain (CST) and deep geothermal energy (DGE). In this thesis, these three technologies are referred to as focus technologies. The focus technologies are mentioned in the federal government's strategy for the underground use and are envisaged as a future forms of use (Federal Geological Commission, 2022). The CST project has received high media attention at the time of writing. The realisation of the CST project has just started (Sutterlüti & Aellig, 2019). This thesis analyses the attitude towards this project, as it is relatively well-known and easily understandable. However, no comparable realised project is known in Europe as European law does not have a legal foundation for an underground freight transport on the one hand (The Federal Council, 2020). On the other hand, there is the newly developed technology of CCS. It is neither known to a wide public nor planned or operated underground in Switzerland (Wallquist et al., 2012). Even though the government envisages partial domestic storage of CO_2 in the Energy Strategy 2050, the process of acquiring the necessary technology and knowledge has only just stared. The Energy Strategy 2050 also encompasses the use of DGE (The Federal Council, 2022). Construction work of energy production plants in Basel and St. Gallen have already started, but both projects had to be shut down due to seismic activity caused by the drilling of the boreholes (Häring et al., 2008). In addition, there are already some DGE plants in existence that generate heat (Geothermie Schweiz, n.d.-a). This technology is already widespread and tangible among the Swiss public. Due to the different levels of public awareness and project statuses, it is interesting to uncover the differences between these three technologies in relation to public's attitude.

1.2 Research questions and goal

The focus of the thesis is directed at assessing the current attitude towards the underground by the Swiss society. Specifically, the aim is to show whether and how often the underground is thematised in the Swiss media and how this has changed over time. Also, the different forms of utilisation of the underground presented in the media should be highlighted. Ultimately, a deep dive for the focus technologies should give an initial overview of the society's attitude towards CCS, CST and DGE. The aim is to show whether the society coincide with the future forms of use proposed by science and the Swiss government. In addition, this allows a comparison of whether there are different attitudes towards technologies at different stages with different levels of publicity. The attitude could have an impact on the prioritisation and planning of projects, as the public is included in decision making in Switzerland. Thus, the results of this analysis are important for future planning. To ensure a systematic and comprehensive answer for this thesis, concrete research questions were formulated.

Q1: How frequently is the underground thematised in the Swiss media since the nuclear disaster in Fukushima and how has the thematization changed over time in terms of quantity?

Q2: What types of usage possibilities of the underground have been discussed and how often have they been addressed in the Swiss media discourse since the nuclear disaster in Fukushima?

Q3: What different attitudes of society are presented in the Swiss media discourse since the Fukushima nuclear disaster regarding:

a. Cargo sous Terrain?
b. Deep geothermal energy?
c. Carbon capture and storage?
d. The underground?

As this is an explorative work, there is a possibility that insufficient or no significant results will be obtained. The underground is not immediately visible and relatively little is known about trade-offs of its use. Therefore, it is questionable whether different and especially critical voices from the society can be captured in the media analysis.

The overall findings of this research are particularly interesting for politicians and investors of underground projects. Politicians will increasingly have to deal with the underground and its use. This is because a variety of aspects are unregulated and the use of the underground takes place without national guardrails (Ruiz, 2018). Therefore, it is crucial for the politicians to know what society and thus the voters think about this issue. For investors, it is critical to know how projects are perceived by the society as such resource and time intensive projects are major investments. The perception of the population is an important risk factor (Ge et al., 2021; Hitzeroth & Megerle, 2013; Liu et al., 2021). Ultimately, there exists an unexplored area of science. Hence, an important goal is to close the knowledge gap and thereby provide inspiration for future research.

1.3 Procedure

The design of this thesis is structured as follows. To answer the research questions discussed in Chapter 1.2, a comprehensive literature review is first carried out. Based on relevant research papers, perception and public attitude formation are defined. Mental models and psychological aspects for exploring attitudes are highlighted. In addition, the current and possible future use of the underground in Switzerland is discussed. There is also a presentation of the focus technologies CCS, CST and DGE. Furthermore, it is discussed why society's attitude is important for future underground projects. Based on the findings from related literature, hypotheses are formulated to investigate the research questions. As this is an unexplored topic and not much literature is available regarding the public attitude of the underground, an exploratory research method is used. According to the discourse research of Michael Foucault, it is possible to analyse the thinking and acting of a society through the publicly available discourses on the analysed topic (Jørgensen, 2002; Keller, 2011). In this thesis, the media as channel of the public discourse will be analysed. The analysis focuses on Swiss media of German and English language. This should provide a base for quantitative research on the frequency of media coverage and the discussed underground usage possibilities. In addition, a qualitative examination of the media tries to reveal the presentation of CST, CCS and DGE in Swiss media. The limitations of the research are also highlighted and recommendations for further research are formulated.

1.4 Delimitation

To ensure keeping the focus on the research questions, certain restrictions were made. These delimitations made are explained in the following section.

Language delimitation

This thesis is intended to provide information about the attitude of the Swiss society. The discourse analysis therefore exclusively evaluates media from Switzerland. However, only media in German and English are considered. Since the analysis requires good knowledge of the media's language, the author's limited knowledge in French, Italian and Romansh meant that media in those languages were excluded. With media in German, 62.3% of the Swiss population could be addressed in their native language. 5.8% of Swiss population denote English as a main language (Federal Statistical Office, 2022b). Therefore, around 68.1% of Swiss population could be theoretically reached with the analysed media. However, it must be noted that there could be overlaps between German and English main language as multilingualism was considered in the statistics.

Carbon capture and storage methods

Carbon capture is conducted using different methods and the gained greenhouse gas carbon dioxide, known under the chemical abbreviation CO_2, is further used in different ways. It is either stored geologically or it can be used in the industry (Lin & Tan, 2021). Industrial use is also known as carbon capture and utilisation (CCU). For example, CO_2 can be used to produce carbon-neutral synthetic fuels or to produce microbial proteins for carbon neutral food production (Becattini et al., 2021; Van Peteghem et al., 2022). As the topic of this thesis is to evaluate the attitude towards the underground, only the geological storage and no industrial utilisation is looked at. The differentiation is important as the Swiss society's attitude towards CO_2 reused in industry differs from geological storage (Nielsen et al., 2022).

2 State of knowledge

To be able to carry out a media analysis, the current state of knowledge needs to be considered. First, there will be a chapter about the formation of opinion to understand how the public's attitude is shaped. Further, the current use and projects aiming to use the underground in the future will be presented. In the end of the chapter, there will be an in-depth presentation of the focus technologies.

The literature review has been mostly carried out through using the search engines swisscovery, ProQuest and Google Scholar. Literature has been stored and organised with help of the research assistant tool Zotero. Exclusively literature fulfilling the following criteria is included in this chapter.

- All papers need to be peer-reviewed.
- Only articles out of top-rated journals according to the rating of Scimago Journal & Country (n.d.) in Quartile 1 and Quartile 2 and A+, A or B rated journals from the VHB-JOURQUAL3 (n.d.) have been included.
- Only literature written in English and German has been considered.
- Care was taken to ensure that the literature was up to date and reflected the latest state of research.
- Keywords were combined with the Boolean operators AND, OR and NOT.

Geographically, there were no restrictions regarding the origin of the journals or articles to guarantee an international diversity.

2.1 Public opinion

One goal of this thesis is to show whether an attitude towards the focus technologies can be identified. To achieve that, the formation of public opinion needs to be understood. First, a definition for the term 'public opinion' must be made. It can be either defined as "societal agreement decided through dialogue, the consensus arrived upon through conversation, a meaningful entity for gauging attitudes, and the aggregation of individual views" (Hoewe, 2016, p. 250) but also negatively afflicted as "a tool for elites to control other individuals and the opinion held by the most vocal group of people" (Hoewe, 2016, p. 250). Furthermore, a distinction between social acceptance, public perception, and public attitude must be clarified. All these terms appear in the literature in combination with public opinion. Thus, public opinion serves as a subordinated term for social acceptance, public perception, and public attitude (Glynn & Huge, 2008). However, there are different meanings:

- Social acceptance: this term is widely used in psychology to express affiliation of a person to a group of people and describing their relationship (DeWall & Bushman, 2011). In the field of emerging technology acceptance, it is also about how a group of people adopts and advocates a new technology (Gupta et al., 2011). Technology acceptance can be categorized in socio-political, community and market acceptance whereas the social acceptance is characterised as socio-political acceptance (Wüstenhagen et al., 2007).

- Public perception: is the process of interpreting something according to discussions with others and influences from the social environment. It focuses on how the macro-level opinion influences the individual opinion on a micro-level (Pan & McLeod, 1991). Public perception is also used to identify opinion on emerging technologies as the study of Stauffacher et al. (2015) shows with the research on public perception of DGE.
- Public attitude: how a person thinks about something and how the person evaluates certain situations. It is not only about thinking but also about a behaviour and feelings a person has towards something. Attitudes are mostly classified as positive, negative, or neutral towards a certain objective (Priester & Petty, 1996).

In summary, social acceptance focuses on the inclusion individuals or groups receive within a society. Public perception refers to the way the public interprets and understands a subject based on available information. Public attitude represents the overall disposition and sentiment of individuals within a society towards a particular object. These concepts are interconnected but represent different aspects of public opinion. Since technology acceptance is treated with all terms in the literature, all concepts are used to evaluate the public opinion. Therefore, all terms are included in the analysis and are quoted to evaluate public opinion. In this thesis, however, the attitude is to be evaluated specifically, and this is justified in the choice of methodology.
Furthermore, it is striking that the terms public attitude, public perception and social acceptance are defined as a process. This and how opinions are formed in the first place will be explained below.

2.1.1 Formation of opinion

A large body of research on how opinions are formed exists. Some critical theories are explained below for a better understanding. This thesis is about finding out how society's attitude is formed and how it can be displayed in the media.
The **Social Representation Theory** created by Moscovici in the 1970s says that people shape their world view based on the communication and interaction with other individuals (Howarth, 2006). Moscovici (1988, p. 211) is outlining "the nature of social representations as capacity to create information, their function which is to familiarise us with the strange, according to the categories of our culture". The **Agenda-Setting Theory** narrows down the formation of opinion more than the Social Representation Theory. Opinion building is also influenced by public discussion, but more specifically by the

media. The agenda setting of the public discourse influences the public opinion, often in political topics. The more a topic is being presented, the more influences it the formation of opinion of the society (McCombs et al., 2014). This theory has been tested over the years in various studies. A meta-analysis with over 90 studies showed a high average correlation of r=.53 (SD=2.31) between the media agenda and the perceived importance of an issue by the public (Wanta & Ghanem, 2006). The theory was further developed in different directions since its invention half a century ago, but the focus remains on the influence of society through the media discourse (Vu et al., 2014). Additional to the agenda-setting theory there exists **discourse research** from Michel Foucault. The findings of Foucault research support the agenda-setting theory. The research states that through publicly accessible discourse, society's thoughts and actions can be mapped (Jørgensen, 2002; Keller, 2011). Discourse can be defined as framework for constructing meaning through social and cultural factors. These factors are submitted through communication (Widdowson, 2007). The media coverage is therefore a part of the discourse defined by Foucault.

In contrast, the **Social Cognitive Theory** includes several factors influencing the learning and the building of attitudes and beliefs. It assumes that people learn and interact with their environment. In this theory, however, it is up to the individual to decide what beliefs he or she wants to adopt and incorporate into his or her own thinking (Bandura, 1989). Conversely, the **Selective Exposure Theory** states that one only consults information that confirms one's own opinion. Other information is ignored and therefore one's opinion is only reinforced by outside influence, but not changed (Hart et al., 2009). This presupposes that the person has a strong opinion of his or her own. In **Cognitive Dissonance Theory** as well as **Social Identity Theory**, it is assumed that people cannot stand by their differing opinion and therefore their thoughts influence their behaviour in society (Davis et al., 2019; Festinger & Carlsmith, 1959).

It is noticeable that all theories commonly include that behaviour and attitudes are dependent on others. People are influenced in their opinions by their environment, their fellow human beings and media coverage. One needs to consider that the formation of opinion is never complete, and that opinions can always change over time. Especially, when emerging technologies are consumed, where lots of developments can be observed, the opinion can be susceptible to change. It is therefore an ongoing process, which is why the superordinate terms at the beginning of this chapter also define it as a process (Devine-Wright et al., 2017; Druckman & Bolsen, 2011).

2.1.2 Importance of opinion for emerging technologies

This subchapter discusses why acceptance by society is important for emerging technologies. Research on various aspects of technological acceptance exists. In particular, the consideration of the social acceptance of technologies has become increasingly important in recent years as it is indispensable to ensure social acceptance to realise concrete projects (Wüstenhagen et al., 2007). The fact that the federal government aims to use the underground in Switzerland in the future to achieve the energy transition will be presented in Chapter 2.2. In Switzerland in particular, major construction projects and the creation of a legal basis can only be carried out with the consent of the population. Switzerland is a direct democratic country where around half of all public referendums in the world are held (Kaufmann et al., 2016). If a law of the federal constitution is introduced or adapted, it requires a referendum. Even if a law introduction or adaption does not require a vote, the population still has the right to force a public referendum against a law, an amendment to it or even to implement a completely new law (Swiss Confederation, n.d.). This ultimately triggers a political debate, as all eligible voters in Switzerland can decide on it and must form their opinion. This is where the previously presented theories on the formation of public's opinion become relevant. In Switzerland, debate and opinion building happens through the media. Different political spectrums on the subject are illuminated (Marquis et al., 2011; Tresch, 2012).

So far, the Swiss law on the use of the underground is still largely undefined at national level. Currently, the first party to claim an area of ground may use it without regards to others. Representatives from geology, industry and the state came to the conclusion that those conflicts of use are unavoidable unless the legal situation is clarified in a near future time horizon (Federal Geological Commission, 2022). Even though Switzerland is a direct democratic country, the electorate has not yet voted on a national level for any law that directly affects the comprehensive use of the underground (Lateltin, 2022). According to the interpretation of the Federal Geological Commission (2022), the Spatial Planning Act can also be applied to the underground, but it is unclear who is responsible for the decisions regarding the use of the underground. Whether this is handled by the federal government, the canton or the local municipality needs to be clarified.

This legal uncertainty also affects the focus technologies of this thesis. However, even if the legal situation is clear, the acceptance of the society is needed. For example for CCS, scientist agree that a wide acceptance in the public would be important to scale up the technology (d'Amore et al., 2020; Wallquist et al., 2009, 2010; Wenger et al., 2021; Wennersten et al., 2015). Lock et al. (2014) and Shackley et al. (2004) have stated that while the society has a fundamentally positive attitude towards CCS and advocate the construction of CCS plants, might still reject and block concrete projects. The rejection of concrete projects can be explained with the NIMBY phenomenon, which is discussed in the following.

NIMBY phenomenon

NIMBY is an abbreviation for 'not in my back yard'. It shows the residents' resistance to change their near environment (Devine-Wright, 2009). NIMBY focuses on all kinds of development projects, but in literature, it is mostly used to measure the acceptance of renewable energy projects (Carley et al., 2020). NIMBYsm could lead to a general rejection of a project by the entire community. Residents are lobbying against the planned project and spread their opposition to others (Schaffer Boudet, 2011). The phenomenon must not be ignored as it could have significant impact on the acceptance of any project. However, it must be noted that the NIMBY phenomenon is widely criticised. According to Petrova (2016) it only focusses on proximity of residents to a planned plant. Thus, the theory was not applicable for her studies on wind turbines as there were other, different aspects driving the acceptance of the residents. Devine-Wright (2009) criticises NIMBY for not considering these changes over time. Furthermore, NIMBY is criticised because it does not take place attachments of residents into account (Devine-Wright, 2013; Wolsink, 2006). The researcher's reasoning against NIMBY entails that notion of people only rejecting a project out of selfishness is too simplistic (Boholm, 2004; van der Horst, 2007). According to Carley et al. (2020) NIMBY is not generalisable as every project has its differences and individual influences regarding the publics' acceptance. But even if NIMBY as scientific phenomenon is being criticised, the quoted researchers nevertheless agree that the phenomenon exists. Also, many researchers using NIMBY agree that the phenomenon is incomplete in itself, but can still serve as a basis for scientific studies when applying some additions (Burningham, 2000; van der Horst, 2007).

The NIMBY phenomenon shows how complex and multi-layered the formation of public opinion on energy technologies is. There are various factors influencing the acceptance of renewable energy technologies. Huijts et al. (2012) identified knowledge and experience, fairness, trust, risks, costs and benefits, consequences of rejection and impact of the technology as significant factors. Druckmann & Bolsen (2011) disagree with the factor of knowledge of the technology as they found that information does not significantly influence opinion formation. Moreover, research shows that not all factors are weighted equally. According to the research of L'Orange Seigo et al. (2014), people are more willing to accept a technology if they weigh the benefit factor more heavily than the risks factor. The opinion and what is known about the factors and opinions on the focus technologies will be discussed in more detail in Chapter 2.3. First, this chapter will discuss the underground in general and the public opinion on it.

2.2 Swiss underground

The word 'underground' is a broad term with different meanings in German as well as in English. Well known dictionaries define it as 'everything that lies under the ground' (Cambridge Dictionary, 2023; Duden, n.d.). The expanse of the underground is not clearly defined. In principle, however, there is geological rock suspected on the earth's crust down to the beginning of the Earth's mantle. In Switzerland, this is expected at a depth of about 40 km (Grotzinger, 2017). In English, the expression 'subsoil' is often used, which is defined as the top layer of soil in whose nutrients the plants thrive (Hine, 2019). However, this distinction is relatively uncommon in German, which is why everything ranging from directly below ground to the outer earth core is considered as underground in this work. Further, underground is also defined as a secret hided activity which is often illegal in word usage. Often, these are groups that operate out of the shadows - the underground - or simply away from the norms of society. In German, also the soil or fundament, which is the top layer of earth on the surface, is commonly referred to as underground (Cambridge Dictionary, 2023; Duden, n.d.). This makes the distinction essential, as only the geological underground is to be investigated in this thesis. This is now presented in detail.

2.2.1 Underground conditions

The federal councillor responsible has commissioned the Federal Geological Commission (FGC) to draw up a strategy and subsequently an action plan for Switzerland's underground use. This demonstrates the need for underground utilisation, as well as the current lack of information and regulation. In this strategy, it was acknowledged, that the underground will be used even more in the future, especially to achieve the energy transition and to guarantee the national supply with energy (Federal Geological Commission, 2022). Adaptions and regulations based on the strategy and the action plan will be highlighted later in this chapter. First, the current status and the underground conditions are explained below.

Data availability

To get to know the Swiss underground better, the Federal Office of Topography, known as swisstopo, has developed a 3D-Model for the region of the Central Plateau named GeoMol17 (swisstopo, n.d.). This area covers around one third of the Swiss surface. Including the cities of Zurich, Lucerne, St. Gallen, Bern, Lausanne and Geneva, this area is home to two thirds of the total population of Switzerland (Federal Department of Foreign Affairs, n.d.). Besides cartographic information, it also includes detailed information on the soil composition. A wide variety of different data has been merged in the model. The data has been collected in the past from boreholes, seismic measurements and digital modelling (swisstopo, n.d.; Vahlensieck, 2018). Yan et al. (2019) remarks that there is still a lack of models for underground infrastructure. The land administration needs knowledge about existing infrastructure like utility networks on the underground via 3D modelling. What needs to be considered is that 3D geological models are never capable of displaying the reality completely. Due to various uncertainties, it can be judged only as an approximation to reality (Wellmann & Regenauer-Lieb, 2012). Despite everything, the basis for planning underground projects for the Central Plateau is given. For the rest of Switzerland, however, there is a lack of data. On the one hand, the data collection has been historically neglected by the federal government. On the other hand, many European countries have collected underground data during the search for resources such as oil and gas. Due to the moderate occurrence of resources in Switzerland, no experience could be gained through resource allocation (Heuberger et al., 2022).

Current and future use of the underground

The use of the Swiss underground has a long history. Tunnel construction created remarkable achievements. In 1882, there was a railway tunnel built through the Gotthard massif. A more recent achievement for remarkable engineering and construction work is the 57-kilometre-long Gotthard base tunnel for the railway (Jorio, 2016). Tunnels for transportation, whether by train, car, metro or on foot, are ubiquitous. Furthermore, underground military shelters as well as the numerous nuclear shelters for the safety of the population in case of a nuclear disaster were built in Switzerland (Ziauddin, 2017). Today, the supply of the population with resources including water, electricity, sewage, internet communication and others are also ensured through underground pipelines. Finally, many parts of buildings, such as multi-storey car parks, are also built underground (Gauch et al., 2016). The underground is not only used, but also explored by scientists. On the one hand, research on the geological composition of the underground and on caves is carried out. On the other hand, archaeological excavations can be used to analyse relics from the past (Heuberger et al., 2022). Resources are also extracted from the underground. Switzerland does not have a large resource base, e.g. in terms of oil and gas. Therefore, this is mostly limited to water extraction and mining of salt and gravel. Historically, there was no mining industry established (Leu, 2014).

The future use of the underground can be versatile. A large part of its future use will be influenced by the federal government's energy strategy. Discussions about the use for energy production have experienced a push forward by the nuclear disaster in Fukushima on the 11th March 2011. An earthquake followed by a tsunami damaged the nuclear power plant in Fukushima, resulting in a release of vast amounts of radioactivity on land and in the sea (Aoki & Rothwell, 2013). In the end of Mai 2011, the nuclear phase-out in Switzerland was approved by the Federal Council and at the end of 2011 by the parliament. As a direct measure resulting from the nuclear disaster and the associated nuclear phase-out, the new Energy strategy and the associated new Energy Act is formed between the end of the year 2011 until the end of 2017. As of the 1st of January 2018, the Energy Act was implemented (Swiss Federal Office of Energy, 2018). The Energy Strategy 2050, also known as the energy perspectives 2050+, envisages that its targets will be achieved with the help of renewable energies like hydroelectric power, photovoltaics, geothermal energy, wind energy, biogas and energy production from wood and waste (The Federal Council, 2021). It is also envisaged that negative emissions will be necessary. This means that CO_2 needs to be captured from the atmosphere. This will be partly achieved through CCS (The Federal Council, 2022). DGE and CCS presuppose the use of the underground. It was recognised that this could lead to possible future conflicts of use between the technologies. Therefore, the underground strategy was formulated (Federal Geological Commission, 2022). The underground plays a crucial role in assisting efforts to combat climate change and achieve success in addressing it. Furthermore, the underground will continue to be utilised for resource extraction and infrastructure development. Finally, the underground is an ecosystem and serves as habitat for plants and animals (Federal Geological Commission, 2022, p. 5). The focus technology CST is neither mentioned in the energy strategy 2050 nor in the underground strategy, but a legal basis has been created with the federal law on the underground transport of goods (The Federal Council, 2020). In doing so, the legislature also recognised that CST contributes to address the climate crisis by ensuring environmentally friendly freight transport (Fedlex, 2022).

Finally, in March 2020, the COVID-19 pandemic resulted in a temporary reduction of energy demand as a consequence of lockdown measures implemented to combat the spread of the virus (Swiss Federal Office of Energy, 2021). In the year 2022, however, the energy transition became omnipresent again because of an energy shortage. This was caused, among other factors, by the beginning of the war between Russia and Ukraine. The war lead to a lack of Russian gas due to embargos and the supply difficulties caused by the pandemic, which also affected fossil fuel supply (Federal Department of the Environment, Transport, Energy and Communications, n.d.).

Not only renewable and resource-efficient technologies for the use of the underground are in political discussion, but also a final repository for nuclear waste is planned too. Radioactive waste from nuclear power plants, research and industry is to be stored at a depth of a few hundred meters, as it emits radioactive radiation for hundreds of thousands of years (Nagra, 2022c). Additionally, infrastructure will be moved underground in the future to relieve the scarce space above ground. This includes for example buildings, roads and railway lines (Federal Geological Commission, 2022). Raw materials also continue to be extracted from the underground (swisstopo, n.d.). Other forms of use are conceivable. The subsequent media analysis of this thesis is intended to provide more information about different future forms of use.

2.2.2 Perception of the underground

As there has not yet been a vote by the Swiss society about the use of the underground, there has not yet been a need for Swiss society to form opinions regarding the underground use on a large scale (Federal Geological Commission, 2022). This could be a possible reason why the use of the underground has not yet been discussed more in literature. Well-known studies mainly focus on public perceptions when people are underground themselves. Specifically, the attitude towards underground work was examined in many studies. For example, the study of E.H. Lee et al. (2019) questioned 1,093 citizens of Singapore and showed that people who have a positive attitude towards being in the underground, feel protected there. Conversely, some negative aspects regarding underground spaces stem from claustrophobia. Tan et al. (2020) on the contrary found out that a well-furnished and greened underground workplace leads to even less fatigue on a physical as well as emotional level compared to aboveground workplaces.
However, Wang et al. (2023, p. 12) recognises the lack of theoretical foundation in building up the general attitude of the society towards the underground. They, therefore,

introduce eight aspects influencing the user perception of underground spaces and allow for more research on this topic. The aspects encompass space connectivity and positioning, physical environment, safety, convenience, facility, landscape, application of smart technology and environmental diversity. It needs to be mentioned that Wang et al. (2023) also focused on people using urban underground spaces like metro stations or malls underground. The aspects do not cover deep underground spaces without public access.

In conclusion, there are numerous studies investigating the perception of people when being underground. But what society thinks about the deeper underground or how they perceive it remains largely unanswered in the literature.

2.3 Introduction of the focus technologies

To enable a comparison between the focus technologies, the following is the current state of knowledge in the literature of the technologies in Switzerland.

2.3.1 Cargo sous Terrain (CST)

CST is a unique freight transport project in Switzerland. The technology and the CST project itself are presented in detail below. An assessment of the public attitude towards CST is also made.

Project details and technology

The CST project aims to build an underground freight transport system. It should comprise 500 kilometres of tunnels from St. Gallen to Geneva and from Basel to Luzern as well as from Bern to Thun until the year 2045. CST is a project which is planned and pursued by the company Cargo sous terrain AG (Cargo sous terrain, n.d.-b). The main shareholders are, among others, the retailers Coop and Migros, the Swiss Post, several insurance and financial institutes as well as logistic service providers. The definition and conceptualisation phases of the project started in the year 2010. From 2013 to 2015, a feasibility study for the underground freight transport was conducted. In 2016 an in-depth proof of concept was made (Cargo sous terrain, n.d.-b). In 2017, the project entered a detailed planning phase. In July 2019, with the adaption of the federal law on the underground transport of good (UGüTG) the Swiss government set the basis to build and operate an underground freight transport as pioneer in Europe (The Federal Council, 2020). In 2021, the parliament verified the law and put it into force (The Swiss Parliament, n.d.). In January 2023, the construction work started with test drillings to analyse the ground composition for the first section between Zurich to Härkingen, which is planned to be put in operation in 2031 (Cargo sous terrain, 2023). There will be a planned tunnel system in depths between 20 and 40 meters underground (Schweizer Radio und Fernsehen (Director), 2016). The tunnels are connected to the subsurface with hubs in cities or logistic centers. The freight is being transported by air, street or rails to the hubs, where CST transports it to the destination hub. From there, the freight will again be transported with another transport method to its final destination. The vehicles underground have an electric drive and move autonomously inside the tunnels. The electricity for the drive of the vehicles is provided via induction (Cargo sous terrain, n.d.-b). Induction technology is seen as seminal and is also discussed as an alternative to battery driven electric vehicles for efficiency reasons (Aydin et al., 2022; de Almeida et al., 2014; Mei et al., 2020). Thus, CST vehicles have no need for recharging and could operate 24 hours a day (Cargo sous terrain, n.d.-b). The technology for CST has been developed together with research institutions, such as the Zurich University of Applied Sciences (Zurich University of Applied Sciences, 2022). To the knowledge of the author no scientific literature about CST exists. In research, CST is classified as underground freight transport technology. A main advantage of underground freight transport is the reduction of traffic on the roads above ground and a flexible, efficient day-and-night operation. This is particularly significant as the Federal Office for Spatial Development expects freight traffic to increase by 37 % between 2010 and 2040 (Federal Office for Spatial Development, 2016). CST is also environmentally friendly as CO_2 pollution and noise pollution by freight transport decreases (Cui & Nelson, 2019; Egbunike & Potter, 2011). According to the environmental balance sheet of the Cargo sous terrain AG, savings of up to 80% CO_2 emissions compared to the road traffic can be expected due to the use of renewable energy (Cargo sous terrain, n.d.-a). Villa and Monzón (2021) see not only the advantage of sustainability and reduction of CO_2 and noise but also the reduction of accidents of underground transport systems compared to conventional subsurface transportation systems. As CST is a cargo transport system without the need of human beings it is not necessary to fulfill safety measures targeting humans as known from rail or street tunnels. No security tunnel, fresh air system or signalization is needed. This also leads to lower construction and maintenance costs compared to human transport systems (Cargo sous terrain, n.d.-b; Villa & Monzón, 2021). However, a potential issue could be conflicts of use. The the underground, especially in cities, is already extensively built on. Finding the right space for tunnel constructions can prove to be difficult (Visser, 2018). Another challenge is the potential lack of support from politicians (Egbunike & Potter, 2011).

Public opinion of CST

Research showed that public acceptance is important for underground freight transport systems (Villa & Monzón, 2021; Xue et al., 2022). In order to achieve the necessary acceptance, it is important to consider the needs of the society already in the development phase (Xue et al., 2022). Projects often fail because of societal factors. This is due to an uncertain future and missing flexibility of the society (Kervall & Pålsson, 2022). However, a detailed survey or acceptance study investigating the publics' opinion cannot be found. The media analysis of this thesis aims to provide an assessment of the society's attitude towards the CST project.

2.3.2 Deep geothermal energy (DGE)

Climate change is now widely recognized and rejected by a decreasing number of researchers (Cook et al., 2013). Therefore, renewable energies such as DGE are increasingly moving into focus as they have a smaller impact on the environment compared to the energy production based on fossil fuels (Perea-Moreno, 2021). The technology of DGE and its advantages and disadvantages is discussed below. Furthermore, the use of DGE in Switzerland and the state of knowledge regarding the acceptance of this technology are explained.

Technologies

In DGE, different procedures and technologies exist. On one hand, DGE aims to produce energy through hydrothermal or petroleum systems which is also known as Enhanced Geothermal-System (EGS) technology. Alternatively, DGE can be used to power heating systems (Hirschberg et al., 2014). The common feature of the system in Switzerland is to use the heat from the underground starting at 3,000 meters below the surface. The depth of the ground source heat pump and the geological layer differs but all systems require two drilling holes. Cold water flows down through one tube and hot water comes up through the other tube, resulting in a water circuit. The hot water is used to power turbines on the surface that consequently feed electricity into the grid (Geothermie Schweiz, n.d.-a; Hirschberg et al., 2014). A minimum temperature of 120 degrees is needed to produce electricity. The water, which still has a minimum needed temperature of 70 degrees Celsius after leaving the water circuit, is finally fed into a district heating network. The water finally flows back cooled and is pumped back into the ground. The combination of energy and heat production is needed to operate a deep geothermal plant economically (Geothermie Schweiz, n.d.-a; Hirschberg et al., 2014). The difference between hydrothermal and EGS technology is that the hydrothermal system in Switzerland draws water up from the depths of 3-5 kilometres. The water is used for producing electricity and transmitting heat. The cooled water is than traced back down again. EGS on the other hand pumps cold water at high pressure into the bedrock at a depth of about 4- 5 kilometres. There the water flows through the cracks in the rock, warms up in the around 150-degree Celsius environment, and is pumped up. After it has been used and thereby cooled down, it is pumped back down (Hirschberg et al., 2014).

DGE plants are mostly spread around the seismic lines of the Pacific Ring of Fire that contains 452 volcanos, island arcs and oceanic trenches (Allaby, 2020; GeoEnergy, 2022). The magma that is present on the subsurface through hot steams is the energy source used by the hydrothermal technology (Pambudi, 2018). The allocation of plants near the Pacific Ring of Fire shows that the use of hydrothermal technology is limited (GeoEnergy, 2022). EGS, however, does not need the presence of hot water streams and therefore has much more use cases. EGS is still in a testing phase and needs several more years for the technology to be economically viable (Geothermie Schweiz, n.d.-b; Hirschberg et al., 2014; Stauffacher et al., 2015). A main issue caused by the flooding of the rock for petroleum systems are seismic events which can be perceived as earthquakes. Seismic events cannot be prevented based on current knowledge. Risk assessment are required and seismic events need to be better monitored (Hirschberg et al., 2014; Mena et al., 2013). Spada et al. (2021) call for measurement and clarification not only of the seismic risk, but also of accident risks above ground. Hydrothermal technology on the other hand, encounter operational issues when the water pressure is insufficient (Hirschberg et al., 2014). Regardless of the technology, there is also criticism regarding the costs of DGE plants. Not only does an energy plant constitute a high initial investment due to the necessity of drilling two bore holes, but also the operating expenses and the maintenance costs are relatively high. Therefore, the amortisation of a DGE plant takes longer compared to energy plants based on other technologies (Pan et al., 2019; Soltani et al., 2021). Also, land availability to build a DGE plant could be an issue as it is most efficient for heat distribution to build it next to a metropolitan area (Pan et al., 2019). Besides the risks, DGE offers a major advantage over other renewable energy technologies. It is available at any time of the day or night and all year round. Wind energy on the contrary depends on wind conditions, photovoltaic needs at least moderate solar radiation. Hydropower also has a certain dependence on the climate and the rainfall (Meenal et al., 2022). An analysis of several projects has shown that DGE is more efficient than hydropower, fossil fuels and biogas. The performance is comparable to offshore wind parks and even slightly more efficient compared to photovoltaic cells (Spada et al., 2021).

DGE in Switzerland

Even if Switzerland does not possess ideal geothermal conditions, operation of DGE is still a viable option to supply the country with renewable energy and heating according to the Energy Strategy 2050 of the Federal Council (2021). The goal of the Federal Council is to supply one million households with geothermal electricity by 2050. Hirschberg et al. (2014) estimate the potential of geothermal energy to one third of the country's energy consumption by 2013, which is the equivalent to 24,000 GWh. However, a test drilling in Lavey-les-Baines in 2022 showed that the heat at a depth at around 3,000 meters can be sufficient to produce electricity with DGE in Switzerland. Also, no seismic activity was triggered by the deep drilling. Nevertheless, the project managers were faced with the issue of insufficient water pressure to drive the turbine for energy production. That prevented the construction of the DGE plant (alpine geothermal power production, 2022). In the year 2006 there were already plans to build the first EGS plant in Switzerland. The project was called "Deep Heat Mining", located in Basel and was supposed to use the EGS technology (Hirschberg et al., 2014). The drilling to a depth of 4,630 meter proceeded smoothly. After starting the fluid injection, two seismic events with a maximum value of M_L 3.4 on the Richter scale have been recorded. Three more events were noticed in the following weeks. Even though they can only be referred to as seismic events of minor strength, they were nevertheless noticeable for the society. After these incidents, the liquid injection and finally the whole project was stopped (Canton of Basel-Stadt, 2009; Häge et al., 2013; Häring et al., 2008). The project gained media attention all over the world and triggered discussions on the risks of deep geothermal energy (Giardini, 2009; Spada et al., 2021; Stauffacher et al., 2015). Viganò et al. (2021) and Giardini (2009) propose different measures to prevent incidents with EGS. It is particularly important that the data basis and monitoring is improved. Knowledge about the underground is crucial to plan the project and assess the risks properly. As discussed in Chapter 2.2.1, the geological composition in Switzerland, especially of the deep underground is widely unknown and may be a major challenge for the use of the technology.

Despite the uncertainties, the city of St. Gallen believed in DGE technology and started with test drillings for a hydrothermal plant between the years 2011 and 2013. However, this project was not successful either; natural gas leaked through the borehole and an earthquake with a maximum value of M_L 3.6 on the Richter scale was registered. As this earthquake was even stronger than the one in Basel, this project also had to be stopped (Omodeo-Salé et al., 2020). Further DGE plants are in the planning phase or under construction. But these systems only supply heat and do not produce electrical energy. Operating plants are located in different cities and distribute heat to surrounding households and industries through district spanning heating networks (Geothermie Schweiz, n.d.-a). At the time of writing, there were two ongoing projects in Switzerland. Test drillings for possible DGE plants are planned in Haute-sorne in the canton of Jura (Geo Energie Suisse, n.d.). In addition, the Swiss Federal Institute of Technology Zurich (ETH) Zurich has opened a test laboratory for DGE in an access tunnel of the Furka railway route. Tests are being conducted to observe the response to simulation from the rock (Bedretto Lab, n.d.).

Public opinion of DGE

The seismic events in Basel have sparked a debate on the acceptance of DGE technologies. There is already a wide range of research literature, and a media analysis. Stauffacher et al. (2015) found in their media analysis designed for Switzerland, that media coverage from the year 1997 to 2013 on this topic is limited with only 193 articles published in Neue Zürcher Zeitung (NZZ) and Tages Anzeiger. Only after significant events related to DGE or energy supply like the Fukushima nuclear catastrophe, reports accumulated. The researchers call for more publicity and open discussion on DGE. The content of a majority of articles are mainly investigating negative reporting but do also cover positive opinions.

It is worth mentioning that acceptance is also strongly country-dependent, even between the Swiss and German population, a gap exists (Knoblauch et al., 2019). The focus of this subchapter lays on the Swiss perception.

The most frequently mentioned risk factor that negatively influences the acceptance of the Swiss population is the seismic risk (Knoblauch et al., 2019; Stauffacher et al., 2015). According to Spada et al. (2021) and Mena et al. (2013) measurements of seismic activity lead to greater acceptance, as the results of the risk assessment can be communicated in an understandable fashion. Trutnevyte and Widmer (2017) envision a traffic light system regarding the erosions, besides the assessment of other different risks, as valuable option for future projects in Switzerland. Another option would be to build DGE plants next to industrial areas where fewer residents are directly affected by seismic activity (Knoblauch et al., 2019). Furthermore, public rejection of DGE arises due to the high construction and operational costs which reflects the concerns of the literature mentioned previously in this chapter (Stauffacher et al., 2015). There is also fear and distrust against new technology observed (Kunze & Hertel, 2017; Stauffacher et al., 2015), lack of knowledge about the underground utilisation (Stauffacher et al., 2015) and due to previous unsuccessful projects (Stauffacher et al., 2015). The health impact of the DGE plants is also registered as a negative factor (Bustaffa et al., 2022). Gross (2013) connects the unknowns of DGE to the public with the gloomy image associated with the underground in sagas and fairy tales. However, there are also parts of the society and opinions that are positive towards DGE. Mentioned are the pioneering role of DGE (Stauffacher et al., 2015), environmentally friendliness (Stauffacher et al., 2015) and the constantly available and renewable resource (Knoblauch et al., 2019; Stauffacher et al., 2015).

2.3.3 Carbon capture and storage (CCS)

In this chapter, it will be explained how CCS works, how it is operated in Switzerland and what is known about its attitude in the Swiss society. It is also explained why there is a need for CCS in the first place.

Technological foundation of CCS

CCS aims to filter carbon dioxide out of the atmosphere. CCS technologies are still under development and there are only 35 operating plants worldwide (International Energy Agency, n.d.). The pre-combustion CO_2 capture method is a recent example of such technologies. CO_2 is emitted after the burning of fossil fuels in industry complexes or power stations. A CO_2 capture solution filters CO_2 after it is leaving the combustion chamber. With the help of an aqueous amine solution, the CO_2 is dissolved from the exhaust gases. After this process, the CO_2 can then be transported to the storage site by rail, ship or pipeline in a liquid form. After transportation it will be injected into the layers underground (MacDowell et al., 2010). Another approach is the oxyfuel method. Here, the fuel is burnt with pure oxygen instead of oxygen during combustion. For the oxygen method, it is important to control the heat in the boiler by recirculating flue gases. Afterwards the CO_2 is transported and stored (Zhu et al., 2021). There are more technologies in development, but they will not be highlighted each as they are not all feasible. Summarized, all technologies include the following three steps: capture of the CO_2, the transportation of the CO_2 and the storage underground (MacDowell et al., 2010). There are various geological sedimentary layers that can be considered for the storage of CO_2. The depth and layer depend on the local conditions (Boot-Handford et al., 2014).

Currently, the main issue with CCS is the high price of installation of CCS plants as well as expenses caused by the ongoing operation (International Energy Agency, n.d.). Holz et al. (2021) is addressing the costs for CO_2 compensation via CCS. The price needs to be high enough to compensate the CO_2 and to build up and maintain the supply chain for CO_2, which must not be neglected. In addition to the high costs, the scalability of CCS is also questioned. Furthermore, CCS is criticised due to its high energy demand to operate the CCS plant itself which could lead to an efficiency reduction of the connected plant where the CO_2 is filtered from. There could also be problems with storage if leaks occur and CO_2 is released back into the atmosphere (de Coninck & Benson, 2014; Rahman et al., 2017). However, the focus of the recent literature is currently not on the advantages and disadvantages of the technologies, as these are still in a development phase. Currently, most of the debate is about whether it will be necessary to use CCS technologies at all. This will be discussed in more detail below.

Need for CO_2 reduction

CCS is being utilised to combat climate change. The CO_2 concentration in the atmosphere is too high. Scenarios thought by the Intergovernmental Panel on Climate Change (IPCC) and analysis by researchers assume an increase in the use of fossil fuels and a decrease in renewable energies in the future. As this will lead to increased CO_2 emissions, more CO_2 must be removed via CCS (Wennersten et al., 2015). In May 2022, there was already a CO_2 concentration of 421 ppm[1] measurable in the atmosphere (National Oceanic and Atmospheric Administration, 2022). Rockström et al. (2009) assess a CO_2 concentration of more than 350 ppm as critical to not overstep the climate related planetary capacity of a liveable space for humanity. Rau (2019) argues that the reduction of hundreds to thousands gigatons of CO_2 until the year 2100 will be unavoidable to meet global temperature goals. There are various estimates on how much CO_2 needs to be removed from the atmosphere in order not to overstep a maximum global warming of 1.5 degrees Celsius: 10 to 20 gigatons each year (IPCC, 2022), 1 to 10 gigatons each year (National

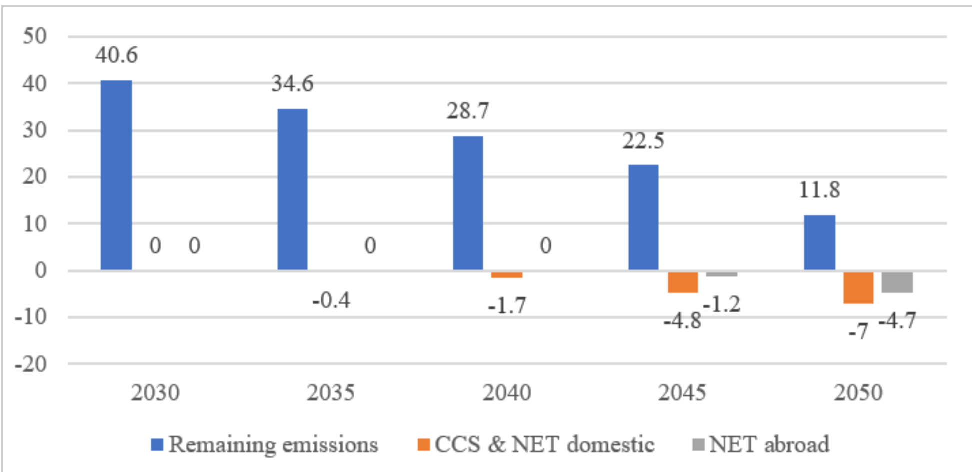
[1] ppm is a chemical unit of measurement. It stands for parts per million (Allaby & Park, 2017)

Academies of Sciences, 2019) or 1,000 to 10,000 gigatons in total (Fuss et al., 2018). While estimates differ, most scientists agree that the CO_2 level needs to be reduced. Also, politics is acting accordingly. That is why 197 of the United Nations' members signed the Paris Agreement that set the global temperature increase of a maximum of 1.5 degrees Celsius above pre-industrial level (United Nations, n.d.). The goals of Switzerland in its Energy Strategy 2050 are even more ambitious. The strategy aims to become climate neutral by 2050 and reduce or even remove CO_2 emissions completely (The Federal Council, 2021). Wennersten et al. (2015) assume that the only way to maintain a stable climate system is to remove CO_2 from the atmosphere through large-scale CCS operation. From a European perspective, CCS is seen as a key measure to reach the climate goals until 2050 (Holz et al., 2021).

CCS in Switzerland

CCS has been addressed for the first time in the Swiss federal government's climate strategy 2050. Nevertheless, the Swiss government admits that more research must be conducted and feasibility of geological storage options needs to be proven (The Federal Council, 2021). A first research paper estimates the storage capacity for CO_2 in Switzerland with 2,68 gigatons (Chevalier et al., 2010). Finally, the authors of the energy strategy 2050 assume that parts of the CO_2 will be stored abroad. The availability of storage abroad is seen as realistic, the construction of pipelines posing the main challenge (The Federal Council, 2021). Figure 1 shows the scenario by the federal government of the development of CO_2 emissions including the part of CCS and net emission technologies (NET) inland and abroad.

Figure 1: Scenario CO_2 emissions in gigatonnes in Switzerland



Source: Own representation based on The Federal Council (2021, p. 54)

In conclusion, the climate strategy 2050 merely states that CCS will be necessary to achieve the climate targets by 2050 (The Federal Council, 2021). Switzerland decided to exit nuclear energy by 2035. Hence, scientists worry about higher CO_2 emissions caused by alternative energy sources and energy imports. As alternatives for Switzerland gas-fired generators, renewable energies and energy imports were elicited. Some of those energy production methods are emitting more CO_2 than nuclear power plants (Kannan & Turton, 2012). In Switzerland, no commercially operated CCS plant storing CO_2 underground exists. However, a test laboratory was opened at the ETH Zurich research facility (ETH Zurich, n.d.)

Public opinion of CCS

CCS is not yet operated on large-scale. This explains why wide parts of the society never heard of CCS. A survey by Carley et al. (2012) in the United States of America claims that 80% of the respondents were not familiar with CCS. Whilst the study of Arning et al. (2019), the knowledge in Germany was a bit higher, but still around 75% of their respondents only had a little knowledge. Despite the relative unfamiliarity, research on the perception and acceptance of the technology was conducted. In Switzerland, a survey with n=693 Swiss citizens showed no strong opposition but also only a moderate acceptance or rather a neutral attitude towards CCS. The researchers' reasoning was that there was too little knowledge about CCS among the participants (Wenger et al., 2021).
A survey by Krause et al. (2014) showed that over 80% of the participants supported CCS technology. Of these, in turn, only 20% were willing to endorse CCS in their community. Therefore, the NIMBY effect can also be observed with CCS (Arning et al., 2019). The main concern of the society on CCS seems to be about the safety of the technology (Krause et al., 2014; Wallquist et al., 2010). Participants of two studies of Wallquist et al. (2009, 2010) conducted in Switzerland reported to be scared of an over-pressurized reservoir for the storage of CO_2 underground. They feared that the pressure under earth could cause an explosion, which in turn could lead to earthquakes. The participants were also afraid of the leakage of the stored CO_2 as it could rise to the surface one day or destroy the ecosystem. According to the research of van Alphen et al. (2007), the media in the Netherlands mentions the high costs and the fact that CCS is not the solution to the actual problem are more often than the risks arising from CCS. Arning et al. (2019) and Terwel et al. (2012) on the other hand, classify the transportation of CO_2 as the main risk perceived by the public. The fear relates to the environment and health implications if transport vessels get damaged. Other risks mentioned, but seen less impactful, were

groundwater pollution and explosions caused by CCS (Arning et al., 2019; Wallquist et al., 2009, 2010). Satterfield et al. (2023) agree with the research findings regarding the acceptance of CCS mentioned above and add that people see moral hazard caused by CCS as an issue. Furthermore, Volkart et al. (2016) refer to possible social conflicts associated with CCS. They see resistance from the Swiss society and non-profit organisations against concrete projects. This is based on a historical rejection of energy and industrial projects. Socio-political factors regarding the decision making process also needs to be considered (Terwel et al., 2012). Especially trust in the involved stakeholders is important in order to receive the citizens acceptance (Terwel et al., 2012; Yang et al., 2016). Ultimately, according to d'Amore et al. (2018) social acceptance must be given the same importance as economic factors in order to be successful. Lee et al. (2019) on the other hand highlight the significance of a balance between economic and environmental factors to lower the transportation and storage risks and to gain acceptance. Even though they weight different factors, the researchers agree that risks can be lowered and acceptance can be increased by employing different strategies based on models that assess risks (d'Amore et al., 2018; S.-Y. Lee et al., 2019). However, there are not only sceptical voices from the society and research site, but also supporters. Scientists claim immediate need for action to combat climate change (S. R. Carley et al., 2012; Satterfield et al., 2023; Shackley et al., 2004). Van Alphen et al. (2007) rate the presentation of CCS in the Dutch media as generally balanced and presented in a positive light. In Dutch media discourse the focus tends to be on the CCS technologies' capability to remove CO_2 from the atmosphere. These findings correspondent with a comparable analysis conducted in Australia, Canada, New Zealand, the United Kingdom and the United States (Gough & Mander, 2006).

2.4 Derivation of hypothesis

Based on the existing knowledge, hypothesis have been formulated to address the research questions following the media analysis. The derivation of the hypotheses is described below.

The Swiss electorate has not yet decided on the use of the underground. The political debate is still in its infancy. The scientific community has also not yet dealt with the issue of public opinion on the use of the underground on a large scale. It is therefore assumed that the media has not yet focused on this issue either. No comparative study for Switzerland could be consulted and there are no scientific appendix points on the

accumulation of articles on the underground. Thus, the formulation of a hypothesis on the first part of research question Q1 is dispensed with. This part is examined holistically and exploratively. For the second part of the question on the change over time of the media coverage, hypothesis H1 is formulated. As it has become established in theory, the nuclear catastrophe in Fukushima has started the discussion and establishment of the Energy Strategy 2050. Subsequently, the Corona pandemic caused new social challenges. This may have decreased media attention of the energy transition in favour of COVID-19 related issues and fears. Other events such as the war between Russia and Ukraine have also contributed to the energy crisis, which has presumably also fuelled media coverage. The assumption that underground reporting depends on energy policy issues is also justified by the hypotheses H2 and H3. There it is assumed that energy issues make up a major part of the underground discussion. For this reason, it is assumed that certain crises can increase media coverage.
H1: After a global crisis, an accumulation of media articles on the underground and its use can be observed.

In Chapter 2.2, the proposed forms of use for the Swiss underground in the federal underground strategy have been presented. It can be assumed that the media will also deal with topics that are addressed in research and are also planned for implementation in Switzerland. All current forms of underground utilisation are still a topic to be discussed. However, due to the political discussions surrounding the new forms of use, it is assumed that these will be the focus of media coverage. Therefore, the following hypothesis regarding research question Q2 will be stated.
H2: The media discourse discusses future forms of use for the underground which are described in the energy strategy 2050.

Research question Q2 addresses what significance the future use of the underground will have in comparison to its current forms of use. As discussed in Chapter 2.2, the nuclear disaster in Fukushima has triggered a series of events in Swiss energy policy. This also meant changes for society. Scepticism about new technologies is to be expected, which is why it is assumed that this leads to greater media interest than the known forms of use.
H3: The future forms of use are lively discussed compared to other underground topics.

Research question Q3 on the presentation of the focus technologies in the media and thus public attitude is split into four hypotheses. There has not been much research on the attitude towards CST project in the scientific community, as highlighted in Chapter 2.3.1. There is no evidence of either positive or negative perceptions. Therefore, it is assumed that the media react neutrally to the project.

H4a: The project Cargo sous terrain is presented in a neutral light in Swiss media discourse.

DGE has already been tested in Switzerland and has caused earthquakes as mentioned in Chapter 2.3.2. This has affected the technology and projects have been stopped. Therefore, it is assumed that the media image of DGE is negative.

H4b: Deep geothermal energy tends to be portrayed negatively in Swiss media discourse.

Studies have found that people have reservations against CCS (cf. Chapter 2.3.3). This image is also expected in the Swiss media discourse.

H4c: Carbon Capture and Storage tends to be portrayed negatively in Swiss media discourse.

The underground itself and its perception has hardly been researched at all. This is another reason why it is assumed that this is not considered a big issue among the society and that the underground is therefore perceived and portrayed neutrally.

H4d: The underground tends to be portrayed neutrally in Swiss media discourse.

3 Methodical approach

To test the hypotheses, scientific research was performed. This chapter looks in detail at how this research consisting of a media analysis was carried out. First, it will be described hereafter why media analysis is suitable to answer the research questions. Then media analysis is presented as part of discourse analysis. Finally, the exact procedure of this work is described.

3.1 Media analysis

According to the agenda-setting theory and the discourse research by Foucault presented in Chapter 2.1.1, public opinion is shaped through media discourse. While other factors that can influence opinion formation, this is one way that societal attitude can be measured. According to Paltridge (2022) the analysis "considers how views of the world, and identities, are constructed through the use of discourse" (Paltridge, 2022, S. 2). First and foremost, discourse analysis aims to gather opinion and not only analysing the language meaning. Discourse analysis is therefore considered as a sociological topic and not only linguistic science according to the social structures evaluated (Pan & McLeod, 1991; Widdowson, 2004). Media coverage is a specific part of the discourse that is analysed.

Especially, in the technology sector people are often focusing on the general social acceptance rather than forming their own individual opinions (Seidl et al., 2013). Therefore, an analysis of the media image is well suited to clarify the public opinion rather than questioning individuals regarding their attitude (Devine-Wright et al., 2017). One needs to consider that various stakeholders of the technologies are benefiting from the opinion built through the media and try to influence the society through press releases and reports (Andsager, 2000). This reinforces the influence of the media in shaping public opinion. Various research papers on renewable energies have already proven that the application of media analysis in this field is suitable to reflect the opinion of the society. For example, van Alphen et al. (2007) analysed 306 media articles in the Netherlands and questioned stakeholders from the government, industry and environmental NGOs regarding their perception of CCS. For the most part, they came up with congruent results and agreed on the perception, which tended to be positive. Devine-Wright (2007) acknowledges in his critical review that the media influence renewable energies. Furthermore, Stauffacher et al. (2015), Bauer (2005) and Heras-Saizarbitoria et al. (2011) recognised media analysis as suitable for studying the perception of emerging technologies like DGE, biotechnology and photovoltaic cells. Finally, Mayring (2022) states that the analysis of media often aims to make statements about their effects on the audience, i.e. the target group. As outlaid in Chapter 2.2.2, the influence on the social aspects on underground usage has been neglected in research so far. As discourse analysis is often used as an exploratory research method, it is employed in this work for initial research analysing the impact of social aspects on underground usage (Mayring, 2022).

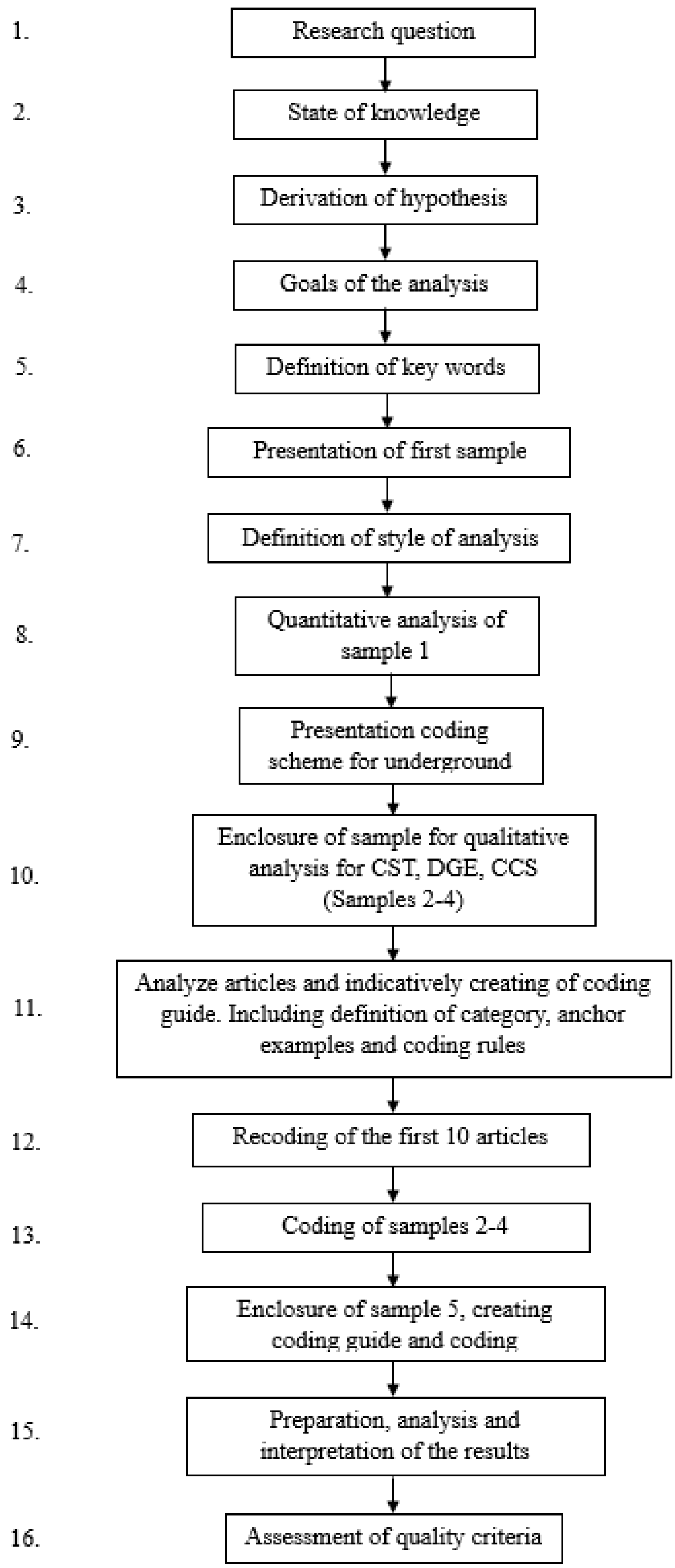
3.2 Research design and procedure

It is possible to analyse any kind of communication in a quantitative as well as qualitative way (Mayring, 2022). In this research, a hybrid approach is applied. This means that research questions Q1 and Q2 will be answered using a quantitative approach, while research question Q3 will be evaluated using a qualitative approach (Mayring, 2022).

The research was carried out in accordance with the procedure of content analysis developed by Mayring (2022). His guidelines facilitate systematic research. It allows qualitative research to be rule based and theory led. In particular, he suggests working with fixed categories to analyze the discourse to make the procedure verifiable. Even though the procedure according to Mayring (2022) was applied, there were slight adjustments being made. The procedure of Mayring proposes ten basic steps for content analysis. These steps were replicated but adapted to the structure and layout of this thesis.

The systematic approach applied to the research of this thesis has been illustrated in Figure 2. The individual steps are then described in detail.

Figure 2: Process model



Source: own representation inspired by Mayring (2022, p. 61)

Steps 1-3

The first three steps of the procedure; the formulation of the research questions, the review of the state of knowledge and the derivation of hypotheses are addressed in the previous chapters (cf. Chapter 1.2 and Chapter 2).

Step 4

Utilising quantitative evaluation, the aim is to use basic data to show changes over time in reporting on the underground and thus analyse research question Q1. For this, a database with general information on articles on the underground is required. For the second research question, the articles must be classified. This is based on the theme of the article, but also on the form of use discussed for the underground. This should make it possible to say whether other new forms of use are also being discussed. Thus, research question Q2 can be answered. Finally, the analysis turns into a content analysis. By applying category labels, it is possible to determine the attitude of an article towards the described focus technologies and the underground. This tackles research question Q3.

Step 5

The fifth step, the definition of the key words to collect the sample material, is assembled based on the first three steps. The sample was compiled by means of search terms. The determination of the search terms is explained in detail in Chapter 3.2.1. Data, in form of full text media articles, was collected from the database Factiva. Factiva provides a comprehensive collection of worldwide media that can be searched using keywords and the results displayed in full text. The database is operated by the American media and news company Dow Jones. The search function in Factiva was used for generating a sample systematically. The search was carried out by the author of this work between mid-March and the end of April 2023.

Step 6

Through the search with help of the key words from step five, a sample of n=1,609 articles on the underground is used. The presentation of sample 1 is made in Chapter 3.2.2.

Step 7

For the definition of the style of analysis, a simple thematic analysis of the articles proposed by Mayring (2022) is chosen. To assess the topics and form of use of the underground, no in-depth assessment of the articles is needed. Therefore, the content of the article is summarised and categorised according to its main theme. In addition, if a form of use is discussed, a categorisation of the form of use is made. No further text or content analysis is carried out with sample 1 of the general underground.

Step 8

Step eight investigate the extent of which the media discusses the underground and what importance it enjoys in the media over time. For this reason, data such as publication dates of the article were collected to examine hypothesis H1. Details regarding the data captured can be found in Table 3. To address hypothesis H2, concrete forms of use discussed in the articles were recorded. Finally, the change in thematization was also be investigated to prove hypothesis H3. Therefore, the articles were classified in a corresponding thematic area. For the quantitative evaluation, the sample with the evaluated data was filled into an Excel worksheet. The theme and the form of use were elicited indicatively when reading the articles. After 100 articles, the topics were consolidated and, where it was appropriate, summarised. The 100 articles were rechecked and, if necessary, recategorized. The articles were cross-read and assigned to a theme and a form of use (if applicable) for the underground. Since all forms of use discussed are to be recorded, it was important not to form a ready-made coding system after these first 100 articles. The coding was therefore further developed during the analysis. Details regarding the procedure of coding and the information captured will be highlighted in Chapter 3.2.3.

Step 9

The themes and proposed forms of use for the underground from the previous step were captured in a coding scheme. Each form of use is associated with the superordinated themes. In the coding scheme, there is a short explanation of each theme and utilisation form. The final version of the coding scheme can be found in Appendix B.

Step 10

To tackle hypothesis H4a, H4b and H4c, sample 1 containing of articles on underground in general was further divided by focus technologies, thus creating one sample per focus technology[2]. This was made by filtering sample 1 with search terms evaluated for each focus technology. The composition of the search terms used is highlighted in Chapter

[2] Sample 2 for CST, Sample 3 for DGE, Sample 4 for CCS

3.2.1. The samples of the focus technologies are therefore a non-randomly selected subset of sample one of underground articles.

Step 11

The samples 2-4 were then analysed in terms of content. Using qualitative content analysis, frequencies and clusters can be detected and significance tests can be conducted. The condition for qualitative analysis is to use ordinal, interval or ratio scales (Mayring, 2022). In this work, a simple ordinal scale was used, which distinguishes between positive, neutral and negative attitudes. This relies on media analysis described and conducted by van Alphen et al. (2007), Heras-Saizarbitoria et al. (2011) and Mayring (2022). Moreover, as discussed in Chapter 2.1.1, attitudes are categorised in positive, neutral and negative attitude. Therefore, the classification of the media articles into these categories also creates consistency between methodology and the research questions.
The text passages in the articles of samples 2-4 are finally assigned to the ordinal scale. The analysis style of 'structuring' according to Mayring (2022) is chosen for this purpose. A structure should be filtered out of the text. The articles should not only be summarised. An attitude towards a technology is to be evaluated. The evaluation of the attitude was done by using coding guidelines. The coding was done by an indicative categorisation. The categories were formed continuously while reading the first articles. Since not enough is known about the possible attitudes and arguments from the current state of knowledge, this approach is recommended and is applied by other media analysis (Mayring, 2022). An example of this is the media analysis of DGE by Stauffacher et al. (2015). Coding guidelines were created for the focus technologies. These contain all themed categories. Each category can take a positive, negative or neutral stance according to the ordinal scale used. For each attitude there is a short explanation and coding rules describing criteria for a positive, neutral or negative attitude. The structure of the coding guidelines is inspired by Mayring (2022). Chapter 3.2.3 presents details of the coding.

Step 12

First, ten articles per focus technology were read and categories were formed on an ongoing basis. These ten articles were chosen based on the grounded theory, that states categories are recorded until no new ones are added (Glaser & Glaser, 2010). After ten articles, no additional categories were found. Thus, the coding guidelines were finalised after ten articles for each focus technology (details see Chapter 3.2.4). Finally, these first ten articles were reclassified according to the finished coding guidelines. This completed the pre-test (cf. Chapter 3.2.4) and ensured that the categories of the first ten articles are correctly classified.

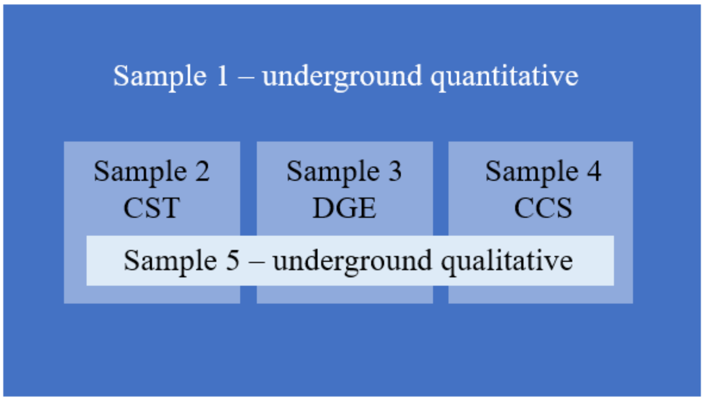
Step 13

Finally, the entire sample of each focus technology was coded following the coding guidelines (cf. Appendix C - E). Finally, the entire coding was repeated to reduce errors.

Step 14

To investigate hypothesis H4d, the underground should be assessed according to its attitude. For this purpose, articles from samples 2-4 used that also addressed the underground itself were used. The articles thematising the underground were marked in sample 2-4 and compiled into a new sample 5. Thus, this was not done with further search terms, but while classifying and assessing hypotheses H4a, H4b and H4c. Sample 5, which was obtained for this purpose, is therefore a further gradation. In summary, samples 2-4 for each focus technologies are obtained from sample 1. Afterwards, the specific sample 5 for the assessment of the attitude towards the underground was subtracted from samples 2-4. The building of the samples is illustrated in Figure 3.

Figure 3: Composition of the samples



Source: own representation

The procedure for the coding of the articles is identical to the procedure applied on the analysis of the focus technologies described in steps 11-13.

Step 15

The previous 14 steps served as the basis for the research. The data analysis was carried out in Excel with the help of filters, formulas and pivot tables. The research questions and hypotheses derived from them formed the basis for the research. In Chapter 4, the hypotheses are evaluated. Consecutively, the evaluations are presented graphically, in tables and illustrated in the course of this work.

Step 16

Finally, it is evaluated whether the quality criteria are met. This is described in Chapter 4.4.

3.2.1 Recherche Journal

In the following, criteria and search terms applied to filter the database Factiva are discussed in detail.

First, the language used as well as region thematised in the articles were determined. In the delimitation of Chapter 1.4, the languages analysed have been restricted to English and German. The attitude by region towards the Swiss underground is to be depicted, which is also derived from the research questions Q1 and Q2 of this thesis. Therefore, the articles with a focus other than Switzerland were removed. Generally, only media created by publishers that are domiciled in Switzerland should be examined. However, there is no filter function in Factiva for this. Since all journals and magazines were to be included in the evaluation, this was not restricted by means of search criteria, but filtered out manually in a further step, which is explained at the end of this chapter. The following search criteria have been established:

Language: German & English, Region: Switzerland

The time constraint was also partly dictated by all three research questions. The opinion of the society since the nuclear disaster in Fukushima (11. March 2011) is to be investigated. Data collection was conducted from mid-March 2023 to the end of April 2023, so all articles were observed until 11. March 2023. Thus, the sample spans over exactly twelve years.

Date: 11.03.2011 – 11.03.2023

Consecutively, the search words were defined. For the quantitative analysis and thus to answer research questions Q1 and Q2, as many articles as possible on the underground in general should be analysed. For this, several search terms must be used including synonyms. To ensure this, the Boolean operators AND, OR and NOT were applied. As a basis for the analysis of keywords, the script of the federal underground strategy was examined and all expressions interchangeable for “underground” were collected.

Subsequently, initial search results skimmed for the synonyms of underground retrieved in the previous step. Furthermore, websites of interest groups as well as dictionary articles on the topic of underground were also analysed. Finally, this led to the selection of the following terms in German: Untergrund, unterirdisch, Tiefe, tief, Georessourcen, Erdkruste, unter der Erde, geologisch, Geologie, Untertagebau and unter Tage. These terms, combined with AND, lead to a sample of n=394,785 articles. A random selection of these articles was cross read. In many cases, they do not correspond to the underground as defined in Chapter 2.2., On this basis, it was determined that an article was only included in the sample if it included the term underground paired with a synonym of the underground. This approach was chosen, as an article on the underground is usually mentioning the word "underground" and further synonyms. For example, in the underground strategy of the Federal Government, the German word "Untergrund" is mentioned 147 times (Federal Geological Commission, 2022). With this combination, many thematically inappropriate articles could be excluded at the same time.

In the next step, all German terms have been translated into English. To obtain a wealth of synonyms there, research papers were consulted in addition to websites and dictionaries. As most relevant research papers are written in English, a search of research papers based on the German synonyms of "underground" did not yield any results. The federal underground strategy, on the other hand, is not translated into English, which is why there was a slightly different procedure here.

The search terms found by browsing the research papers are as follows: underground, below ground, depth, deep, georesources, geological, geology, underground mining, earth crust or under the earth. All these terms combined with AND together with all previously defined search criteria discussed in this chapter leads to a sample of n=6,372 articles.

Search terms: (Untergrund AND (unterirdisch OR Tiefe OR tief OR Georessourcen OR unter Tage OR Erdkruste OR unter der Erde OR geologisch OR Geologie OR Untertagebau OR unter Tage)) OR (Underground AND (below ground OR depth OR deep OR georesources OR geological OR geology OR underground mining OR earth crust OR unter the earth))

Through cross-reading utilising randomly chosen articles and headlines, it has come to light that a considerable portion of the articles continue to make references to underground-related word connotations that are not pertinent to the focus of this thesis.

Many articles thematising a social, criminal and ideological underground. But also, a musical underground, i.e. non-mainstream articles or scene festivals, are discussed.

Sporting events, which are less noticed, are also presented. Therefore, the articles were filtered with help of the exclusion of the following subjects.
Subject: NOT Sports NOT Religion NOT Festivals NOT Financial Crime NOT Hate Crime NOT Illegal Gambling NOT Illegal Immigration NOT Digital Piracy NOT Murder/Manslaughter NOT Sex Crimes NOT Gangs NOT Terrorism NOT Whistleblowers

This combination finally revealed a sample of n=5,901 articles. However, it is noticeable that there are various short contributions. For example, press releases that were quoted, or even short messages on the underground without detailed content. These articles fail to offer a comprehensive understanding of the topic and hinder the ability to develop an informed viewpoint. Articles of the sample containing between 300 and 600 words were cross read again. Based on the observations made in the process of cross reading the articles, a restriction to a minimum of 500 words proved to be a sensible delimitation. Therefore, the following search term which is Boolean for articles that contains more than 500 words for word count (WC) was added.
Supplement to search term: AND WC>500

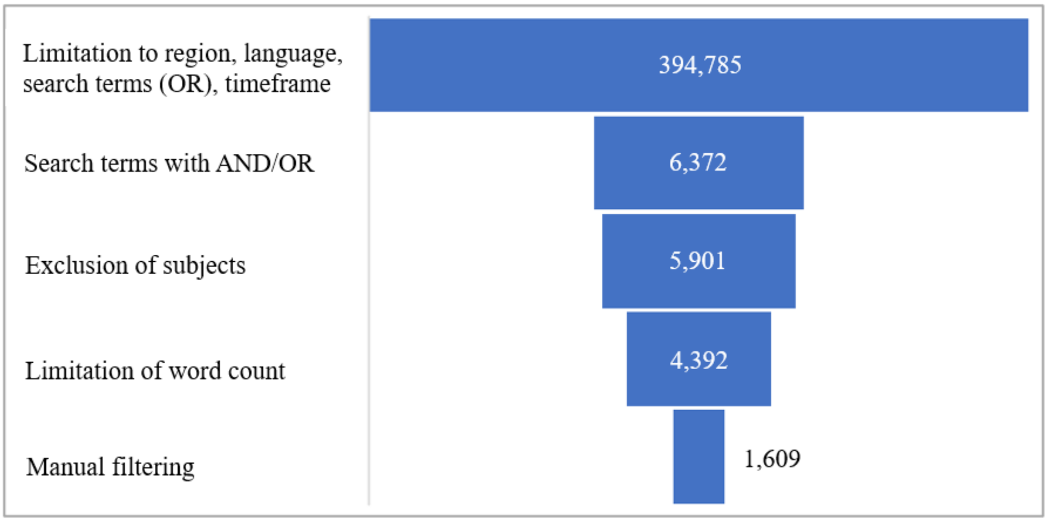
Finally, all restrictions were combined to a search query. The final Factiva search query can be found in Appendix A. This search led to a sample of n=4,392 articles. Following that, the articles underwent another round of filtering, this time it was done manually by the author. This process considered the classification of the research questions and the specific scope of this thesis. This was done according to the following criteria:

- News from the **Swiss Federal Administration** were excluded. Such announcements do not serve to form the opinion of the population. This news can be classified as official announcements rather than mass media.
- Articles that do not **geographically** concern Switzerland were filtered out. This was already captured in the search criteria.
- **Specialist journals**, especially scientific and industrial journals, were excluded because they are only read by a small minority of the society.
- **Duplicates** were filtered out. Duplicates refer to articles that are published twice in the same journal, for example in the online version as well as in the print version.
- The few articles that were not **thematically suitable** were also excluded which leads to a further substantial reduction.

- Scripts of **video, radio and TV** contributions were excluded. Generally, radio, video and television reports and social media posts are not integrated in the analysis of this thesis. It can be assumed that due to the different forms of media, gestures (video), tone of voice (radio), emojis (social media) used can additionally influence opinion. Therefore, this would require further research.
- **Journals** that are not domiciled in Switzerland were excluded. It can be assumed that Swiss public form their opinions through local magazines and do not consult foreign media extensively. Therefore, only Swiss domiciled newspapers are considered.
- Certain Swiss sources were excluded too. On the one hand, these were all sources acting as **dispatch agencies** (Keystone-SDA, News aktuell OTS, AWP Swiss News, Reuters Nachrichten etc.). The aim of those outlets is to pass on information to newspapers in a neutral form so that they can write their articles. They are, therefore, not consulted by the society itself. Thus, they do not significantly shape the Swiss public's opinion.

After the filtering according to the criteria above, the sample was reduced to n=1,609 articles. This sample is referred to as sample 1. The reduction of articles just described is visually depicted in Figure 4. It must be noted that the first stage of the funnel containing 394,785 articles is not linear.

Figure 4: Filtering of articles



Source: own representation

Addressing research question Q3, samples 2-5 for the three focus technologies were generated[3]. However, the basis of this was sample 1. These articles were re-filtered using search criterion for the focus technology. This also ensures that the focus technologies were considered in combination with the underground. Again, synonyms for CST, DGE and CCS were searched for. The procedure remained unchanged from the general search conducted for underground-related content.

Relatively few synonyms have been detected for CST. It is a concrete project with a uniquely assignable name. The technology used is also unique and therefore, cannot be covered by one term. The technology of CST is referred to as “unterirdischer Gütertransport” or “underground freight transport” in literature, which is why this was added to the different spellings and abbreviations of CST.

Search term CST: Cargo sous Terrain OR CST OR Cargo sous terrain OR unterirdischer Gütertransport OR underground freight transport

Synonyms of DGE were searched by analysing research papers. Often, DGE is referred to as geothermal energy in English or “Geothermie” in German. As defined in Chapter 2.3.2, DGE is facing projects drilling 3,000 meters below the surface. The geothermal projects not reaching the defined depth were excluded manually. The term has become widely adopted and is not only used as a technical term. A synonym to DGE in the German language is “Erdwärme” which is interchangeable with the English expressions “Geothermal energy”, “Geothermal power” and “Geothermal heat”. No other common synonyms could be found in dictionaries. Also, a comparable study from Stauffacher et al. (2015) did not use further synonyms.

Search terms DGE: Geothermie OR Tiefengeothermie OR Erdwärme OR Geothermics OR Geothermal energy OR Geothermal power OR Geothermal heat

A wide variety of expressions used synonymously to CCS can be found. As this paper focuses uniquely on the underground storage for CO_2, rather than any other uses of CO_2. Nevertheless, utilisation was included in the search terms, as in studies the expression CCUS is addressing storage and utilisation together. The following terms were found in literature, science and reports:

Search terms CCS: Carbon Capture and Storage OR CO2-Sequestrierung OR Carbon sequestration OR Carbon dioxide capture and storage OR CCS OR CCUS OR Carbon

[3] Sample 2 for CST articles, Sample 3 for DGE articles, Sample 4 for CCS articles

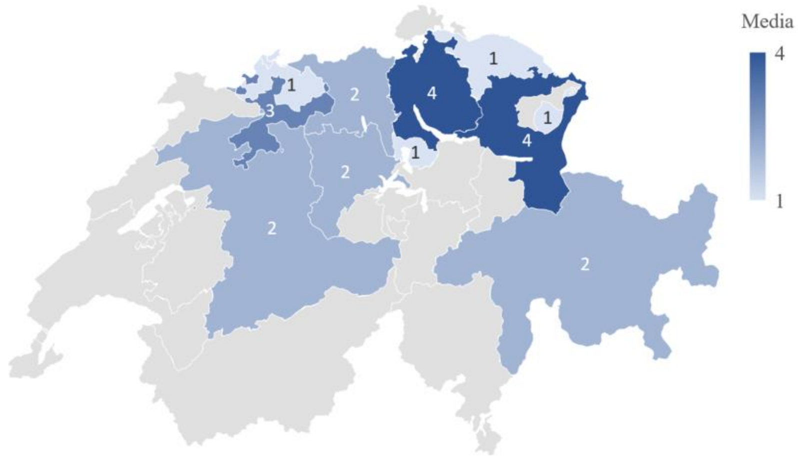
Capture utilization and sequestration OR carbon capture utilization and storage OR Speicherung von CO2 OR Negativemissionen OR CO2-Abscheidung und Speicherung OR CO2- Abscheidung und -Speicherung OR Abscheidung und Speicherung von CO2

3.2.2 Sample

According to Zurich University of Applied Sciences (n.d.) 69 Swiss sources in the four Swiss national languages and English were covered in the database Factiva in 2019. These are mostly daily, Sunday and weekly newspapers as well as regularly published magazines. Factiva as a database is constantly adding new sources. Not all publications analysed had been in the database since the beginning of the study period. Therefore, Table 1 includes the period during which the analysed media were available in the database.

According to the supplementary bulletin of the WEMF AG for media research, sample 1 adds up to a total edition of 2,583,359 in 2022 (WEMF AG, 2022). 2,583,359 readers are equivalent with around 29.56% of the Swiss resident population of 2021 (Federal Statistical Office, n.d.). It must be noted that there can be overlaps, as one person can be among the recipients of several newspapers at the same time. On the other hand, a medium could also be consumed by several people. However, a high number of individuals of the population are represented in the analysis of these reports. It must be noted that not all Swiss media that would meet the search criteria were represented on Factiva. Factiva is a private-sector database that has only recorded a selection of Swiss media. The sample is therefore only an excerpt of the Swiss mass media landscape. Nevertheless, the sample is diverse. Considering the quality assessment from the Research Centre for the Public Sphere and Society of the University of Zurich, different quality scores are represented. On the one hand, the highest rated Swiss media NZZ am Sonntag (quality score 7,6) and NZZ (quality score 7.6) are included in the sample. Also, the lowest rated magazines Blick (quality score 4.9) and 20 Minuten (quality score 5.3) are represented (Research Center for the Public Sphere and Society, 2022). In terms of regional coverage, there are n=18 media that cater to readers from across German-speaking Switzerland. Additionally, n=24 regional media are included in the analysis. The coverage of the regional media is illustrated in Figure 5. The media are presented on the respective region concerned. There is a cluster in north-eastern Switzerland, while central Switzerland is underrepresented.

Figure 5: Distribution of regional media



Source: own representation

The sample 1 to investigate research questions Q1 and Q2 is described again in Table 1. The media building samples 2-5 to analyse research question Q3, are listed in Table 2.

Table 1: Sample 1, quantitative analysis

Characteristic	**Sample**
Articles	1609 Articles
Newspapers	42 German- & English-language Swiss newspapers;
2011-2018	Zentralschweiz am Sonntag
2011-2023	Aargauer Zeitung, Basler Zeitung (online), Beobachter, Berner Zeitung (online), Bilanz, Blick (online), Bündner Tagblatt, Der Bund (online), Die Südostschweiz, Finanz und Wirtschaft (online), Handelszeitung (online), Neue Luzerner Zeitung, Neue Zürcher Zeitung, NZZ am Sonntag, Oltner Tagblatt, Schweiz am Wochenende, SonntagsBlick, SonntagsZeitung, St. Galler Tagblatt, Tages Anzeiger (online), Zofinger Tagblatt
2012-2023	Die Weltwoche
2015-2023	ZEIT Schweiz
2016-2018	Ostschweiz am Sonntag
2016-2023	20 minuten online, Appenzeller Zeitung, Basellandschaftliche Zeitung, Das Magazin, Der Landbote (online), Neue Zuger Zeitung, NZZ Folio, Thurgauer Zeitung, Toggenburger Tagblatt, Wiler Zeitung, Zürichsee-Zeitung (online)
2017-2023	Glückspost, Schweizer LandLiebe
2018-2023	Grenchner Tagblatt, Limmattaler Zeitung, Solothurner Zeitung
2021-2023	The Local

Source: own representation

Table 2: Samples 2-5, qualitative analysis

Technology & Sample	**Articles**	**Newspapers**
CST, Sample 2	51 Articles	22 German-language Swiss newspapers; Aargauer Zeitung, Appenzeller Zeitung, Basler Zeitung (online), Berner Zeitung (online), Der Bund (online), Der Landbote (online), Die Südostschweiz, Grenchner Tagblatt, Handelszeitung (online), Neue Luzerner Zeitung, Neue Zürcher Zeitung, NZZ am SonntagsZeitung, Oltner Tagblatt, Solothurner Zeitung, St. Galler Tagblatt, Tages Anzeiger (online), Thurgauer Zeitung, Toggenburger Tagblatt, Wiler Zeitung, ZEIT Schweiz, Zofinger Tagblatt, Zürichsee-Zeitung (online)
DGE, Sample 3	228 Articles	29 German-language Swiss newspapers; 20 minuten online, Aargauer Zeitung, Appenzeller Zeitung, Basellandschaftliche Zeitung, Basler Zeitung (online), Beobachter, Berner Zeitung (online), Der Bund (online), Der Landbote (online), Die Südostschweiz, Die Weltwoche, Grenchner Tagblatt, Handelszeitung (online), Limmattaler Zeitung, Neue Luzerner Zeitung, Neue Zuger Zeitung, Neue Zürcher Zeitung, NZZ am Sonntag, Oltner Tagblatt, Schweiz am Wochenende, Solothurner Zeitung, SonntagsZeitung, St. Galler Tagblatt, Tages Anzeiger (online), Thurgauer Zeitung, Toggenburger Tagblatt, Wiler Zeitung, Zofinger Tagblatt, Zürichsee-Zeitung (online)
CCS, Sample 4	27 Articles	18 German-language Swiss newspapers; Aargauer Zeitung, Basellandschaftliche Zeitung, Basler Zeitung (online), Berner Zeitung (online), Blick (online), Bündner Tagblatt, Der Bund (online), Die Südostschweiz, Die Weltwoche, Grenchner Tagblatt, Limmattaler Zeitung, NZZ am Sonntag, Oltner Tagblatt, Solothurner Zeitung SonntagsZeitung, St. Galler Tagblatt, Tages Anzeiger (online), Zofinger Tagblatt
Underground, Sample 5	171 Articles	29 German-language Swiss newspapers; Aargauer Zeitung, Appenzeller Zeitung, Basellandschaftliche Zeitung, Basler Zeitung (online), Beobachter, Berner Zeitung (online), Blick (online), Der Bund (online), Der Landbote (online), Die Südostschweiz, Die Weltwoche, Grenchner Tagblatt, Handelszeitung (online), Limmattaler Zeitung, Neue Luzerner Zeitung, Neue Zuger Zeitung, Neue Zürcher Zeitung, NZZ am Sonntag, Oltner Tagblatt, Schweiz am Wochenende, Solothurner Zeitung, SonntagsZeitung, St. Galler Tagblatt, Tages Anzeiger (online), Thurgauer Zeitung, Toggenburger Tagblatt, Wiler Zeitung, Zofinger Tagblatt, Zürichsee-Zeitung (online)

Source: own representation

Assessment of sample size

Riffe (2014) proposes different sample techniques. The methodology of this thesis can be classified as a simple random sample. The sample size for newspaper and other media articles differ and is dependent from the field of analysis (Riffe, 2014). It must be noted that this research is not a full covering study in terms of media articles available because the word count and type of media were limited. Otherwise, all articles gathered from search in German and in English language, which relate to Switzerland in the defined period by means of the search terms, were analysed. Therefore, the sample size of sample 1 can be classified as sufficient. For samples 2-5, there is a selection bias as it was a non-random sampling (Winship & Mare, 1992). The selection of these samples must therefore be viewed critically. They are an excerpt from articles in the focus technologies, which also mention the underground and synonyms of it. On the attitude of the underground, only articles are analysed that also deal with the focus technologies. This can also lead to a distortion of the results.

3.2.3 Coding

This chapter discussed the different coding applied to the different samples.

Underground – quantitative research

First, all articles of sample 1 were entered in an Excel list. In the list, the columns captured in the following table were recorded to categorise them in the analysis.

Table 3: Categorising of sample 1

Column name	Explanation
Article number	The articles have been numbered for better clarity and classification.
Title	The title of the article
Newspaper	The publishing journal
Date	The date of publication. If the article was published again after a minimal correction (the case with online versions), the first date was selected.
Word count	This specifies how many words the article contains in total.
Theme	This is an umbrella category and represents various topics concerning the underground that are discussed. For example, the underground is used for resource allocation, but also future forms of use are proposed, or current research is reported.
Form of use	Concrete forms of use discussed, detailing the Theme. Resource allocation includes, for example, the mining of salt, gas, oil and others.

Source: own representation

The themes and forms of use were recorded indicatively from the texts. A coding overview (cf. Appendix B) with explanations of the categories has been created. There are also articles in which more than one theme or form of use are discussed at the same time. For example, Brupbacher (2016) from Der Landbote reports on the search for a suitable nuclear waste repository underground (= form of use: nuclear repository). For this purpose, geologists explore the underground (=geological knowledge). Finally, the category that was the focus of the article was chosen, in this case the nuclear repository. The finished Excel list can finally be filtered and used to evaluate the results. In Table 4 is an example from the coding scheme showing a theme and its subcategories.

Table 4: Coding scheme underground

Theme	**Explanation**	**Form of use**	**Explanation**
Community services	Services to the residential population by means of supply of utilities and disposal of things. These services are provided using the underground.	Public supply	Providing the population with water, electricity, etc.
		Geothermal energy	Heating with geothermal technology up to 3,000 meters under the surface.
		Waste disposal	Waste dumping underground.
		Bodies disposal	Cemeteries

Source: own representation

Focus technologies – quantitative research

The coding of the individual media reports was done in an Excel table. Each article of the sample occupies a row. Then, basic information on each article was entered. This allows it to make statements about certain anomalies at a later stage. This was followed by the coding. The individual columns of the sample are shown in Table 5.

Table 5: Categorizing of samples 2-5

Column name	**Explanation**
Article Number	The articles have been numbered for better classification.
Title	<u>Basic information</u>: The title of the article
Subtitle	<u>Basic information</u> If a subtitle was available, it was also copied in. Otherwise “no subtitle” as recorded.
Newspaper	<u>Basic information:</u> The publishing newspaper was recorded.
Publishing date	<u>Basic information:</u> The publication date has been added. If the article appeared on several days or was published again after a minimal correction, the first date was selected.
Journalist	<u>Basic information:</u> The name of the journalist listed as the author of the article. If no journalist was listed, "no journalist mentioned" was recorded.
Word count	<u>Basic information:</u> How many words the article contains in total.

Style of article	Classification of the style on the basis of the Research Center for the Public Sphere and Society (2022) media quality review.
Region	Basic information: The regions the article applies to.
Technology focus	Content: Whether the content of the article included the analysed technology as focus (=yes) or whether the technology was mentioned in another context but is not the focus of the article (=no).
Summary	Content: A short summary of the article
Reasoning coding technology/ underground	Coding: A short-written statement on the coding was also added. There, the reasons for the rating were explained. The coding logic regarding the overall rating is explained on page 46.
Categories technology/ underground	Coding: All coding categories were listed in a column. If the category was approached in the article, the coding in positive, negative or neutral argument is added.
Rating technology/ underground	Rating: Overall sentiment of the article in positive, negative or neutral attitude.

Source: own representation

The articles were read through in detail and categorised. Following the indicative coding procedure, a new line was initially created in the coding guide and in the Excel worksheet for each new category until article ten of each technology were reflected. Thereafter, this was followed by the pre-test which are explained in Chapter 3.2.4. The completed coding guide for each focus technology and the underground can be found in Appendix C - F. All categories are recorded in the guide, a definition of the category and the coding rule was specified following the example of Mayring (2022). According to the ordinal scale used, a category has a negative, positive or neutral value. Therefore, a description and rules for positive, neutral and negative evaluation is included for each category. An example of a category from the CCS technology is shown in Table 6.

Table 6: Coding scheme focus technologies

Category	**Definition of category**	**Coding rules**
Contribution to the solution of the climate crisis	Whether and to what extent CCS can make a significant contribution to solving the climate crisis.	Positive arguments: - CCS is an important solution to solve climate crisis - Negative emissions are unavoidable Neutral when mentioning: - CCS is neither the solution nor does it strengthen climate crisis

		- The impact of CCS is not clear yet Negative when mentioning: - CCS cannot stop climate crisis - CCS is counterproductive, as fewer emissions are thus avoided

Source: own representation

The grading and assessment of attitudes was modelled in the media analysis of van Alphen et al. (2007) and Heras-Saizarbitoria et al. (2011). The researchers also conducted media analysis in the renewable technologies sector. To ensure that uniform and comprehensible coding prevails, the following rule for grading was established.

When an article mentions an argument related to a specific category, it is assigned a score of 0, 1 or 2, corresponding to the ordinal scale used. A score of 0 represents a neutral attitude, 1 indicates a positive attitude, and 2 signifies a negative attitude. If a category is mentioned in the article without an evaluative context, it is assigned a score of 0. However, for a positive or negative evaluation, the text must explicitly present it using appropriate adjectives or by comparing it to similar technologies. An example of a ready-coded article is given as an example in Appendix G. Subsequently, the evaluation of the individual categories led to an overall rating which should indicate the overall sentiment of the article. In other words, whether it is in favour of the technology, against it or neutral. An equal number of positive or negative scores leads to a neutral evaluation. However, it is important to note that in content analysis interpretation takes precedence over the category system as the macro context should be evaluated (Mayring, 2022). Thus, the classification of text components was made according to the pragmatic theory of meaning. The theory states that users of a language share a common history and therefore have a common understanding of different linguistic terms (Preyer, 2018). The context of the discourse should be depicted by its real meaning. This is why the correct interpretation of the context lies with the author.

Finally, the coding was done again to reduce the source of errors and to check whether the results are reproduceable. The same style of coding is then done with the factors on the underground, if this was dealt with in the article.

3.2.4 Pre-test

The pre-test serves to test the formation of categories. Ideally, this is done by several coders creating the categories and comparing them after a certain number of articles and eliminating ambiguities (Hussy et al., 2013; Mayring, 2022). As this work is written by one author, comparison with other coders is not possible. Nevertheless, after ten articles, the coding of samples 2-5 was considered again in a consolidated way. For sample 1, after analysing 100 articles, a modification is made to the coding scheme. First, it is examined whether categories could be summarised or renamed. This procedure led to the summary of categories shown in Table 7.

Table 7: Pre-test

Sample or Technology	**Category 1**	**Category 2**	**New summarising category**
Underground, Sample 1	Public supply	Waste disposal	Community services
Underground, Sample 1	Workspace underground	Habitat underground	Work and residence
CST	Privately operated	Foreign participation	Legal structure of ownership
CST	Structural obstructions	Noise pollution	Side effects of project
CCS	CO_2 Leakage	Health hazard (due to CO_2 leakage)	Risk of CO_2 Leakage

Source: own representation

Subsequently, each of the articles included in the pre-test are coded again, as new categories are also added. This check ensures that the first articles are also correctly classified. This helps to get a sense of how the categories could be interpreted similarly across all the articles.

4 Results

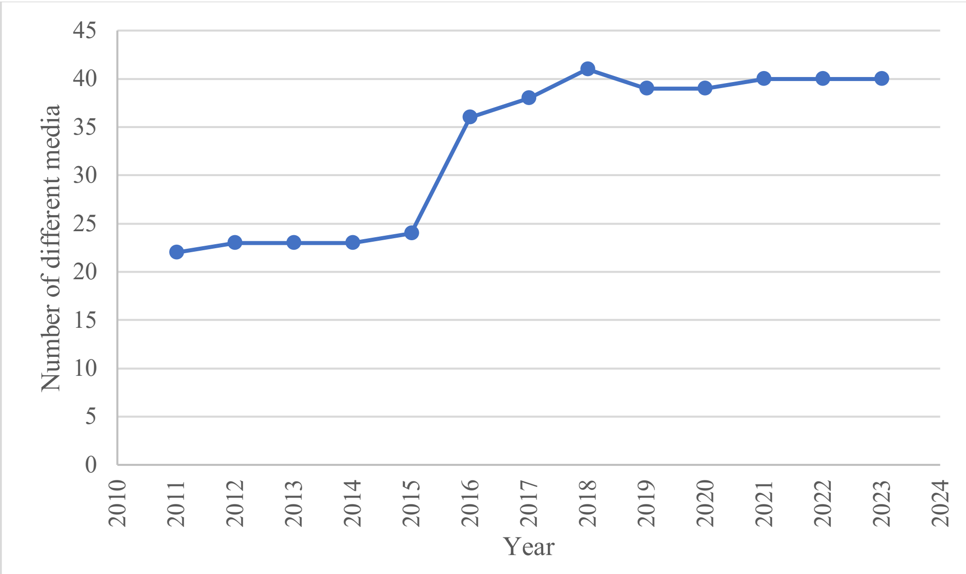
This chapter presents the results of the media analysis described in Chapter 3.2 and is structured according to the research questions. Chapter 4.1 deals with research question Q1, Chapter 4.2 addresses research question Q2 and Chapter 4.3 presents the results of research question Q3.

4.1 Quantitative reporting

Research question Q1, how often the underground is addressed and how the coverage of the underground has changed since the Fukushima nuclear disaster, is examined below. This concerns hypotheses H1 and H2, which are analysed.

Sample 1 consisting of n=1,609 articles with an average of 863.7 words per article is consulted. 42 different media have dealt with the topic of the underground with varying frequency. As described on page 41, not all media were available in the database Factiva over the entire research period. Figure 6 shows how many mediums were available in each year of the analysis.

Figure 6: Number of different media



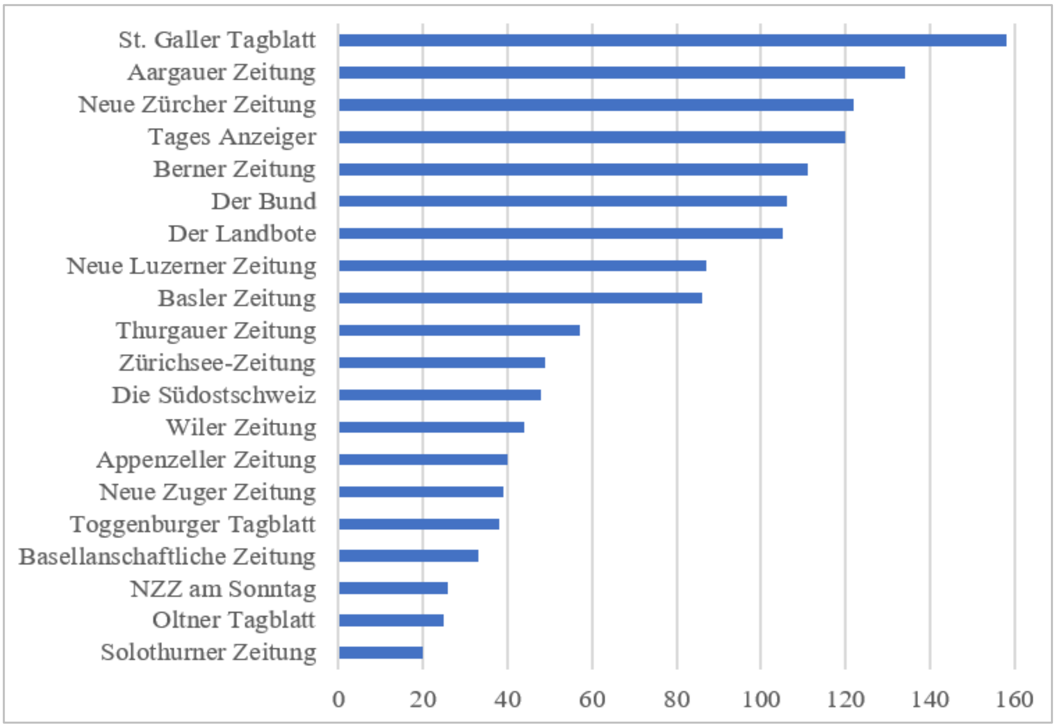
Source: own representation

At the beginning in 2011, there were 22 media sources available, while in 2023 there were 40. The largest increase in the number of available media sources took place in 2016, when 12 new media were added to Factiva. Only two media (Ostschweiz am Sonntag and Zentralschweiz am Sonntag) were removed from Factiva as they were discontinued. Details on the availability of the individual media during the study period can be found in the description of the sample (cf. Table 1). Over time, an average of 32.9 media sources are analysed. Moreover, it happens that articles are taken over exactly and published by several media at almost the same time. In sample 1 there are 184 articles that appeared several times with a total number of 661 duplicates. What is also striking is the different number of articles that a medium publishes. Figure 7 lists all media that have published more than 20 articles in the research period. As expected, the first six media were represented over the whole period. It is interesting to note the low numbers of articles from Blick (n=12) and 20 minuten (n=3) as major daily newspapers in the country[4]. Additionally, the underground topic receives the highest number of publications from two regional newspapers, namely St. Galler Tagblatt and Aargauer Zeitung. The themes

[4] Blick and 20 minuten are not represented in Figure 7 as they have not published 20 articles

discussed in Aargauer Zeitung are diverse, there is no discernible trend for a certain topic. In St. Galler Tagblatt, there is an accumulation of n=43 articles concerning DGE.

Figure 7: Articles per Medium (from 20 articles/medium)

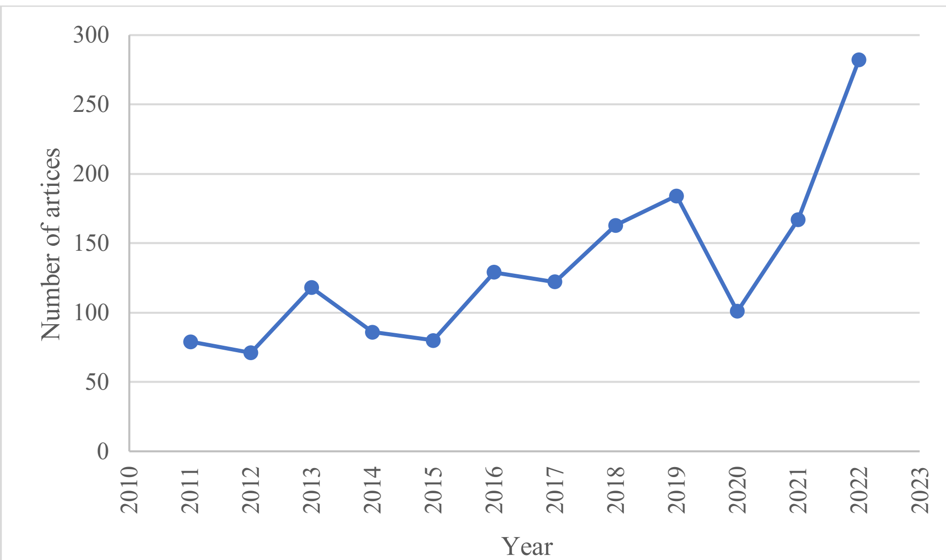


Source: own representation

Development over time

The development over time in relation to number of media articles is shown in Figure 8. However, the year 2023 was omitted, as only a few weeks were examined here and are therefore not significant for the whole year 2023.

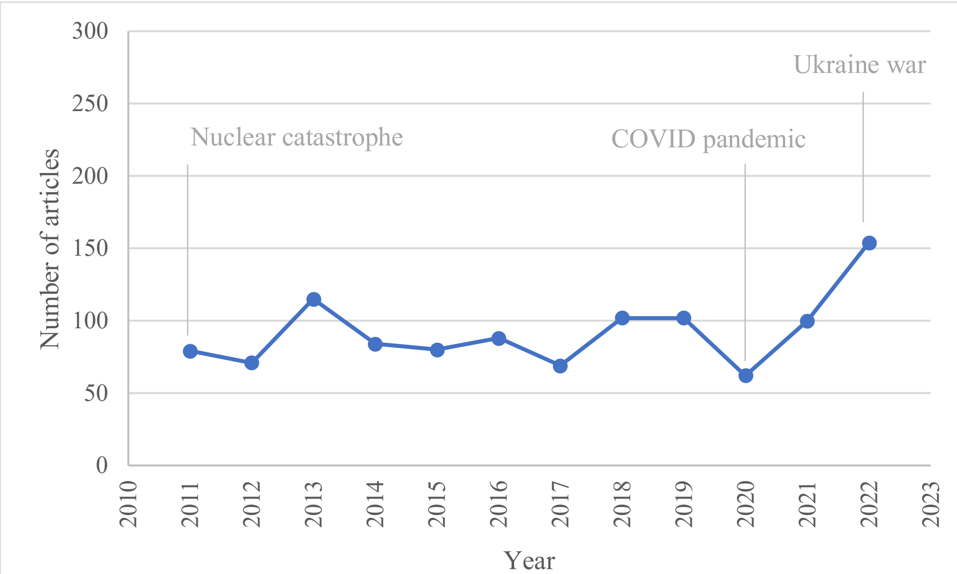
Figure 8: Development of articles over time



Source: own representation

However, as discussed at the beginning of the chapter and by means of Figure 6, not always the same number of media were represented in the sample. As the number has increased between 2011 and 2022, this could also have led to a general increase in the number of articles and thus to a bias. Therefore, in Figure 9, the development over time is shown again, but only for the media represented during the entire time. This concerns n=21 media listed in Table 1 with availability from 2011-2022. These media together reached a circulation of 1,262,006 in 2022 according to the statistics of WEMF AG (2022).

Figure 9: Development of articles over time – media limited



Source: own representation

Even if the adjusted sample is considered, an upward trend emerges. On average, if only whole years are considered (2012-2022), there were 93.4 articles each year discussing underground with a standard deviation of 31.1 articles. As shown in Figure 9, the articles in 2021 (n=100) and 2022 (n=154) exceed the average. If global crises are superimposed as in Figure 9, H1 can be examined. The research commenced with the nuclear disaster in Fukushima in 2011, prompted by the research question. Other crises that can also be observed in the media landscape according to the Research Center for the Public Sphere and Society (2022) are the COVID pandemic, which was triggered in 2020, and the war between Russian and Ukraine, which began in 2022. An effect of the nuclear catastrophe cannot be observed. Yet, during the COVID pandemic, media coverage of the underground is declining slightly. At the beginning of the Russia-Ukraine war, it is rising sharply. Whether this has a causation, however, remains questionable. As it is illustrated by Figure 10Figure 9, the most proposed form of use for the underground is the one as nuclear repository. There was a peak number of articles on underground as site for the nuclear repository in 2022. If the repository has a connection with the Ukraine war is questionable. Since these deviations from the times of crisis are not pronounced and causation cannot be established, H1 cannot be confirmed.

~~H1: After a global crisis, an accumulation of media articles on the underground and its use can be observed.~~

H1: It is not possible to establish links between global crises and underground reporting.

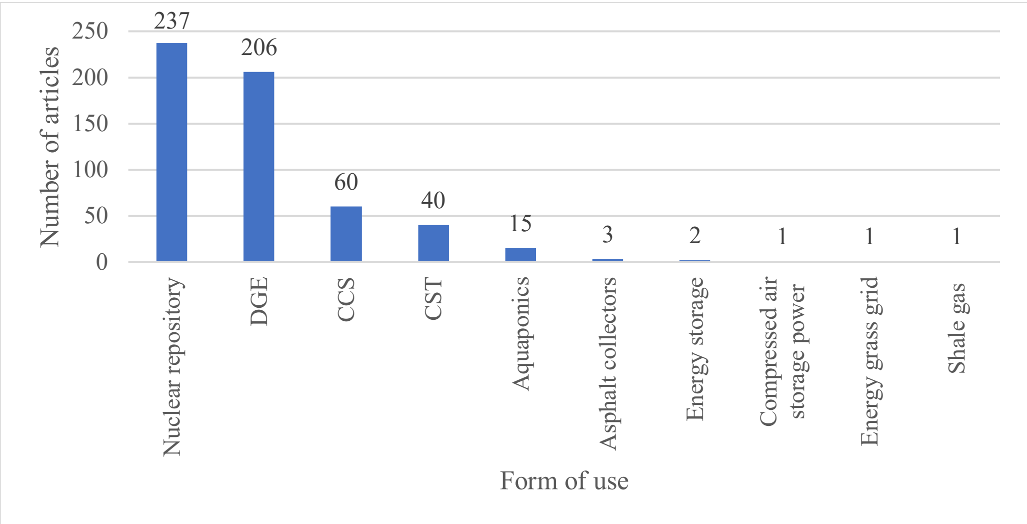
4.2 Future forms of use of the underground

To answer research question Q2, which deals with the topics of the underground news coverage, H2 and H3 are considered separately.

Hypothesis H2

To evaluate hypothesis H2, the discussed future forms of use are looked at. In total, n=566 articles of sample 1 dealt with future forms of use. The breakdown by concrete technologies is shown in Figure 10.

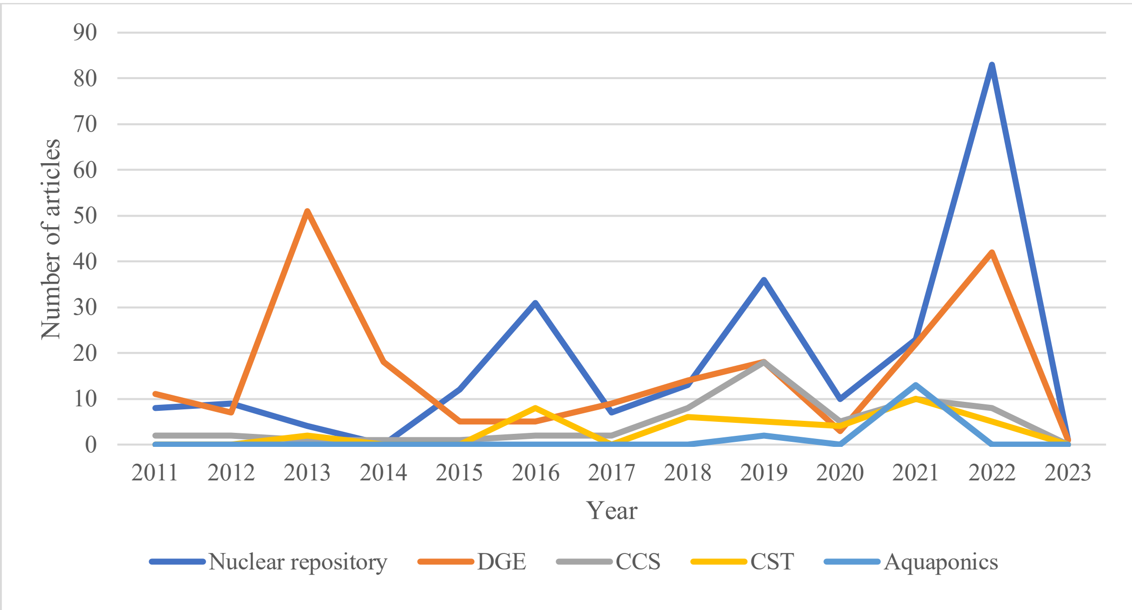
Figure 10: Articles regarding forms of use



Source: own representation

The nuclear repository is covered the most with n=237 articles. In Switzerland, the federal government formed the National Cooperative for the Disposal of Radioactive Waste (Nagra) in 2008, which is dedicated to finding a site for a nuclear repository for radioactive waste underground. The geological structures for the deposit should be as stable and impermeable as possible and the deposit should be formed at a depth of several hundred meters for the next million years (Nagra, 2022c). In relation of media coverage, the nuclear repository is followed by the three known focus technologies: DGE (n=206 articles), CCS (n=60 articles) and CST (n=40 articles). With n=15 articles, there are multiple mentions of the use for "aquaponics". This term refers to underground planting of food and organisms as well as animals in a replicated, resource-conserving habitat (Gadient, 2019). According to Gadient (2019) from Thurgauer Zeitung, arable land on the subsurface has been exhausted. It is for this reason aquaponics gains relevance in media. Asphalt collectors came up with n=3 articles. The Tages Anzeiger presents them as water pipes in the shallow underground that are used to cool the roads in summer and to heat the asphalt in winter (Fassbind, 2019). N=2 articles deal with the storage of energy underground. Finally, there are three forms of use, each of which was discussed in only one article. Läubli (2012) discusses air storage power. Hot air is stored at high pressure in salt caverns. In Der Bund the technology is described as a beacon of hope for the future of energy production. Furthermore, energy grass grid is proposed. Here, underground pipes can be used to create artificial ice on grass by cooling it (Vogt, 2013). Finally, shale gas is listed. According to Schwander (2011) from Basler Zeitung, this novel technology for extracting gas from shale layers could revolutionise the gas market. Apart from DGE and CCS, none of the proposed utilisation methods are outlined in the Federal Government's Energy Perspectives 2050 (Swiss Federal Office of Energy, 2013). Looking at the development of the leading five future uses over time, there are periodic changes. This is shown in Figure 11.

Figure 11: Articles regarding forms of use over time



Source: own representation

Generally, the number of articles increased over time. One reason is the increased number of medium analysed as illustrated in Figure 6. However, there are remarkable observations, especially in the case of the nuclear repository. From 2014 to 2021, apart from 2017 and 2018, most of the articles on the future utiliation of the underground were devoted to the nuclear repository. During this time, test drillings were carried out for possible sites (Nagra, 2022a, 2022b). A peak of articles on nuclear repositories could be observed in 2022 with n=83 articles. This is the time when Nagra has completed the site search and communicated its decision for the repository (Nagra, 2022a, 2022b). The number of reports on DGE also shows considerable fluctuations. Not only technologies and forms of use targeting sustainability are discussed. In general, these are not only energy topics that envisage the use of the underground like H3 proposed. In particular, the issue of the future nuclear repository is receiving a lot of media attention. Thus, it is even more represented in media than individual sustainable technologies.

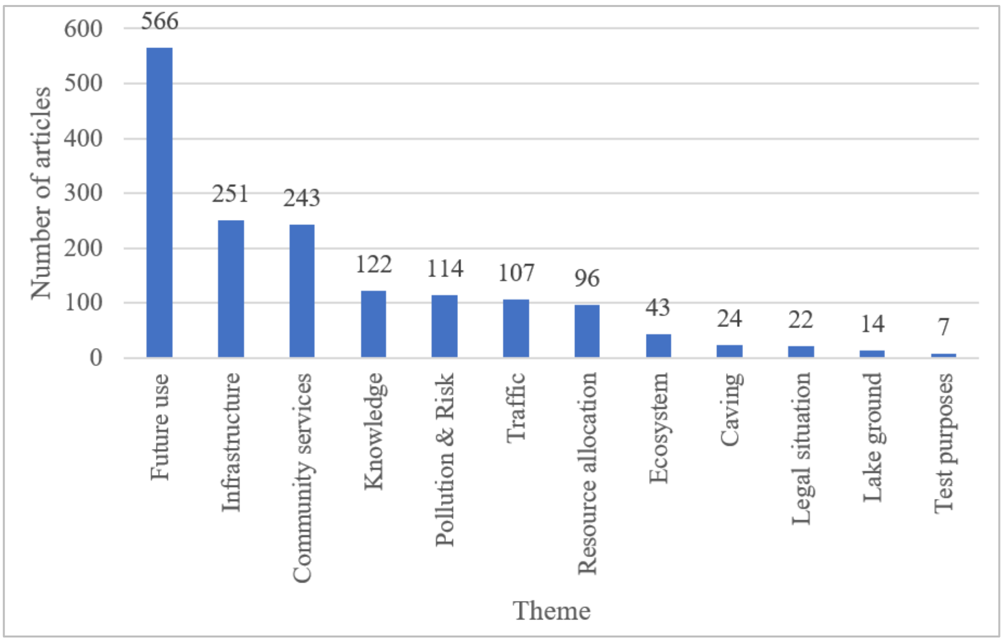
~~H2: The media discourse discusses future forms of use for the underground which are described in the energy strategy 2050~~.

H2: Not only future forms of use of the energy strategy 2050 are discussed but also for example a nuclear repository is thematised.

Hypothesis H3

In H3, the aim is to show which forms of use and themes appear in media coverage. The corresponding breakdown by themes across sample 1 is visualised in Figure 12.

Figure 12: Themes discussed in the media



Source: own representation

The graph shows the occurrence of the thematic categories. According to the coding scheme, they have been further deepened into concrete forms of use. The proposed future forms of use (Future use) have already been presented in Figure 11. The articles thematising infrastructure projects underground (n=251), were further divided. On the one hand, it is infrastructure that is available to a broad public, which is represented by n=167 articles These consist of underground stations, parking infrastructures, museums and other underground buildings. Underground work and living spaces are discussed in n=81 articles, i.e. spaces where people stay underground for longer periods of time. A minority of n=3 articles deals with underground storage spaces.

The third most common topic, the community services (n=243), are divided into concrete forms of use. There is the public supply (n=133), i.e. the supply of water, sewage, electricity and other services via underground lines. In earlier times, waste disposal was often carried out underground. N=67 articles deal with the subject of waste disposal and the pollution caused by it. In Arbon, for example, household waste was buried until 1948, which did lead to groundwater pollution today (Eichenberger, 2011). N=38 articles are dealing with the supply of heat to residents by making use of geothermal energy. However, this is not DGE due to the shallow depth of less than 3,000 meters. In addition, n=5 articles deal with cemeteries and bodies disposal underground. The three most common issues described before are related to the use of the underground. Only in fourth place are articles on imparting knowledge about the underground. This is geological knowledge (n=65) and archaeology (n=57). For example, the Basellandschaftliche Zeitung reported on excavated graves from the year 550 (Stula, 2020). The theme 'Pollution & Risk' (n=114) is also not concerned with use, but with hazards emanating from the underground, such as earthquakes or leaking toxic substances. This is followed by two more themes of underground use. Traffic (n=107) includes all tunnels for rail, car, bicycle and pedestrian traffic. Resource allocation (n=97) discusses the extraction of gas (n=56), salt (n=19), gravel (n=13), oil (n=2), ore (n=2) gemstones (n=2) and mineral water (n=1) from the Swiss underground. Caving (n=24), discussions about the legal situation (n=22), the lake ground (n=14) and test purposes (n=7) are not further subdivided and are described in detail in the coding scheme (cf. Appendix B).

The discussion about future forms of future use of the underground is the most frequently addressed topic, accounting for 35.2% of the total articles. The infrastructure in second place account for 15.6%. Since the other topics are diverse and not directly connected, it can be said that the future forms dominate the reporting and H3 can therefore be accepted.

H3: The future forms of use are lively discussed compared to other underground topics.

4.3 Portrait of underground and focus technologies

To answer research question Q3, hypotheses H4a, H4b, H4c and H4d are examined. Each of the following subchapters deals with a sub-hypothesis and a focus technology, respectively the general underground.

Cargo sous terrain

For the technology CST, n= 51 articles from 22 different media outlets with an average word count of 899.6 were analysed. The evaluation of the basic data shows that no medium is overrepresented (most represented medium: Berner Zeitung, n=6 articles). The articles mainly focus on Switzerland as a whole country (n= 27 articles), followed by the regions of the Central Platform (n=11 articles) and Eastern Switzerland (n=9 articles). What is striking is that with n=17 articles one third of the articles did not put a focus on CST. It is notable, that eight articles appeared in several media at the same time. These eight articles were published 31 times combined. N=51 articles thematise CST and contain a total of n=186 positive arguments against n=69 negative arguments and n=108 neutral arguments. This leads to an average of 7.1 positive, negative or neutral arguments per article. The positive and negative scores can be seen in Table 8 and Table 9, in addition with the number of mentions (n) and the percentage of the total arguments.

Table 8: Positive statements regarding CST

Positive Statements	**n**	**Percentage**
Visionary, innovative project	35	18.8
Efficient & flexible logistics	27	14.5
Relaxation of scare space above ground	25	13.4
Environmentally friendly project	23	12.4
Government involvement	16	8.6
Legal structure of ownership	14	7.5
Political support	11	5.9
Side effects of project	10	5.4
Feasibility	9	4.8
Economic operation	7	3.8
Investment	4	2.2
Clear legal situation	4	2.2
Transportation costs	1	0.5
Total	**186**	**100**

Source: own representation

Table 9: Negative statements regarding CST

Negative Statements	**n**	**Percentage**
Feasibility	12	17.4
Political support	12	17.4

Funding of the project	11	15.9
Side effects of project	10	14.5
Unclear legal situation	7	10.1
No relaxation of scare space above ground	6	8.7
Investment	5	7.2
Legal structure of ownership	2	2.9
Limited impact on traffic congestion	2	2.9
Legal structure of ownership	1	1.4
Governmet involvement	1	1.4
Total	**69**	**100**

Source: own representation

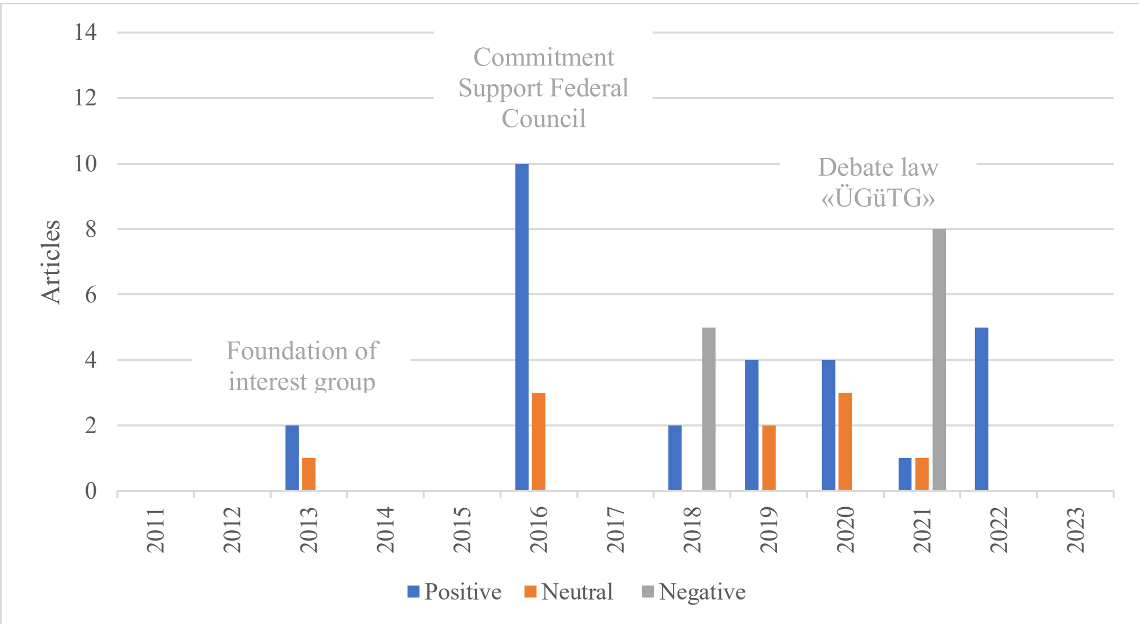
The most important positive argument for CST is that it is a visionary project (n=35). This argument highlights the project, but also the technology itself as promising. Finally, the project is praised for representing Switzerland's innovative strength. In NZZ am Sonntag, CST is presented as "not only a solution to the impending traffic collapse on the roads, but also a lighthouse project with which Switzerland could once again present itself internationally as a centre of innovation." (Friedli, 2016, para. 6). In addition, it is discussed that the project brings strong advantages in terms of efficiency and flexibility for logistics (n=27). Professor Stölzle of the University of St. Gallen, for example, mentions in an article of the Handelszeitung sending even small consignments using CST is worthwhile (Vonplon, 2016). Not only does this make logistics more flexible, but it also relieves the burden on the roads (n=25). Only in fourth place of the positive arguments is it mentioned that the project also has a positive effect on the environment (n=23). This is due to the shift from the road to electronically powered vehicles in the underground. The four arguments have a share between 10% and 20% each of all the arguments. Combined, they account for a share of 59.1% of all arguments. The remaining 40.9% are distributed over nine different topics. Of these topics, each has a share of less than 10% of the total arguments and are mentioned 1-16 times in the CST sample. On the negative side, the first four arguments that are mentioned most often are relatively evenly represented and together account for 65.2% of all negative arguments. The feasibility of the project is questioned most. In n=12 articles it is questioned whether this project can ever be realised. There are also voices from politics that criticise the project (n=12 arguments). In addition, there are concerns about the availability of the required founding (n=11 arguments). N=10 articles shed light on possible negative side effects. For example, more traffic above ground in the villages with CST hubs is mentioned (Felber-Eisele, 2021).

These four main negative arguments are followed by seven other arguments, each of which has a share of 10% or less of the overall result. Finally, the analysis of the individual arguments led to the following overall assessment of attitude.

Positive attitude	n=28 articles, 54.9%
Neutral attitude	n=10 articles, 19.6%
Negative attitude	n=13 articles, 25.5%

A comparison over time in Figure 13 shows that there are differences over the period from 2011 to 2023. The peak of positive articles in 2016 is striking. These remarkable observations are complemented in Figure 13 with events of the project presented in Chapter 2.3.1. For example, the commitment of support from the federal council in 2016 was a milestone for the project. Also interesting is that the first article on CST was published in 2013 (03.03.2013). Even though not all newspapers were represented from the beginning, which explains the increase in articles on CST to a certain extent, there still seems to be conspicuousness here.

Figure 13: Attitude towards CST



Source: own representation

Based on the results shown in Figure 13, hypothesis H4a can be refuted. The presentation of CST is predominantly positive with 54.9% positive articles. Even though there was an accumulation of negative articles in the second half (2019-2021) of the analysed period, the majority is overwhelmingly positive even in this phase.

~~*H4a: The project Cargo sous Terrain is presented in a neutral light in Swiss media discourse.*~~

H4a: The project Cargo sous Terrain is presented positively in Swiss media discourse.

Deep geothermal energy

Sample 3 on DGE includes 29 media, which published n=228 articles with an average word count of 813.1. In this sample, there were 26 articles that were published by several media, resulting in a total of 93 duplicate publications. Subsequently, the authors of these duplicates tend to have a higher frequency of appearances, but there is no striking accumulation of publishing journalists here either. However, it is worth mentioning that an accumulation of articles that concern the region of St. Gallen, namely n=47 articles (=20.6%). They relate to the test drillings in St. Gallen. Thus, the St. Galler Tagblatt is the dominant medium with n=47 articles (=20.6%). Otherwise, reports on region Jura (n=17 articles) and Thurgau (n=16 articles) are also more frequently represented. Finally, n=37 articles mention the DGE project in Haute-Sorne (Canton Jura). The publishing media are otherwise relatively evenly distributed. For the time being, there have been n=204 articles with the writing style of a report published on DGE. Only isolated interviews (n=13) and opinion articles (n=9) can be mentioned. What is less occurring with DGE than CST is the number of articles that do not treat DGE as a main focus; n=33 (14.5%). Most articles discuss energy production in combination with heat production (n=119 articles) or do not specify whether energy or heat production is addressed (n=63 articles). Only n=29 articles on DGE deal with energy production only and n=17 articles with heat production only. The 228 articles thematising DGE include a total of n=651 positive arguments divided into 20 different categories. This is compared to n=538 negative arguments divided into 21 categories. N=548 neutral arguments were included. This led to an average of 7.6 positive, negative or neutral arguments per article. In Table 10 and Table 11, the positive and negative arguments are listed.

Table 10: Positive Statements regarding DGE

Positive Statements	**n**	**Percentage**
Government involvement & support	98	15.1
Environmental friendly & renewable	88	13.5
Essential power supply	71	10.9
Support from science	57	8.8
Good geological conditions	46	7.1
Feasibility of technology	45	6.9
Political support	35	5.4
Availability of geological data	35	5.4

Continous availability, regeneration	29	4.5
Acceptance of habitants	29	4.5
Visionary	24	3.7
Good experiences from previous projects	22	3.4
Clear legal situation	18	2.8
Positive side effects	15	2.3
Self-sufficient power supply, no dependencies	13	2.0
Economic operation of DGE plants	9	1.4
Earthquake risk eliminated	8	1.2
Low energy costs out of DGE	7	1.1
Low investment risk	1	0.2
Low investment costs	1	0.2
Total	**651**	**100**

Source: own representation

Table 11: Negative Statements regarding DGE

Negative Statements	**n**	**Percentage**
Bad experiences with previous projects	99	18.4
Earth quake risk	92	17.1
Missing acceptance of habitants	50	9.3
Missing feasibility of concrete projects	48	8.9
High investment risk	33	6.1
Missing geological data	31	5.8
Bad geological conditions	30	5.6
High investment costs	28	5.2
Negative side effects	24	4.5
No political support	23	4.3
Legal insecurity	18	3.3
No significant contribution to power supply	13	2.4
Conflicts of use	11	2.0
Feasibility of technology	9	1.7
High energy costs out of DGE	9	1.7
No economic operation possible	8	1.5
No government involvement & support	7	1.3
Not regenerative	2	0.4
Not environmental friendly & renewable	1	0.2
No visionary technology	1	0.2
Dependencies on abroad	1	0.2
Total	**538**	**100**

Source: own representation

More than 10% of all arguments are on the support of the government (n=98 arguments). Despite negative arguments and happenings, government continue to support DGE. For example, media mentions the negative experiences with previous projects most often as negative argument (n=99 arguments). Also, earthquake risks (n=92 arguments) are highlighted.

Environmentally friendly and renewable electricity production is positively highlighted in n=88 articles. With n=71 arguments, and thus over one tenth of all positive arguments, essential power supply is mentioned. Lampart (2011), for example, estimates the energy production resulting of DGE in Switzerland to be 30%, of the total production. This corresponds to approximately 58 terawatt hours. Furthermore, many positive as well as negative arguments make up individually single-digit percentage share, of the total. Those less prevalent arguments are further described in the coding guidelines in Appendix D. The overall rating of attitude for each article is presented in the following results:

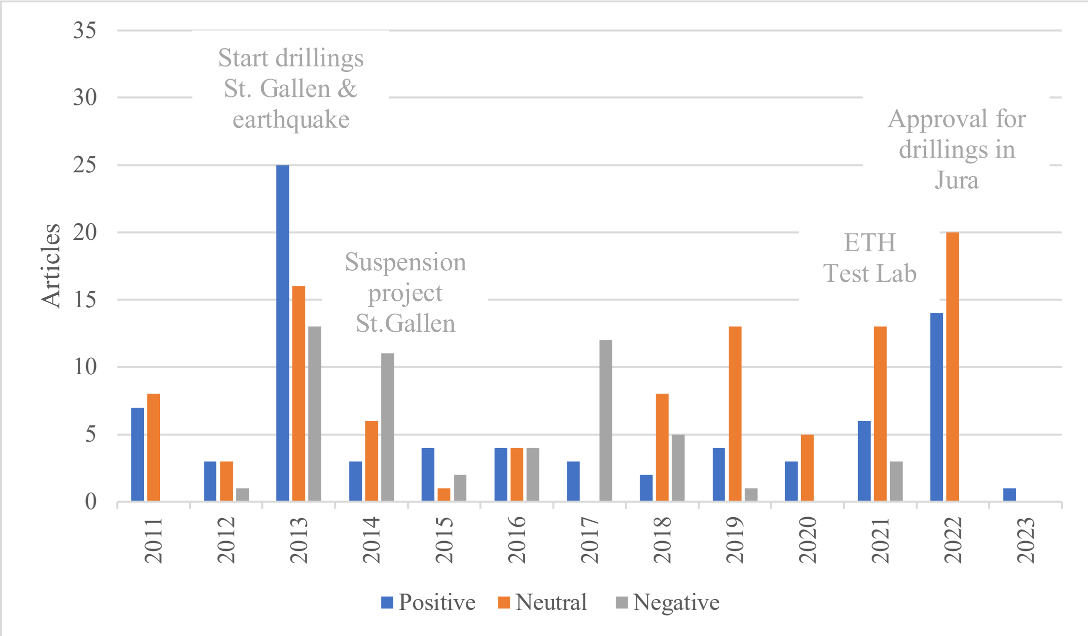
Positive attitude n=79 articles, 34.7%

Neutral attitude n=97 articles, 42.5%

Negative attitude n=52 articles, 22.8%

The development over time is displayed in Figure 14. Milestones of the development of DGE discussed in the theory have been added. The temporal analysis shows that both, the negative and positive articles on DGE, became less common over time. Conversely, neutrally written articles became more common and starting from 2018 on represented the dominant attitude of the media coverage. Particularly in 2013, during the commencement of test drilling in St. Gallen, the media coverage exhibited a significant and predominantly positive tone, accounting for 46.3% of the total reporting. Neutral arguments accounted for 29.6%, while negative arguments constituted only 24.1%. The negative articles finally become dominant (55%) in 2014 compared to the neutral (30%) and positive (15%) articles. This was during the suspension of the St. Gallen project. Only from the year 2019 to 2023, the positive articles (33.7% in this period) consistently outweigh the negative articles (4.8% in this period).

Figure 14: Attitude towards DGE



Source: own representation

The analysis thus leads to neutral articles being overrepresented. Followed by positive articles and finally the negative articles count with a greater distance. The presentation is therefore rather neutral and not negative as assumed in the hypothesis.

~~H4b: Deep geothermal energy tends to be portrayed negatively in Swiss media discourse.~~

H4b: Overall, deep geothermal energy tends to be portrayed rather neutrally in Swiss media discourse.

Carbon capture and storage

What is noticeable when looking at the sample 4 of CCS is the striking difference to sample 1. In sample 1, CCS is mentioned 60 times as a future form of use of the underground. Using the defined search terms for CCS from Chapter 3.2.1 to generate sample 4 only 27 articles from 18 media can be found. The lack of mentioning the search terms in the articles lead to a discrepancy of 33 articles between sample 1 and sample 4. The media articles often do not use terms but adjectives to describe the procedure of CCS. An example of this is a report in the Neue Luzerner Zeitung, which describes CCS, but only uses paraphrases such as "filtering greenhouse gas out of the air" (Lorenz-Meyer, 2018, para. 2), “removing climate gases from the atmosphere” (Lorenz-Meyer, 2018, para. 1) or “the gas (…) which is pumped 700 metres deep underground” (Lorenz-Meyer, 2018, para. 3). This discrepancy between sample 1 and filtered samples 2 and 3 could not be observed at all in CST and DGE. In addition, the sample of 27 articles also includes three articles that appeared in several media. A total of 15 articles were published as duplicates. Moreover, 17 articles do not have CCS as a focus. Otherwise, the data is relatively heterogeneous. Various media and authors published articles with an average word count of 947. In sample 4, there are n=99 positive arguments, n=40 neutral arguments and n=75 negative arguments mentioned in the articles. The average amount of arguments per article is 7.9. Table 12 and Table 13 show the identified positive and negative arguments respctively.

Table 12: Positive Statements regarding CCS

Positive Statements	**n**	**Percentage**
Solution to fight climate crisis	23	23.2
Massive CO_2 reduction	21	21.2
Good geological conditions	11	11.1
CO_2 leakage risk under control	11	11.1
Feasibility	7	7.1
Government involvement & support	7	7.1
Support from science	6	6.1
Political support	4	4.0
Promising technology	3	3.0
No significant efficiency reduction of power plants	2	2.0
Good experiences from other projects	2	2.0
Many possible locations in Switzerland	1	1.0
Market-ready prices for CO_2 reduction	1	1.0
Total	**99**	**100**

Source: own representation

Table 13: Negative Statements regarding CCS

Negative Statements	**n**	**Percentage**
Difficult site search	12	16.0
Missing acceptance in society	12	16.0
Earthquake risk	10	13.3
Rejection of environmental groups	7	9.3
Bad geological conditions	6	8.0
High costs for CO_2 reduction	6	8.0
Risk of CO_2 leakage, health hazard	5	6.7
Feasibility	4	5.3
Development & investment costs	4	5.3
Efficiency reduction of power plants	3	4.0
Unclear legal situation	2	2.7
Does not solve the climate crisis	1	1.3
Excessive implementation timeline	1	1.3
Huge space requirement underground	1	1.3
No political support	1	1.3
Total	**75**	**100**

Source: own representation

Considering the positive arguments, two related arguments are mentioned first. On the one hand, CCS is seen as a solution to the climate crisis (n=23 arguments). On the other hand, the potential for CO_2 reduction is estimated to be massive (n=21 arguments). The arguments are mentioned separately from each other and are strongly emphasised. The geological conditions for storage in Switzerland are assessed as good (n=11 arguments), while negative arguments highlight the lack of acceptance among the Swiss society (n=12 arguments). Furthermore, the difficulty of finding a suitable site (n=12 arguments) is mentioned. According to an article of Der Bund, it will not be possible to store all CO_2 emitted in Switzerland inland and, in addition, the location search in Switzerland is challenging due to difficult geological conditions (Läubli, 2021). Finally, fear that CCS can cause earthquakes exists (n=10 arguments). Even though many negative arguments can be found, the overall attitude of the articles towards CCS is very favourable and positive. This leads to the following assessment.

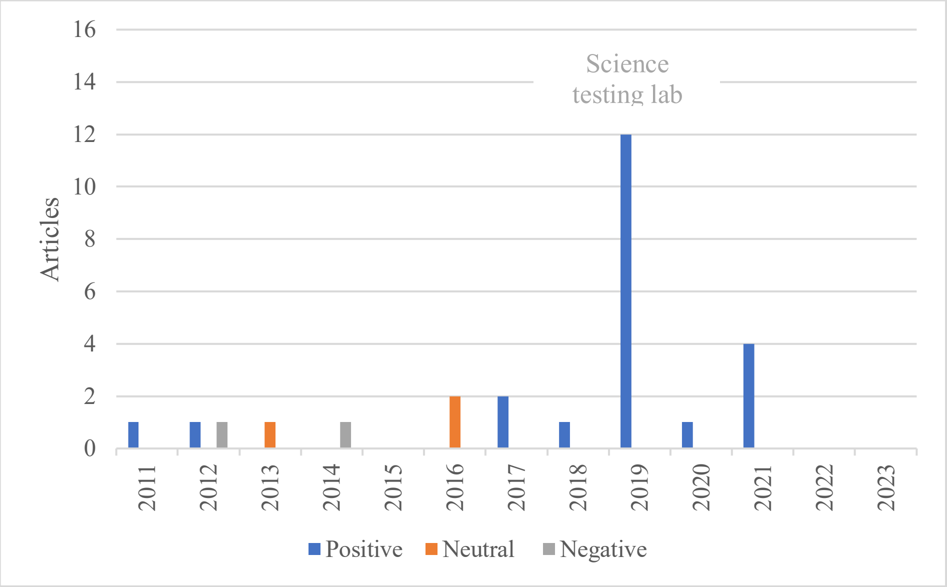
Positive attitude n=22 articles, 81.5%

Neutral attitude n=3 articles, 11.1%

Negative attitude n=2 articles, 7.4%

The development over time in Figure 15 shows that the attitude of the articles is distributed relatively evenly over the years. However, there is an accumulation of articles in 2019. This coincides with the public presentation of an ETH testing lab.

Figure 15: Attitude towards CCS



Source: own representation

In summary, the attitude of the articles towards CCS is very positive. This leads to the rejection of hypothesis H4c.

~~*H4c: Carbon Capture and Storage tends to be portrayed negatively in Swiss media discourse.*~~

H4c: Carbon Capture and Storage is portrayed very positively in Swiss media discourse.

The underground

The sample 5 for analysing the attitude towards the underground consists of n=171 articles. Four duplicates (identical articles that were present in two samples of the focus technologies) were removed. In addition, the sample also includes 20 articles that appeared in several media. A total of 74 articles were published as duplicates. The average word count of the articles is 834. The articles contain n=142 positive, n=104 neutral and n=113 negative arguments. The average amount of arguments per article is 2.1. The positive and negative arguments of the articles on the underground in general and its use are listed in Table 14 and Table 15 respectively.

Table 14: Positive statements regarding the underground

Positive Statements	**n**	**Percentage**
Good geological structures	42	29.6
Good data availability	22	15.5
Government involvement & support regarding the underground use	16	11.3
Spatial planning resource	15	10.6
Clear legal situation	12	8.5
Political discussions, support for underground use	10	7.0
Support for tunneling underground	6	4.2
Positive environmental impact of use of the underground	5	3.5
Innovation & engineering skills	4	2.8
Social factors	4	2.8
Mythical	3	2.1
Positive side effects of underground use	3	2.1
Total	**142**	**100**

Source: own representation

Table 15: Negative statements regarding the underground

Negative Statements	**n**	**Percentage**
Lack of data availability	33	29.2
Legal insecurity	22	19.5
Negative side effects of underground use	21	18.6
Conflicts of use	15	13.3
Political discussions, against the use of the underground	7	6.2

Bad geological structures	7	6.2
No government support / involvement regarding the underground use	3	2.7
Negative environmental impact of underground use	2	1.8
No spatial planning resource	1	0.9
Disapproval for tunneling underground	1	0.9
Social factors	1	0.9
Total	**113**	**100**

Source: own representation

There is much discussion, both positive and negative, of the data availability on the Swiss underground (n=22 positive arguments, n=33 negative arguments). In addition, 22 arguments thematise the uncertain legal treatment of the underground. Potential positive (n=3 arguments) and negative side effects (n=21 arguments) of the use of the underground are discussed. Jäggi (2020, para. 3) cites the following "the underground has long been used for infrastructures that would interfere with the surface" which can be classified as a positive side effect. In a negative light, danger from man-made earthquakes caused by underground usage are mentioned (Berner Zeitung Online, 2017). Despite the mentioned fears, the geological conditions in Switzerland are generally considered to be good (n=42). Compiled, the following attitudes towards the underground can be observed.

Positive attitude n=78 articles, 45.6%

Neutral attitude n=52 articles, 30.4%

Negative attitude n=41 articles, 24.0%

Thus, the underground and its use are mostly presented in a positive or neutral light. Nevertheless, negative opinions and uncertainties about the use of the underground can be observed. Overall, a positive attitude towards the use of the underground can be detected.

~~*H4d: The underground tends to be portrayed neutrally in Swiss media discourse.*~~

H4d: The underground tends to be portrayed rather positively in Swiss media discourse.

In summary, all hypotheses have now been addressed. Table 16 provides an overview of the hypotheses and the results of their investigation.

Table 16: Final review of hypotheses

Nr.	Hypothesis	Result
H1	After a global crisis, an accumulation of media articles on the underground and its use can be observed.	**Refuted** It is not possible to establish links between global crises and underground reporting.
H2	The media discourse discusses future forms of use for the underground which are described in the energy strategy 2050.	**Refuted** Not only future forms of use of the energy strategy 2050 are discussed but also for example a nuclear repository is thematised.
H3	The future forms of use are lively discussed compared to other underground topics.	**Confirmed**
H4a	The project Cargo sous terrain is presented in a neutral light in Swiss media discourse.	**Refuted** CST is presented positively
H4b	Deep geothermal energy tends to be portrayed negatively in Swiss media discourse.	**Refuted** DGE is presented rather neutrally
H4c	Carbon capture and storage tends to be portrayed negatively in Swiss media discourse.	**Refuted** CCS is presented very positively
H4d	The underground tends to be portrayed neutrally in Swiss media discourse.	**Refuted** The underground is presented rather positively

Source: own representation

4.4 Quality criteria

In research it is important to prove the observance of the quality criteria. They guarantee constancy in the research process. In quantitative research the quality criteria reliability, validity and objectivity are usually proven (Hussy et al., 2013; Mayring, 2022). Objectivity of the evaluation is achieved when the results are independent of the researcher. However, the objectivity of the interpretation is difficult to prove. Since qualitative research often involves coding work, there is room for interpretation. Interpretation is even desired in some cases (Hussy et al., 2013; Mayring, 2022). Reliability stands for consistent results that can be replicated. Usually, in qualitative research the intercoder reliability is used for this reason (Mayring, 2022). This means that either the entire analysis or parts of it are conducted by several coders. This can be analysed and interpreted by calculating the statistical measure Krippendorff's Alpha. While the entire coding of this thesis was done twice, so that the results of one author are congruent, independent coding by several individuals would be preferable. Validity stands for the transferability of the results to a larger totality (Hussy et al., 2013). It is also important to understand that this study focuses exclusively on Switzerland. Thus, the conclusion drawn may not be applicable to countries or regions outside of Switzerland. Because of the interpretive work needed when it comes to coding, researchers disagree on whether the classical quality criteria can be applied (Hussy et al., 2013; Mayring, 2022).

5 Discussion

In this chapter, the results of the study are acknowledged. Now comes the critical appraisal of the results. First the quantitative and qualitative results of the underground and then the qualitative results of the focus technologies are discussed.

5.1 The underground

First, the quantity of articles was evaluated. Since this is an exploratory procedure, the results cannot be put in relation to other studies. No similar research that could be used as a comparison was found. Nevertheless, many media articles in the period from 2011-2023 could be found and were assessed as part of this thesis. For example, not only daily newspapers reported on the underground, but also magazines like Glückspost and the Beobachter. Such magazines tend to focus on explosive topics rather than daily news.

Furthermore, it is also interesting to see how the number of articles has changed over time. A significant increase in 2022 can be identified. The additional media attention was much higher than after the Fukushima disaster. No other extreme anomalies impacting the number of articles on the underground could be detected in the analysed time period (e.g. pandemic influence in 2020 was low). An unequivocal explanation for increase in the number of articles in 2022 could not be found. A possible cause might be the Russia-Ukraine war. Energy became scarce due to the war, which led to people looking for alternatives (Kuzemko et al., 2022). Suitable alternatives might be the discussed forms of use of the underground from the federal government's energy strategy for a sustainable energy production. But what may also have contributed to the increase in articles on the underground in 2022 is the decision on where to build Switzerland's nuclear repository in the underground (Nagra, 2022b). Whether the increase in articles on the nuclear repository could also be put in relation to a NIMBY effect would have to be investigated in further research. While a need for a nuclear repository is recognised by the Swiss society, one would not want to have this under one's place of residence (S. Carley et al., 2020; Devine-Wright, 2009). This circumstance may have fuelled the discussion and increased media interest. Regional media are relatively strongly represented in the sample and published a high number of underground articles (cf. Figure 7). Regional magazines tend to deal with projects that have an impact on their region. Accordingly, it is assumed that they are also the voice of the society regarding the acceptance of projects in their region. The big and far-reaching media 20 minuten and Blick do not seem to be taking much notice of the underground and only published few articles on the topic. Other media with large coverage, which have received a higher quality score from the Research Center for the Public Sphere and Society, such as the NZZ, report on the underground usage actively. The question, therefore, arises as to whether the underground appeals more to higher quality media and is deemed too uninteresting for tabloid media.

It is striking that a relatively high number of media republish articles from other media. By being published multiple times, an article gains more coverage and weight. For example, an article on an underground project published by an Eastern Switzerland outlet might get republished by eastern Switzerland media (e.g. Thurgauer Tagblatt, Toggenburger Zeitung, St. Galler Zeitung and Appenzeller Zeitung). The republication of articles also accentuates a characteristic of the media landscape in Switzerland. Despite its small size, Switzerland seems to be dominated by regional media. Even nationwide consumed media such as Blick and the Tages Anzeiger are not exclusively responsible for opinion formation (Jørgensen, 2002; Keller, 2011).

Finally, it would be interesting to compare the results from the quantitative analysis on the underground to another topic to assess the relevance of the underground. Such a comparison could underline the relevance of the underground and help to classify it.

On the thematic classification of the underground discussed in the Swiss media, the results reflect expectations mostly. The focus is on the future forms of use. Apart from the dominance of the nuclear repository, mainly the mentioned forms of use from the federal government's Energy Strategy 2050 were discussed. Further reporting apart from future uses has mainly been concerned with local infrastructure projects. Underground structures such as railway stations also continue to be present and generate media interest. The main thing that stands out here is that the focus is on the use of the underground in different ways. However, on a smaller scale, the underground also seems to be attracting interest from the society. Finally, knowledge about the underground, the ecosystem and relics from earlier times is also published.

Attitude towards the underground

When looking at the results of the attitude towards the underground it should be noted that the underground was not the focus of these articles, but the sample was drawn from the focus technologies. This is probably the main reason why average number of arguments mentioned in an article is much lower than in the samples of CST, DGE and CCS. It would be interesting to see whether also a rather positive attitude would have been achieved if articles with the focus on the underground had been analysed.

The findings of this thesis regarding the public's attitude towards the underground align with the quantitative analysis of the discussed topics as presented in the first section of this chapter. The underground is not described as very mystical, gloomy or even fairy tale (Gross, 2013; Ulmi, 2018). It is rather a realistic discussion in which the underground is seen as another building area. Good data availability, legal certainty and suitable geological conditions are necessary for building infrastructure in the underground. Suitable conditions are the most frequently cited arguments for or against the use of the underground as a space for building. The results of this thesis show that the data quality can be considered rather poor for planning projects. However, this is only partially supported by the theory. According to swisstopo (n.d.) and Vahlensieck (2018), the Swiss underground is at least well mapped for two thirds of the country and implies comprehensive data is available. However, studies quoted in the state of knowledge and results from this thesis agree on the legal situation. The national legal situation is classified as deficient (Federal Geological Commission, 2022; Lateltin, 2022). The geological conditions are predominantly considered positively in the media. However, the topic of geological conditions is multifaceted, and the assessment is very dependent on the form of use or evaluation approach.

In summary, in Swiss media the focus has been more on the attitude of the society towards the use of the underground rather than the general attitude towards the underground. While the result of this thesis represents everything that was discussed in the articles on the underground, the focus has been somewhat blurred. Media discourse do not discuss how people feel underground. In contrast, the attitude of the society towards this topic has garnered significant attention in scientific discussion (Wang et al., 2023). Whether feelings of the society when being underground will receive more attention in media once more infrastructure is moved underground remains to be seen. Finally, the Federal Geological Commission (2022) states in its strategy for the underground that increased use is expected in the future. Since the strategy was only published at the end of 2022, it remains to be seen whether the well-being of people underground will also find its way from science discussions into the media coverage.

5.2 Focus technologies

The attitude towards the three focus technologies is discussed below. This should lead to the answer to research question Q3.

Cargo sous Terrain

At the moment of writing, there is no existing scientific literature on the society's attitude towards CST or general underground transportation systems. This makes it difficult to classify the positive results of the CST project. However, the debate on the project has brought other aspects than DGE and CCS to the forefront. It is not the technology or the environmental aspect that is most discussed but solving a problem above ground. Namely, the overcrowded roads and inefficient and inflexible logistics systems. In this context, the underground is seen as a way out of a tangible problem. Having the solution underground and thus out of sight seems interesting to the society. This also fits with the fact that the first articles on CST were only published in 2013. There seems to be no accumulation of articles following the environmental disaster in Fukushima and the associated federal energy strategy. While it is acknowledged that CST is an environmentally friendly project, this does not seem to be the focus. The focus is much more on solving a problem above ground.

The finding that the society could view CST in a positive light might also have led to the adoption of the ÜGüTG law, which serves as basis for CST. As has been discussed in Chapter 2.2.2, the Swiss society can take a referendum against newly implemented laws. The research shows that this is often done (Kaufmann et al., 2016). However, referendum was not used in the context of the introduction of ÜGüTG. According to Marquis et al. (2011) and Tresch (2012), a lot of opinion building on laws happens through the media. That no referendum was taken, therefore, is in line with the findings of this thesis. The media spread a positive image of CST, which could be the reason why the society was convinced about the law and did not take the referendum. According to the results of this thesis, what contradicts this account is the lack of political support. Politicians often publicly question CST about the financing and the feasibility of the project. So, is the media image perhaps only this positive because a broad spectrum does not believe in the implementation of CST anyway? This would be supported by the results of DGE that the more advanced and concrete the project was, the more negative arguments were added.

These assumptions would need to be further verified and a causality between project progress and acceptance measured. This could be another important step for the project as there are still many uncertainties.

Deep geothermal energy

The survey showed that DGE is viewed rather neutrally. Even though the attitude got increasingly negative. Originally the attitude was positive until the test drillings in St. Gallen. The media discussed the failed project in St. Gallen, but did not use its voice to negatively frame deep geothermal energy. With some disillusionment, the advantages and potential of DGE were nevertheless acknowledged. This result is surprising, as previous media research in Switzerland indicated a negative perception. The investigation of Stauffacher et al. (2015) detected more negative arguments than positive arguments about DGE. On the one hand, there might be a discrepancy here because not the same media as in this thesis were examined. This study includes many local media, whereas Stauffacher and his colleagues analysed uniquely NZZ and Tages Anzeiger articles. Furthermore, their study analysed media articles published between 1997-2013. An important factor during that time period was the inception and implementation of the Deep Heat Mining project in Basel (2006). Whereas the analysed period of this study is significantly impacted by the St. Gallen project (2013) and its high media attention that lasted for several years. What stands out, however, is that although the project in St. Gallen was a damper, it did not lead to the same reaction as the failure in Basel. As Giardini (2009) and Spada et al. (2021) write in their research papers on DGE, Basel led to a global outcry. For the test drillings in St. Gallen this was not the case. The earthquake in St. Gallen was relatively strong (Richter scale value 3.6). The failure of the project lead to negatively charged reporting in the short term which is congruent with Stauffachers results. However, in the long run, the attitude of the society towards DGE returned to neutral. The reasons for this are not entirely clear. The author sees a possible explanation in the communication of the city of St. Gallen. Good realistic communication and a consistent support from the authorities might have shaped the attitude of the society towards DGE. After all, the most frequently mentioned positive argument was that the federal government and the cantons continue to support DGE and recognise its potential. Research has called for better risk assessments to be carried out (Hirschberg et al., 2014; Mena et al., 2013; Spada et al., 2021). To what extent this has been done and how it changed the communication of risks remains open. Also, the St. Gallen electorate clearly approved the project, so a NIMBY effect could not be observed beforehand and the experience from Basel did not seem to have played an important role. The deviating results of this study and that of Stauffacher et al. (2015) could therefore be related to the specific projects in Basel and St. Gallen.

To conclude, there is an outlook for DGE. Switzerland has limited geological conditions for hydrothermal technology (GeoEnergy, 2022). As it is often cited in literature, EGS technology needs more research (Hirschberg et al., 2014). With the opening of the ETH testing labratory, a milestone has been reached. It remains questionable, however, in what timeframe functioning systems can really be expected in Switzerland. The goals set in the federal government's energy strategy are ambitious, and it remains to be seen whether research and the private sector can contribute to achieve them. This study does not consider the media image to be the inhibiting factor. The society is not negatively influenced by media. However, the acceptance and especially the acceptance of habitants must be further investigated and assessed. The acceptance of the society is an important and decisive factor for the successful establishment of DGE in Switzerland (Knoblauch et al., 2019).

Carbon Capture and Storage

The results of the analysis of CCS indicate that CCS is the least known and least tangible technology to the Swiss society out of the three technologies analysed. The fact that most of the articles on CCS do not appear when using related search terms is interesting. On one hand, this is not ideal, as it reduces the size of the sample used to express attitudes towards CCS. On the other hand, it highlights the interesting finding that no general terms are being used when it comes to CCS. Most terms related to CCS seems to be of technical nature and not widely used in common language. The term CCS includes various technologies and processes, including alternatives to underground storage, for mitigating CO_2 from the atmosphere. For instance, pre-combustion CO_2 capture and oxyfuel methods are notable technological approaches in this regard. Even if the term and the functionality of CCS have not yet become known to society, the need to reduce CO_2 is widely recognised in Swiss media, science and world politics (Fuss et al., 2018; IPCC, 2022; Rau, 2019; Rockström et al., 2009).

Due to the unfamiliarity of the related terms on CCS and because it is a relatively unknown topic, a small sample of media articles was obtained. The small sample aligns with the conclusions drawn by Carley et al. (2012) and Arning et al. (2019). Their studies recognise a lack of public knowledge regarding CCS. Since the media contribute to the formation of opinion, it can be concluded from this thesis that the scarcity of articles indicates a lack of public knowledge or at least a lack of opinion formation on CCS. Perhaps the technology is not yet tangible and seems too utopian. Also, due to the lack of experience with existing CCS projects, it is not yet possible to properly forecast the impact of the technology. Nevertheless, the Swiss media discourse is already pointing out possible risks caused by CCS. The risks are largely in line with the evaluated risks mentioned by Swiss habitants in the survey of Wenger et al. (2021). Those risks are foremost connected to safety aspects like earthquake risks and fear of CO_2 leakages. Additionally, scientist also mentions risks in particular related to the transport of CO_2 (Arning et al., 2019; Terwel et al., 2012). Furthermore, literature highlights warnings about the potential moral hazard associated with CCS. (Satterfield et al., 2023; Wallquist et al., 2009). Moral hazards did not receive any attention in the Swiss media. In contrast, Dutch media have already discussed moral hazards caused by CCS (van Alphen et al., 2007). Overall, however, the analysis of the attitude towards CCS in this work mirrors the results of the study of van Alphen et al. (2007) in the Netherlands and comparable studies in Australia, Canada, New Zealand, United Kingdom and United States (Gough & Mander, 2006; van Alphen et al., 2007). These studies all refer to a positive attitude of the society towards CCS. Wenger et al. (2021), in contrary, evaluated only a neutral to slightly positive attitude. However, it must also be noted that Wenger and his colleagues, compared to the other studies mentioned, conducted individual interviews and no media analysis.

Comparison between the technologies

In comparison, there is a notable tendency to present projects in the initial stage, where CST and CCS can be categorised, with a positive attitude. Over time, the attitude towards DGE, the most advanced technology with tangible projects, has shown a decline. In this study, however, a worsened attitude towards DGE has only occurred due to projects that do not meet the expectations or are considered a failure. It remains to be seen whether CST and CCS will suffer a slump when the first CST and CCS underground projects are being constructed. Derived from this, the comparison between the three focus technologies in this thesis allows an assumption. It is possible that projects are seen as visionary at first which represents the evaluation of CST and CCS. As time goes by, more and more disadvantages and risks become known, which weaken the positive perception somewhat over time, what happened to DGE in the analysis of this thesis. The more investigated and better known a technology becomes, the more media attention it gets.

This is exemplified by the fact that DGE has enjoyed significantly higher media coverage than CCS and CST. It must be said, however, that this assumption would have to be verified in further research. The findings of Stauffacher et al. (2015) challenges this assumption. According to their research, which primarily focuses on the period from 1997 to 2013, negative arguments outweighed the positive ones towards DGE. It is worth noting that this research was conducted prior to the timeframe covered by this thesis and therefore the euphora caused by the introduction of a new technology is not supported here.

Another difference between the three focus technologies that stands out is, that with CST and DGE practical projects were initiated first. In DGE, a test laboratory of the ETH followed on several test drillings for commercially operating plants (Bedretto Lab, n.d.). CST has not even test facilities in the form of a laboratory. With CCS, a different approach then with DGE and CST seems to be followed. A test laboratory was set up from the beginning rather than starting with concrete CCS projects (ETH Zurich, n.d.). A learning from the failed projects of DGE could be that test facilities are better to be set up early on. But it is also possible that the private sector is not leading the way in CCS in combination with underground storage in Switzerland because there are unanswered issues regarding economic viability. As discussed in Chapter 2.3.3, the price for removed CO_2 and the market potential is still unclear (Holz et al., 2021). However, there are also other incentives than with CST and DGE. Goods distribution, electricity and heat that are the outputs of CST and DGE, are all basic needs of the population. Negative emissions as targeted by CCS, in contrary, are not basic needs of individuals. A comparison of these technologies, especially regarding their economic potential, is thus difficult.

What all three technologies have in common is government support. According to the government and the energy strategy 2050, each technology is further promoted.

Furthermore, what is striking is the different discussion of the geological conditions. In CST, there is no such discussion. Tunnel construction is well established in Switzerland and has a long history. There is also experience with massive geological rock formations (Jorio, 2016). For DGE and CCS, however, the situation is different. Switzerland does not have much experience with deep boreholes and there is a lack of concrete geological data for the two forms of use. The issue of the missing data basis runs through the entire research of this thesis.

Finally, the NIMBY phenomenon that can be found in literature, could not be directly observed in context for any of the analysed technologies. There was no lobbying against specific projects (Schaffer Boudet, 2011).

5.3 Answer to research questions

Research question Q1 can be answered as follows. The underground was discussed in 1,609 articles in the Swiss-German and English-language media available in the Factiva database over the period from 11.03.2011 to 11.03.2023. The number of articles over time was stable until 2022, when there was a significant increase in the number of articles. The reasons for this are manifold, but the site search of a nuclear waste repository had a significant influence.

In relation to research question Q2, the thematic content on the underground was also diverse. Most discussed were future forms of use in the future. The most prominent form of use is the repository for nuclear waste. This is followed by the three focus technologies DGE, CST and CCS. Other forms of use and topic related to the underground itself are negligible.

Looking at research question Q3, the findings show a neutral attitude of the Swiss media towards the use of the underground. Towards CST, on the other hand, a very positive attitude of Swiss media discourse can be observed. However, this is not so much due to sustainability and energy-saving considerations, but rather to shift from above- to underground infrastructure and thus not further aggravate the issue of scare space above ground. DGE, on the other hand, is widely met with an overall neutral attitude after an initial euphoria and failed projects. CCS is viewed positively in the media landscape, although the technology is still in its infancy and in Swiss media context largely unknown.

5.4 Limitations and further research

This thesis is subject to certain limitations. Some areas that need further research have already been mentioned during this chapter. Research on the acceptance of all focus technologies in Switzerland, as well as on the underground in general, is a relatively scare. Derived from the limitations, specific research areas of importance are outlined in the following.

First, the evaluation of the quality criteria reveals certain limitations of this thesis. To start with the articles being coded solely by the author. An objective assessment is therefore difficult to achieve. Language is a matter of interpretation, as the pragmatic theory of meaning shows (Preyer, 2018). An interpretation is also dependent on the thought patterns and assessment of the authors. This is a potential source of bias. This cannot be ruled out even with several coders, but it can be reduced through discussions and statistical checks.

Furthermore, while this thesis aims to analyse and draw conclusion for Switzerland, the focus lied on media in German and English. By excluding media in French- and Italian-language, a significant part of the Swiss population is not or only partially represented. Even though media in English were included, only very few English articles could be found. The Factiva database employed only one English-language medium. Moreover, in Chapter 3.2.2, it was highlighted that there was a selection bias for samples 2-5. This is visualised in Figure 3. Further research on the underground in general, the focus technologies and the societal attitudes towards them is, therefore, proposed.

Further limitations are related to the selection of media. Not all Swiss media are captured in the Factiva database, which served as the basis for the data evaluation. Finally, foreign media were excluded. This is of relevance as these could also be consumed by the Swiss society. The influence of foreign media is, therefore, not captured by the analysis conducted as part of this thesis. This is of particular importance to the English-speaking population, as the offer of English newspapers in Switzerland is limited. Thus, further research could include a wider variety of articles from the Swiss media landscape as well as from mediums abroad in order not to generate a broader perspective of the Swiss society's opinion.

Another aspect to consider is that this work focuses on the attitude towards the underground in terms of its general existence as well as its use. Although this combination gives a wide-ranging viewpoint of the general underground. Further research could treat the general attitude towards the underground and its use separately.

Interesting conclusions could be drawn from a case study comparing St. Gallen and Basel DGE projects in terms of public acceptance. While the public's acceptance of the St. Gallen project did not suffer too much after the earthquakes, a very different reaction on the Deep Heat Mining project in Basel could be observed. The handling of the incident in St. Gallen might serve as success story and important learnings for future projects could be derived.

5.5 Implications for theory and practice

Implications for practice are derived from the results. Further research is needed to make statements on how the society perceives the use of the underground and the focus technologies. The results of this thesis must be confirmed or refuted with additional studies to make generalisable statements. Therefore, the implication for theory is to address the topic of public opinion of the underground use in further studies. A better understanding of the attitude of the Swiss society is required to ensure acceptance for future forms of use.

The call for more thematization on the underground, its use and on the focus technologies, does not only refer to the field of research. This also applies to politics, government and the economy. In the future, opinions will have to be formed to circumvent conflicts of use by means of regulations. Legislation in Switzerland is largely dependent on the opinion of the society. Furthermore, it must be noted that opinion-forming is an ongoing process (Devine-Wright, 2007; Druckman & Bolsen, 2011). Moreover, the more discourse that takes place, the more likely an opinion will be formed (McCombs et al., 2014). This leads to the recommendation to encourage media coverage on the underground and its forms of use to ensure high acceptability of society. Information to the society conveyed by the state, politics or the private sector can also contribute to reduce the society's lack of knowledge. That this is worthwhile has been shown by the example of the DGE project in St. Gallen. The successful management of the earthquake incident could serve as a key takeaway for the managers of future projects. Through communication, the opinion of the society has not been negatively influenced strongly, despite the failure of the project.

6 Bibliography

Allaby, M. (2020). Pacific Ring of Fire. In *A Dictionary of Geology and Earth Sciences* (5th ed.). Oxford University Press.

Allaby, M., & Park, C. (2017). *A Dictionary of Environment and Conservation* (3rd ed.). Oxford University Press.

alpine geothermal power production. (2022). *News*. AGEPP. https://www.agepp.ch

Andsager, J. L. (2000). How Interest Groups Attempt to Shape Public Opinion with Competing News Frames. *Journalism & Mass Communication Quarterly*, *77*(3), 577–592. https://doi.org/10.1177/107769900007700308

Aoki, M., & Rothwell, G. (2013). A comparative institutional analysis of the Fukushima nuclear disaster: Lessons and policy implications. *Energy Policy*, *53*(1), 240–247. https://doi.org/10.1016/j.enpol.2012.10.058

Arning, K., Offermann-van Heek, J., Linzenich, A., Kaetelhoen, A., Sternberg, A., Bardow, A., & Ziefle, M. (2019). Same or different? Insights on public perception and acceptance of carbon capture and storage or utilization in Germany. *Energy Policy*, *125*, 235–249. https://doi.org/10.1016/j.enpol.2018.10.039

Aydin, E., Aydemir, M. T., Aksoz, A., El Baghdadi, M., & Hegazy, O. (2022). Inductive Power Transfer for Electric Vehicle Charging Applications: A Comprehensive Review. *Energies (Basel)*, *15*(14). https://doi.org/10.3390/en15144962

Bandura, A. (1989). Human Agency in Social Cognitive Theory. *The American Psychologist*, *44*(9), 1175–1184. https://doi.org/10.1037/0003-066X.44.9.1175

Bauer, M. W. (2005). Public Perceptions and Mass Media in the Biotechnology Controversy. *International Journal of Public Opinion Research*, *17*(1), 5–22. https://doi.org/10.1093/ijpor/edh054

Becattini, V., Gabrielli, P., & Mazzotti, M. (2021). Role of Carbon Capture, Storage, and Utilization to Enable a Net-Zero-CO2-Emissions Aviation Sector. *Industrial & Engineering Chemistry Research*, *60*(18), 6848–6862. https://doi.org/10.1021/acs.iecr.0c05392

Bedretto Lab. (n.d.). *Scope*. Bedretto. http://www.bedrettolab.ethz.ch/en/about/scope/

Berner Zeitung Online. (2017, October 3). Der Mensch als Erdbeben-Verursacher. *Berner Zeitung Online*. https://www.bernerzeitung.ch/der-mensch-als-erdbeben-verursacher-543754096692

Blumer, Y. B., Braunreiter, L., Kachi, A., Lordan-Perret, R., & Oeri, F. (2018). A two-level analysis of public support: Exploring the role of beliefs in opinions about the Swiss energy strategy. *Energy Research & Social Science*, *43*, 109–118. https://doi.org/10.1016/j.erss.2018.05.024

Boholm, Å. (2004). Editorial: What are the new perspectives on siting controversy? *Journal of Risk Research*, *7*(2), 99–100. https://doi.org/10.1080/1366987042000158677

Boot-Handford, M. E., Abanades, J. C., Anthony, E. J., Blunt, M. J., Brandani, S., Mac Dowell, N., Fernández, J. R., Ferrari, M.-C., Gross, R., Hallett, J. P., Haszeldine, R. S., Heptonstall, P., Lyngfelt, A., Makuch, Z., Mangano, E., Porter, R. T. J., Pourkashanian, M., Rochelle, G. T., Shah, N., … Fennell, P. S. (2014). Carbon capture and storage update. *Energy & Environmental Science*, *7*(1), 13–189. https://doi.org/10.1039/c3ee42350f

Breu, M. (2013, March 27). St. Gallen setzt die Bohrer an; In der Ostschweiz entsteht derzeit das grösste Geothermie-Projekt der Schweiz. *Basler Zeitung*. https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=168607960341908682990828626266

Broere, W. (2016). Urban underground space: Solving the problems of today's cities. *Tunnelling and Underground Space Technology*, *55*(May), 245–248. https://doi.org/10.1016/j.tust.2015.11.012

Brupbacher, M. (2016, December 31). Wo der Opalinuston ans Tageslicht kommt. *Der Landbote*. https://www.landbote.ch/wo-der-opalinuston-ans-tageslicht-kommt-788241704842

Burningham, K. (2000). Using the Language of NIMBY: A topic for research, not an activity for researchers. *Local Environment*, *5*(1), 55–67. https://doi.org/10.1080/135498300113264

Bustaffa, E., Curzio, O., Bianchi, F., Minichilli, F., Nuvolone, D., Petri, D., Stoppa, G., Voller, F., & Cori, L. (2022). Community Concern about the Health Effects of Pollutants: Risk Perception in an Italian Geothermal Area. *International Journal of Environmental Research and Public Health*, *19*(21). https://doi.org/10.3390/ijerph192114145

Cambridge Dictionary. (2023, April 5). *Underground*. Cambridge Dictionary. https://dictionary.cambridge.org/dictionary/english/underground

Canton of Basel-Stadt. (2009, December 10). *Geothermieprojekt 'Deep Heat Mining Basel' kann nicht weitergeführt werden*. Departement für Wirtschaft, Soziales und Umwelt des Kantons Basel-Stadt. https://www.wsu.bs.ch/nm/2009-12-10-wsd-001.html

Cargo sous terrain. (n.d.-a). *Nachhaltiges Transportsystem & City-Logistik*. Cargo sous terrain. https://www.cst.ch/warum-cst/

Cargo sous terrain. (n.d.-b). *Unterirdisches digitales Logistiksystem*. Cargo sous terrain. https://www.cst.ch/

Cargo sous terrain. (2023, January 25). *CST beginnt mit Arbeiten im Gelände*. Cargo sous terrain. https://www.cst.ch/cst-beginnt-mit-arbeiten-im-gelaende/

Carley, S., Konisky, D. M., Atiq, Z., & Land, N. (2020). Energy infrastructure, NIMBYism, and public opinion: A systematic literature review of three decades of empirical survey literature. *Environmental Research Letters*, *15*(9). https://doi.org/10.1088/1748-9326/ab875d

Carley, S. R., Krause, R. M., Warren, D. C., Rupp, J. A., & Graham, J. D. (2012). Early Public Impressions of Terrestrial Carbon Capture and Storage in a Coal-Intensive State. *Environmental Science & Technology*, *46*(13), 7086–7093. https://doi.org/10.1021/es300698n

Chevalier, G., Diamond, L. W., & Leu, W. (2010). Potential for deep geological sequestration of CO2 in Switzerland: A first appraisal. *Swiss Journal of Geosciences*, *103*(3). https://doi.org/10.1007/s00015-010-0030-4

Cook, J., Nuccitelli, D., Green, S. A., Richardson, M., Winkler, B., Painting, R., Way, R., Jacobs, P., & Skuce, A. (2013). Quantifying the consensus on anthropogenic global warming in the scientific literature. *Environmental Research Letters*, *8*(2), 1–7. https://doi.org/10.1088/1748-9326/8/2/024024

Cui, J., & Nelson, J. D. (2019). Underground transport: An overview. *Tunnelling and Underground Space Technology*, *87*, 122–126. https://doi.org/10.1016/j.tust.2019.01.003

d'Amore, F., Lovisotto, L., & Bezzo, F. (2020). Introducing social acceptance into the design of CCS supply chains: A case study at a European level. *Journal of Cleaner Production*, *249*. https://doi.org/10.1016/j.jclepro.2019.119337

d'Amore, F., Mocellin, P., Vianello, C., Maschio, G., & Bezzo, F. (2018). Economic optimisation of European supply chains for CO2 capture, transport and sequestration, including societal risk analysis and risk mitigation measures. *Applied Energy*, *223*, 401–415. https://doi.org/10.1016/j.apenergy.2018.04.043

Davis, J. L., Love, T. P., & Fares, P. (2019). Collective Social Identity: Synthesizing Identity Theory and Social Identity Theory Using Digital Data. *Social Psychology Quarterly*, *82*(3), 254–273. https://doi.org/10.1177/0190272519851025

de Almeida, A. T., Ferreira, F. J. T. E., & Baoming, G. (2014). Beyond Induction Motors-Technology Trends to Move Up Efficiency. *IEEE Transactions on Industry Applications*, *50*(3), 2103–2114. https://doi.org/10.1109/TIA.2013.2288425

de Coninck, H., & Benson, S. M. (2014). Carbon Dioxide Capture and Storage: Issues and Prospects. *Annual Review of Environment and Resources*, *39*(1), 243–270. https://doi.org/10.1146/annurev-environ-032112-095222

Dermont, C. (2019). Environmental decision-making: The influence of policy information. *Environmental Politics*, *28*(3), 544–567. https://doi.org/10.1080/09644016.2018.1480258

Devine-Wright, P. (2007). Reconsidering public attitudes and public acceptance of renewable energy technologies: A critical review (Working Paper No. 15). *Economic & Social Research Council*. https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=8d23c43b8af92fc8a4a8668b5cd4efc5a2e2391e

Devine-Wright, P. (2009). Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *Journal of Community & Applied Social Psychology*, *19*(6), 426–441. https://doi.org/10.1002/casp.1004

Devine-Wright, P. (2013). Explaining "NIMBY" Objections to a Power Line: The Role of Personal, Place Attachment and Project-Related Factors. *Environment and Behavior*, *45*(6), 761–781. https://doi.org/10.1177/0013916512440435

Devine-Wright, P., Batel, S., Aas, O., Sovacool, B., Labelle, M. C., & Ruud, A. (2017). A conceptual framework for understanding the social acceptance of energy infrastructure: Insights from energy storage. *Energy Policy*, *107*, 27–31. https://doi.org/10.1016/j.enpol.2017.04.020

DeWall, C. N., & Bushman, B. J. (2011). Social Acceptance and Rejection: The Sweet and the Bitter. *Current Directions in Psychological Science : A Journal of the American Psychological Society*, *20*(4), 256–260. https://doi.org/10.1177/0963721411417545

Druckman, J. N., & Bolsen, T. (2011). Framing, Motivated Reasoning, and Opinions About Emergent Technologies. *Journal of Communication*, *61*(4), 659–688. https://doi.org/10.1111/j.1460-2466.2011.01562.x

Duden. (n.d.). *Untergrund ▷ Rechtschreibung, Bedeutung, Definition, Herkunft*. Duden. https://www.duden.de/rechtschreibung/Untergrund

Durmisevic, S. (1999). The future of the underground space. *Cities*, *16*(4), 233–245. https://doi.org/10.1016/S0264-2751(99)00022-0

Egbunike, O. N., & Potter, A. T. (2011). Are freight pipelines a pipe dream? A critical review of the UK and European perspective. *Journal of Transport Geography*, *19*(4), 499–508. https://doi.org/10.1016/j.jtrangeo.2010.05.004

Eichenberger, M. (2011, September 22). Seepromenade war auch Deponie 1925 bis 1974 aufgeschüttet Mit der Vergangenheit konfrontiert. *St. Galler Tagblatt*. https://www.tagblatt.ch/ostschweiz/arbon-kreuzlingen-weinfelden/seepromenade-war-auch-deponie-ld.725622

ETH Zurich. (n.d.). *Carbon Removal Lab*. ETH Zurich. https://istp.ethz.ch/research/carbon-removal-lab.html

Fassbind, T. (2019, September 30). Heisser Asphalt als Energiequelle. *Tages Anzeiger Online*. https://www.tagesanzeiger.ch/heisser-asphalt-als-energiequelle-951299708363

Federal Department of Foreign Affairs. (n.d.). *Swiss Plateau*. Federal Department of Foreign Affairs. https://www.eda.admin.ch/aboutswitzerland/en/home/umwelt/geografie/mittelland.html

Federal Department of the Environment, Transport, Energy and Communications. (n.d.). *Energy: Strengthening security of supply*. Federal Department of the Environment, Transport, Energy and Communications. https://www.uvek.admin.ch/uvek/en/home/energie/energieversorgungssicherheit-ukraine-krieg.html

Federal Geological Commission. (2022). *Strategie Untergrund Schweiz*. https://www.newsd.admin.ch/newsd/message/attachments/75195.pdf

Federal Office for Spatial Development. (2016). *Transport Outlook 2040—Development of passenger and freight transport in Switzerland*. Federal Office for Spatial Development. https://www.are.admin.ch/are/en/home/verkehr-und-infrastruktur/grundlagen-und-daten/verkehrsperspektiven2050/verkehrslandschaft2050-annahmen/perspektiven-des-schweizerischen-gueterverkehrs.html

Federal Statistical Office. (n.d.). *Current situation and change*. Federal Department of Home Affairs. https://www.bfs.admin.ch/bfs/en/home/statistiken/bevoelkerung/stand-entwicklung.html

Federal Statistical Office. (2022a). *Demografisches Porträt der Schweiz*. Federal Department of Home Affairs. https://www.bfs.admin.ch/bfs/de/home/statistiken/kataloge-datenbanken.assetdetail.21764558.html

Federal Statistical Office. (2022b, February 21). *Die häufigsten Hauptsprachen der ständigen Wohnbevölkerung—2010-2020*. Federal Department of Home Affairs. https://www.bfs.admin.ch/asset/de/21344038

Fedlex. (2022, August 1). *SR 749.1—Bundesgesetz vom 17. Dezember 2021 über den unterirdischen Gütertransport (UGüTG)*. https://www.fedlex.admin.ch/eli/cc/2022/373/de

Felber-Eisele, P. (2021, June 1). Unterirdische Güterbahn: Cargo Sous Terrain: Anlieger-Dörfer wollen für mehr Verkehr entschädigt werden. *Der Landbote*. https://www.landbote.ch/cargo-sous-terrain-anlieger-doerfer-wollen-fuer-mehr-verkehr-entschaedigt-werden-524904242631

Festinger, L., & Carlsmith, J. M. (1959). Cognitive consequences of forced compliance. *The Journal of Abnormal and Social Psychology*, *58*, 203–210. https://doi.org/10.1037/h0041593

Friedli, D. (2016, January 17). Güterbahn wird Fall für Bundesrat ; Bund erhebt Nutzen von «Cargo sous terrain» – politischer Grundsatzentscheid geplant. *NZZ Am Sonntag*. https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=1686060083657031084931745669664

Fuss, S., Lamb, W. F., Callaghan, M. W., Hilaire, J., Creutzig, F., Amann, T., Beringer, T., de Oliveira Garcia, W., Hartmann, J., Khanna, T., Luderer, G., Nemet, G. F., Rogelj, J., Smith, P., Vicente, J. L. V., Wilcox, J., del Mar Zamora Dominguez, M., & Minx, J. C. (2018). Negative emissions-Part 2: Costs, potentials and side effects. *Environmental Research Letters*, *13*(6). https://doi.org/10.1088/1748-9326/aabf9f

Gadient, J. (2019, March 5). Prototyp des «Green Farmings» unter Tag. *Thurgauer Zeitung*.

https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=168606021118101076265224872569

Gauch, M., Matasci, C., Hincapié, I., Hörler, R., & Böni, H. (2016). *Material- und Energieressourcen sowie Umweltauswirkungen der baulichen Infrastruktur der Schweiz*. Bundesamt für Umwelt. https://www.empa.ch/documents/56122/728861/MatCH_Bericht_Bau_v8_161017.pdf/3a733b91-ab69-43cd-ad81-2b6817716eff

Ge, Y., Cui, C., Zhang, C., Ke, Y., & Liu, Y. (2021). Testing a social-psychological model of public acceptance towards highway infrastructure projects: A case study from China. *Engineering, Construction, and Architectural Management*, *28*(9), 2772–2787. https://doi.org/10.1108/ECAM-03-2020-0183

Geo Energie Suisse. (n.d.). *Tiefengeothermie-Pilotprojekt in Haute-Sorne (JU)*. Geo-Energie Suisse AG. https://www.geo-energie.ch/standorte/haute-sorne/

GeoEnergy. (2022, May 25). *Geothermal Energy Production & Utilisation | ThinkGeoEnergy—Geothermal Energy News*. Think GeoEnergy. https://www.thinkgeoenergy.com/geothermal/geothermal-energy-production-utilisation/

Geothermie Schweiz. (n.d.-a). *Factsheets Geothermie*. Geothermie Schweiz. https://geothermie-schweiz.ch/projekte/

Geothermie Schweiz. (n.d.-b). *Technologie – Geothermie Schweiz*. Geothermie Schweiz. https://geothermie-schweiz.ch/waermestrom/petrothermal/technologie/

Giardini, D. (2009). Geothermal quake risks must be faced. *Nature (London)*, *462*(7275), 848–849. https://doi.org/10.1038/462848a

Glaser, B. G., & Glaser, B. G. (2010). *Grounded Theory: Strategien qualitativer Forschung* (3th ed.). Huber.

Glynn, C. J., & Huge, M. E. (2008). Public Opinion. In *The International Encyclopedia of Communication*. John Wiley & Sons. https://doi.org/10.1002/9781405186407.wbiecp124

Gough, C., & Mander, S. (2006). *Carbon Dioxide Capture and Storage in the Media*. IEA Greenhouse Gas R&D Programme. https://research.manchester.ac.uk/en/publications/carbon-dioxide-capture-and-storage-in-the-media

Gross, M. (2013). Old Science Fiction, New Inspiration: Communicating Unknowns in the Utilization of Geothermal Energy. *Science Communication*, *35*(6), 810–818. https://doi.org/10.1177/1075547012469184

Grotzinger, J. (2017). *Press/Siever Allgemeine Geologie* (7th ed.). Springer Spektrum.

Gupta, N., Fischer, A. R. H., & Frewer, L. J. (2011). Socio-psychological determinants of public acceptance of technologies: A review. *Public Understanding of Science*, *21*(7), 782–795. https://doi.org/10.1177/0963662510392485

Häge, M., Blascheck, P., & Joswig, M. (2013). EGS hydraulic stimulation monitoring by surface arrays - location accuracy and completeness magnitude: The Basel Deep Heat Mining Project case study. *Journal of Seismology*, *17*(1), 51–61. https://doi.org/10.1007/s10950-012-9312-9

Häring, M. O., Schanz, U., Lander, F., & Dyer, B. C. (2008). Characterisation of the Basel 1 enhanced geothermal system. *Geothermics*, *37*(5), 469–495. https://doi.org/10.1016/j.geothermics.2008.06.002

Hart, W., Albarracín, D., Eagly, A. H., Brechan, I., Lindberg, M. J., & Merrill, L. (2009). Feeling Validated Versus Being Correct:A Meta-Analysis of Selective Exposure to Information. *Psychological Bulletin*, *135*(4), 555–588. https://doi.org/10.1037/a0015701

Heras-Saizarbitoria, I., Cilleruelo, E., & Zamanillo, I. (2011). Public acceptance of renewables and the media: An analysis of the Spanish PV solar experience. *Renewable & Sustainable Energy Reviews*, *15*(9), 4685–4696. https://doi.org/10.1016/j.rser.2011.07.083

Hessami, Z. (2016). How Do Voters React to Complex Choices in a Direct Democracy? Evidence from Switzerland. *Kyklos (Basel)*, *69*(2), 263–293. https://doi.org/10.1111/kykl.12111

Heuberger, S., Nibourel, L., Fulda, D., & Vernooij, M. G. C. (2022). 120 years of georesources research in Switzerland: The Swiss Geotechnical Commission (1899–2018). *Swiss Journal of Geosciences*, *115*(1), 10–35. https://doi.org/10.1186/s00015-022-00410-3

Hine, R. (2019). *Subsoil* (8th ed.). Oxford University Press.

Hirschberg, S., Wiemer, S., & Burgherr, P. (2014). *Energy from the Earth: Deep Geothermal as a Resource for the Future?* vdf Hochschulverlag.

Hitzeroth, M., & Megerle, A. (2013). Renewable Energy Projects: Acceptance Risks and Their Management. *Renewable & Sustainable Energy Reviews*, *27*, 576–584. https://doi.org/10.1016/j.rser.2013.07.022

Hoewe, J. (2016). Using Political Journalists' Definitions of Public Opinion to Predict Source Use in Political News. *Communication Research Reports*, *33*(3), 247–252. https://doi.org/10.1080/08824096.2016.1187121

Holz, F., Scherwath, T., Crespo del Granado, P., Skar, C., Olmos, L., Ploussard, Q., Ramos, A., & Herbst, A. (2021). A 2050 perspective on the role for carbon capture and storage in the European power system and industry sector. *Energy Economics*, *104*. https://doi.org/10.1016/j.eneco.2021.105631

Howarth, C. (2006). A social representation is not a quiet thing: Exploring the critical potential of social representations theory. *British Journal of Social Psychology*, *45*(1), 65–86. https://doi.org/10.1348/014466605X43777

Huijts, N. M. A., Molin, E. J. E., & Steg, L. (2012). Psychological factors influencing sustainable energy technology acceptance: A review-based comprehensive framework. *Renewable & Sustainable Energy Reviews*, *16*(1), 525–531. https://doi.org/10.1016/j.rser.2011.08.018

Huijts, N. M., Midden, C. J., & Meijnders, A. L. (2007). Social acceptance of carbon dioxide storage. *Energy Policy*, *35*(5), 2780–2789. https://doi.org/10.1016/j.enpol.2006.12.007

Hussy, W., Schreier, M., & Echterhoff, G. (2013). *Forschungsmethoden in Psychologie und Sozialwissenschaften für Bachelor* (2nd ed.). Springer. https://doi.org/10.1007/978-3-642-34362-9

International Energy Agency. (n.d.). *Carbon capture, utilisation and storage—Fuels & Technologies*. IEA. https://www.iea.org/fuels-and-technologies/carbon-capture-utilisation-and-storage

IPCC. (2022). *Climate Change 2022: Mitigation of Climate Change*. IPCC. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf

Jäggi, W. (2020, August 11). Raumplanung der Zukunft: Die Stadt unter der Stadt. *Tages Anzeiger Online*. https://www.tagesanzeiger.ch/die-stadt-unter-der-stadt-356290140671

Jørgensen, M. (2002). *Discourse analysis: As theory and method*. SAGE.

Jorio, L. (2016, May 31). *Acht wichtige Fakten über den Gotthard*. SWI swissinfo.ch. https://www.swissinfo.ch/ger/kultur/viel-mehr-als-eine-bahnstrecke_acht-wichtige-fakten-ueber-den-gotthard/42181462

Kammermann, L., & Ingold, K. (2019). Going beyond technocratic and democratic principles: Stakeholder acceptance of instruments in Swiss energy policy. *Policy Sciences*, *52*(1), 43–65. https://doi.org/10.1007/s11077-018-9341-5

Kannan, R., & Turton, H. (2012). Cost of ad-hoc nuclear policy uncertainties in the evolution of the Swiss electricity system. *Energy Policy*, *50*(1), 391–406. https://doi.org/10.1016/j.enpol.2012.07.035

Kaufmann, B., Kreis, G., & Gross, A. (2016). Direkte Demokratie und europäische Integration: Die Handlungsspielräume der Schweiz. *Global Europe – Basel Papers on Europe in a Global Perspective*, *75*. https://doi.org/10.24437/global_europe.v0i75.122

Keller, R. (2011). The Sociology of Knowledge Approach to Discourse (SKAD). *Human Studies*, *34*(1), 43–65. https://doi.org/10.1007/s10746-011-9175-z

Kervall, M., & Pålsson, H. (2022). Barriers to change in urban freight systems: A systematic literature review. *European Transport Research Review*, *14*(1), 1–19. https://doi.org/10.1186/s12544-022-00553-2

Knoblauch, T. A., Trutnevyte, E., & Stauffacher, M. (2019). Siting deep geothermal energy: Acceptance of various risk and benefit scenarios in a Swiss-German cross-national study. *Energy Policy*, *128*, 807–816. https://doi.org/10.1016/j.enpol.2019.01.019

Krause, R. M., Carley, S. R., Warren, D. C., Rupp, J. A., & Graham, J. D. (2014). 'Not in (or Under) My Backyard': Geographic Proximity and Public Acceptance of Carbon Capture and Storage Facilities. *Risk Analysis*, *34*(3), 529–540. https://doi.org/10.1111/risa.12119

Kunze, C., & Hertel, M. (2017). Contested deep geothermal energy in Germany—The emergence of an environmental protest movement. *Energy Research & Social Science*, *27*, 174–180. https://doi.org/10.1016/j.erss.2016.11.007

Kuzemko, C., Blondeel, M., Dupont, C., & Brisbois, M. C. (2022). Russia's war on Ukraine, European energy policy responses & implications for sustainable transformations. *Energy Research & Social Science*, *93*. https://doi.org/10.1016/j.erss.2022.102842

Lampart, C. (2011, September 16). Geothermie könnte Lösung sein Potenzial der Geothermie. *St. Galler Tagblatt*. https://www.tagblatt.ch/ostschweiz/arbon-kreuzlingen-weinfelden/geothermie-koennte-loesung-sein-ld.845765

Lateltin, O. (2022, September 16). «Der Schweizer Untergrund braucht eine Governance». *scnat netzwerk*. https://scnat.ch/de/id/uYvkK

Läubli, M. (2012, October 23). Wärmespeicher. *Der Bund*. https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=1686060436506029250595957056824

Läubli, M. (2021, September 13). Mit einer Pipeline CO2 wegschaffen. *Der Bund*. https://www.derbund.ch/mit-einer-pipeline-co2-wegschaffen-348598514922

Lee, E. H., Luo, C., Sam, Y. L., Roberts, A. C., Kwok, K. W., Car, J., Soh, C.-K., & Christopoulos, G. I. (2019). The underground workspaces questionnaire (UWSQ): Investigating public attitudes toward working in underground spaces. *Building and Environment*, *153*, 28–34. https://doi.org/10.1016/j.buildenv.2019.02.017

Lee, S.-Y., Lee, I.-B., & Han, J. (2019). Design under uncertainty of carbon capture, utilization and storage infrastructure considering profit, environmental impact, and risk preference. *Applied Energy*, *238*, 34–44. https://doi.org/10.1016/j.apenergy.2019.01.058

Leu, W. (2014). Erdöl-Erdgasexploration in der Trendwende: Potenzial der unkonventionellen Ressourcen in der Schweiz und Europa : Anstrengungen und

Kontroversen. *Swiss Bulletin für angewandte Geologie*, *19*(1), 29–32. https://doi.org/10.5169/seals-583913

Lin, B., & Tan, Z. (2021). How much impact will low oil price and carbon trading mechanism have on the value of carbon capture utilization and storage (CCUS) project? Analysis based on real option method. *Journal of Cleaner Production*, *298*. https://doi.org/10.1016/j.jclepro.2021.126768

Liu, Y., Xu, M., Ge, Y., Cui, C., Xia, B., & Skitmore, M. (2021). Influences of environmental impact assessment on public acceptance of waste-to-energy incineration projects. *Journal of Cleaner Production*, *304*. https://doi.org/10.1016/j.jclepro.2021.127062

Lock, S. J., Smallman, M., Lee, M., & Rydin, Y. (2014). "Nuclear energy sounded wonderful 40 years ago": UK citizen views on CCS. *Energy Policy*, *66*, 428–435. https://doi.org/10.1016/j.enpol.2013.11.024

L′Orange Seigo, S., Dohle, S., & Siegrist, M. (2014). Public perception of carbon capture and storage (CCS): A review. *Renewable & Sustainable Energy Reviews*, *38*, 848–863. https://doi.org/10.1016/j.rser.2014.07.017

Lorenz-Meyer, A. (2018, January 15). Wie man Treibhausgas einfängt. *Neue Luzerner Zeitung*. https://www.luzernerzeitung.ch/wirtschaft/cleantech-wie-man-treibhausgas-einfaengt-ld.84956

MacDowell, N., Florin, N., Buchard, A., Hallett, J., Galindo, A., Jackson, G., Adjiman, C. S., Williams, C. K., Shah, N., & Fennell, P. (2010). An overview of CO2 capture technologies. *Energy & Environmental Science*, *3*(11), 1645–1669. https://doi.org/10.1039/c004106h

Marquis, L., Schaub, H.-P., & Gerber, M. (2011). The Fairness of Media Coverage in Question: An Analysis of Referendum Campaigns on Welfare State Issues in

Switzerland. *Swiss Political Science Review*, *17*(2), 128–163. https://doi.org/10.1111/j.1662-6370.2011.02015.x

Mayring, P. (2022). *Qualitative Inhaltsanalyse: Grundlagen und Techniken* (13th ed.). Beltz.

McCombs, M. E., Shaw, D. L., & Weaver, D. H. (2014). New Directions in Agenda-Setting Theory and Research. *Mass Communication & Society*, *17*(6), 781–802. https://doi.org/10.1080/15205436.2014.964871

Meenal, R., Binu, D., Ramya, K. C., Michael, P. A., Vinoth Kumar, K., Rajasekaran, E., & Sangeetha, B. (2022). Weather Forecasting for Renewable Energy System: A Review. *Archives of Computational Methods in Engineering*, *29*(5), 2875–2891. https://doi.org/10.1007/s11831-021-09695-3

Mei, J., Zuo, Y., Lee, C. H. T., & Kirtley, J. L. (2020). Modeling and Optimizing Method for Axial Flux Induction Motor of Electric Vehicles. *IEEE Transactions on Vehicular Technology*, *69*(11), 12822–12831. https://doi.org/10.1109/TVT.2020.3030280

Mena, B., Wiemer, S., & Bachmann, C. (2013). Building Robust Models to Forecast the Induced Seismicity Related to Geothermal Reservoir Enhancement. *Bulletin of the Seismological Society of America*, *103*(1), 383–393. https://doi.org/10.1785/0120120102

Moscovici, S. (1988). Notes towards a description of Social Representations. *European Journal of Social Psychology*, *18*(3), 211–250. https://doi.org/10.1002/ejsp.2420180303

Nagra. (2022a, June 28). Die Mission. *Nagra*. https://nagra.ch/die-mission/

Nagra. (2022b, July 29). Standortsuche. *Nagra*. https://nagra.ch/wissensforum/standortsuche/

Nagra. (2022c, July 29). Wie entsorgen? *Nagra*. https://nagra.ch/wissensforum/wie-entsorgen/

National Academies of Sciences, E. (2019). *Negative emissions technologies and reliable sequestration: : A research agenda*. The National Academies Press. https://nap.nationalacademies.org/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda

National Oceanic and Atmospheric Administration. (2022, June 3). *Carbon dioxide now more than 50% higher than pre-industrial levels*. National Oceanic and Atmospheric Administration. https://www.noaa.gov/news-release/carbon-dioxide-now-more-than-50-higher-than-pre-industrial-levels

Nielsen, J. A. E., Stavrianakis, K., & Morrison, Z. (2022). Community acceptance and social impacts of carbon capture, utilization and storage projects: A systematic meta-narrative literature review. *PloS One*, *17*(8), e0272409–e0272409. https://doi.org/10.1371/journal.pone.0272409

Omodeo-Salé, S., Eruteya, O. E., Cassola, T., Baniasad, A., & Moscariello, A. (2020). A basin thermal modelling approach to mitigate geothermal energy exploration risks: The St. Gallen case study (eastern Switzerland). *Geothermics*, *87*. https://doi.org/10.1016/j.geothermics.2020.101876

Paltridge, B. (2022). *Discourse analysis: An introduction* (3rd ed.). Bloomsbury Academic.

Pambudi, N. A. (2018). Geothermal power generation in Indonesia, a country within the ring of fire: Current status, future development and policy. *Renewable & Sustainable Energy Reviews*, *81*, 2893–2901. https://doi.org/10.1016/j.rser.2017.06.096

Pan, S.-Y., Gao, M., Shah, K. J., Zheng, J., Pei, S.-L., & Chiang, P.-C. (2019). Establishment of enhanced geothermal energy utilization plans: Barriers and strategies. *Renewable Energy*, *132*, 19–32. https://doi.org/10.1016/j.renene.2018.07.126

Pan, Z., & McLeod, J. M. (1991). Multilevel Analysis in Mass Communication Research. *Communication Research*, *18*(2), 140–173. https://doi.org/10.1177/009365091018002002

Perea-Moreno, A.-J. (2021). Renewable Energy and Energy Saving: Worldwide Research Trends. *Sustainability (Basel, Switzerland)*, *13*(23). https://doi.org/10.3390/su132313261

Petrova, M. A. (2016). From NIMBY to acceptance: Toward a novel framework — VESPA — For organizing and interpreting community concerns. *Renewable Energy*, *86*, 1280–1294. https://doi.org/10.1016/j.renene.2015.09.047

Preyer, G. (2018). *Soziologische Theorie der Gegenwartsgesellschaft II: Lebenswelt—System—Gesellschaft*. Springer Fachmedien.

Priester, J. R., & Petty, R. E. (1996). The Gradual Threshold Model of Ambivalence: Relating the Positive and Negative Bases of Attitudes to Subjective Ambivalence. *Journal of Personality and Social Psychology*, *71*(3), 431–449. https://doi.org/10.1037/0022-3514.71.3.431

Rahman, F. A., Aziz, M. M. A., Saidur, R., Bakar, W. A. W. A., Hainin, M. R., Putrajaya, R., & Hassan, N. A. (2017). Pollution to solution: Capture and sequestration of carbon dioxide (CO2) and its utilization as a renewable energy source for a sustainable future. *Renewable & Sustainable Energy Reviews*, *71*, 112–126. https://doi.org/10.1016/j.rser.2017.01.011

Rau, G. H. (2019). The race to remove CO2 needs more contestants. *Nature Climate Change*, *9*(4), 256–256. https://doi.org/10.1038/s41558-019-0445-5

Research Center for the Public Sphere and Society. (2022). *Jahrbuch Qualität der Medien 2022*. Schwabe.

Riffe, D. (2014). *Analyzing media messages: Using quantitative content analysis in research* (3rd ed.). Routledge. https://doi.org/10.4324/9780203551691

Rockström, J., Steffen, W., Noone, K., & Scheffer, M. (2009). A safe operating space for humanity. *Nature (London)*, *461*(7263), 472–475. https://doi.org/10.1038/461472a

Ruiz, G. (2018). Niemandsland unter der Schweiz. *Horizonte*, *118*, 12–13. https://www.horizonte-magazin.ch/wp-content/uploads/2018/08/SNF_horizonte_118_DE.pdf

Satterfield, T., Nawaz, S., & St-Laurent, G. P. (2023). Exploring public acceptability of direct air carbon capture with storage: Climate urgency, moral hazards and perceptions of the 'whole versus the parts'. *Climatic Change*, *176*(2). https://doi.org/10.1007/s10584-023-03483-7

Schaffer Boudet, H. (2011). From NIMBY to NIABY: Regional mobilization against liquefied natural gas in the United States. *Environmental Politics*, *20*(6), 786–806. https://doi.org/10.1080/09644016.2011.617166

Schwander, A. (2011, October 7). Schiefergas – neue Regeln im grossen Spiel; Die noch unbekannte Revolution der Energiegewinnung ist eine echte Alternative zu Kohlekraftwerken. *Basler Zeitung*. https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=1686060615046037051818253234436

Schweizer Radio und Fernsehen (Director) (Director). (2016, January 26). 10vor10 vom 26.01.2016. In *10vor10*. https://www.srf.ch/play/tv/10-vor-10/video/10vor10-vom-26-01-2016?urn=urn:srf:video:5cd5a529-2c87-4859-a0b3-b3ffbe3b5c67&startTime=996

Scimago Journal & Country Rank. (n.d.). *Scimago Journal & Country Rank*. SJR. https://www.scimagojr.com/

Seidl, R., Moser, C., Stauffacher, M., & Krütli, P. (2013). Perceived Risk and Benefit of Nuclear Waste Repositories: Four Opinion Clusters: Perceived Risk and Benefit of Nuclear Waste Repositories. *Risk Analysis*, *33*(6), 1038–1048. https://doi.org/10.1111/j.1539-6924.2012.01897.x

Shackley, S., McLachlan, C., & Gough, C. (2004). The public perception of carbon dioxide capture and storage in the UK: Results from focus groups and a survey. *Climate Policy*, *4*(4), 377–398. https://doi.org/10.1080/14693062.2004.9685532

Soltani, M., Moradi Kashkooli, F., Souri, M., Rafiei, B., Jabarifar, M., Gharali, K., & Nathwani, J. S. (2021). Environmental, economic, and social impacts of geothermal energy systems. *Renewable and Sustainable Energy Reviews*, *140*. https://doi.org/10.1016/j.rser.2021.110750

Spada, M., Sutra, E., & Burgherr, P. (2021). Comparative accident risk assessment with focus on deep geothermal energy systems in the Organization for Economic Co-operation and Development (OECD) countries. *Geothermics*, *95*. https://doi.org/10.1016/j.geothermics.2021.102142

Stauffacher, M., Muggli, N., Scolobig, A., & Moser, C. (2015). Framing deep geothermal energy in mass media: The case of Switzerland. *Technological Forecasting & Social Change*, *98*, 60–70. https://doi.org/10.1016/j.techfore.2015.05.018

Stula, B. (2020, January 10). Merowinger setzten sich in Reinach fest ; Vor 1550 Jahren strömten Fremde in die Region. Dies belegen jüngste Gräberfunde. *Basellandschaftliche Zeitung*. https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=168606131740904224901027503119 6

Sutterlüti, P., & Aellig, P. (2019). Umfassende Logistiklösung für die Schweiz mit Cargo sous terrain (CST). *Swiss Bulletin für angewandte Geologie*, *24*(1), 35–40. https://doi.org/10.5169/seals-869521

Swiss Confederation. (n.d.). *Mandatory referendums and optional referendums in Switzerland*. Ch.Ch. https://www.ch.ch/en/votes-and-elections/referendums/how-to-launch-an-optional-referendum/

Swiss Federal Office of Energy. (2013). *Energieperspektiven 2050. Zusammenfassung*. Federal Department of the Environment, Transport, Energy and Communications. https://www.bfe.admin.ch/bfe/de/home/politik/energiestrategie-2050/dokumentation/energieperspektiven-2050.html

Swiss Federal Office of Energy. (2018). *Energiestrategie 2050: Chronologie*. Federal Department of the Environment, Transport, Energy and Communications. https://www.uvek.admin.ch/uvek/de/home/uvek/abstimmungen/abstimmung-zum-energiegesetz/chronologie-und-grafiken.html

Swiss Federal Office of Energy. (2021). *Überblick über den Energieverbrauch der Schweiz im Jahr 2020*. Federal Department of the Environment, Transport, Energy and Communications. https://www.newsd.admin.ch/newsd/message/attachments/67197.pdf

swisstopo. (n.d.). *Tiefer Untergrund*. Bundesamt für Landestopografie swisstopo. https://www.swisstopo.admin.ch/de/wissen-fakten/geologie/geologische-daten/3d-geologie/tief.html

Tan, Z., Roberts, A. C., Lee, E. H., Kwok, K.-W., Car, J., Soh, C. K., & Christopoulos, G. (2020). Transitional areas affect perception of workspaces and employee well-being: A study of underground and above-ground workspaces. *Building and Environment*, *179*. https://doi.org/10.1016/j.buildenv.2020.106840

Terwel, B. W., ter Mors, E., & Daamen, D. D. (2012). It's not only about safety: Beliefs and attitudes of 811 local residents regarding a CCS project in Barendrecht. *International Journal of Greenhouse Gas Control*, *9*, 41–51. https://doi.org/10.1016/j.ijggc.2012.02.017

The Federal Council. (2020). *Botschaft zum Bundesgesetz über den unterirdischen Gütertransport*. The Federal Council. https://www.fedlex.admin.ch/eli/fga/2020/2362/de

The Federal Council. (2021). *Langfristige Klimastrategie der Schweiz*. The Federal Council. https://www.bafu.admin.ch/bafu/de/home/themen/klima/fachinformationen/emissionsverminderung/verminderungsziele/ziel-2050/klimastrategie-2050.html

The Federal Council. (2022). *CO2-Abscheidung und Speicherung (CCS) und Negativemissionstechnologien (NET)*. The Federal Council. https://www.newsd.admin.ch/newsd/message/attachments/71551.pdf

The Swiss Parliament. (n.d.). *20.081 | Transport souterrain de marchandises. Loi | Business | The Swiss Parliament*. The Federal Assembly — The Swiss Parliament. https://www.parlament.ch/en/ratsbetrieb/suche-curia-vista/geschaeft?AffairId=20200081

Tresch, A. (2012). The (Partisan) Role of the Press in Direct Democratic Campaigns: Evidence from a Swiss Vote on European Integration. *Swiss Political Science Review*, *18*(3), 287–304. https://doi.org/10.1111/j.1662-6370.2012.02073.x

Trutnevyte, E., & Wiemer, S. (2017). Tailor-made risk governance for induced seismicity of geothermal energy projects: An application to Switzerland. *Geothermics*, *65*, 295–312. https://doi.org/10.1016/j.geothermics.2016.10.006

Ulmi, N. (2018). Das fantastische Reich. *Horizonte*, *118*, 22–23. https://www.horizonte-magazin.ch/wp-content/uploads/2018/08/SNF_horizonte_118_DE.pdf

United Nations. (2022). *World Population Prospects 2022*. United Nations. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

United Nations. (n.d.). *The Paris Agreement | UNFCCC*. United Nations. https://unfccc.int/process-and-meetings/the-paris-agreement

Vahlensieck, Y. (2018, September 6). Das Innenleben der Schweiz auf Karte gebannt. *Horizonte*. https://www.horizonte-magazin.ch/2018/09/06/karte-des-schweizer-untergrunds/

van Alphen, K., van Voorst tot Voorst, Q., Hekkert, M. P., & Smits, R. E. (2007). Societal acceptance of carbon capture and storage technologies. *Energy Policy*, *35*(8), 4368–4380. https://doi.org/10.1016/j.enpol.2007.03.006

van der Horst, D. (2007). NIMBY or not? Exploring the relevance of location and the politics of voiced opinions in renewable energy siting controversies. *Energy Policy*, *35*(5), 2705–2714. https://doi.org/10.1016/j.enpol.2006.12.012

Van Peteghem, L., Sakarika, M., Matassa, S., Pikaar, I., Ganigué, R., & Rabaey, K. (2022). Towards new carbon–neutral food systems: Combining carbon capture and utilization with microbial protein production. *Bioresource Technology*, *349*, 126853–126853. https://doi.org/10.1016/j.biortech.2022.126853

Verband der Hochschullehrerinnen und Hochschullehrer für Betriebswirtschaft e.V. (n.d.). *Willkommen im VHB!* VHB e.V. https://vhbonline.org/

Viganò, A., Ranalli, G., Andreis, D., & Martin, S. (2021). Inversion for the static friction coefficient of seismogenic faults: Application to induced seismicity of the Basel Enhanced Geothermal System, Switzerland. *Journal of Geodynamics*, *145*. https://doi.org/10.1016/j.jog.2021.101843

Villa, R., & Monzón, A. (2021). A Metro-Based System as Sustainable Alternative for Urban Logistics in the Era of E-Commerce. *Sustainability*, *13*(8). https://doi.org/10.3390/su13084479

Visser, J. G. (2018). The development of underground freight transport: An overview. *Tunnelling and Underground Space Technology*, *80*, 123–127. https://doi.org/10.1016/j.tust.2018.06.006

Vogt, M. (2013, August 28). Erfindung soll Gewinn bringen; Erziehungsdepartement will Energie-Rasengitter für das Eglisee vermarkten. *Basler Zeitung*. https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=168606166946009112648614781882

Volkart, K., Bauer, C., Burgherr, P., Hirschberg, S., Schenler, W., & Spada, M. (2016). Interdisciplinary assessment of renewable, nuclear and fossil power generation with and without carbon capture and storage in view of the new Swiss energy policy. *International Journal of Greenhouse Gas Control*, *54*, 1–14. https://doi.org/10.1016/j.ijggc.2016.08.023

Vonplon, D. (2016, January 28). Die verlängerte Rampe. *Handelszeitung*. https://global.factiva.com/ha/default.aspx?page_driver=searchBuilder_Search#./!?&_suid=1686061761940043077198540515205

Vu, H. T., Guo, L., & McCombs, M. E. (2014). Exploring "the World Outside and the Pictures in Our Heads": A Network Agenda-Setting Study. *Journalism & Mass Communication Quarterly*, *91*(4), 669–686. https://doi.org/10.1177/1077699014550090

Wallquist, L., Seigo, S. L., Visschers, V. H., & Siegrist, M. (2012). Public acceptance of CCS system elements: A conjoint measurement. *International Journal of Greenhouse Gas Control*, *6*, 77–83. https://doi.org/10.1016/j.ijggc.2011.11.008

Wallquist, L., Visschers, V. H. M., & Siegrist, M. (2010). Impact of Knowledge and Misconceptions on Benefit and Risk Perception of CCS. *Environmental Science & Technology*, *44*(17), 6557–6562. https://doi.org/10.1021/es1005412

Wallquist, L., Visschers, V., & Siegrist, M. (2009). Experts' and laypeople's perception of carbon capture and storage in Switzerland. *IOP Conference Series. Earth and Environmental Science*, *6*(17). https://doi.org/10.1088/1755-1307/6/17/172034

Wang, X., Shen, L., & Shi, S. (2023). Evaluation of underground space perception: A user-perspective investigation. *Tunnelling and Underground Space Technology*, *131*. https://doi.org/10.1016/j.tust.2022.104822

Wanta, W., & Ghanem, S. (2006). Effects of Agenda Setting. In Preiss R.W., Gayle B.M., Burrell N. & Allen M. (Eds.), *Mass Media Effects Research: Advances Through Meta-Analysis* (pp. 37–52). Routledge.

Wellmann, J. F., & Regenauer-Lieb, K. (2012). Uncertainties have a meaning: Information entropy as a quality measure for 3-D geological models. *Tectonophysics*, *526–529*, 207–216. https://doi.org/10.1016/j.tecto.2011.05.001

WEMF AG. (2022). *WEMF Auflagebulletin 2022*. WEMF AG. https://wemf.ch/media/wemf.ch/media/wemf_auflagebulletin.pdf?redirect=true

Wenger, A., Stauffacher, M., & Dallo, I. (2021). Public perception and acceptance of negative emission technologies – framing effects in Switzerland. *Climatic Change*, *167*(3), 53. https://doi.org/10.1007/s10584-021-03150-9

Wennersten, R., Sun, Q., & Li, H. (2015). The future potential for Carbon Capture and Storage in climate change mitigation – an overview from perspectives of technology, economy and risk. *Journal of Cleaner Production*, *103*, 724–736. https://doi.org/10.1016/j.jclepro.2014.09.023

Widdowson, H. G. (2004). *Text, context, pretext: Critical issues in discourse analysis*. Blackwell.

Widdowson, H. G. (2007). *Discourse analysis*. University Press.

Winship, C., & Mare, R. D. (1992). Models for Sample Selection Bias. *Annual Review of Sociology*, *18*(1), 327–350. https://doi.org/10.1146/annurev.so.18.080192.001551

Wolsink, M. (2006). Invalid theory impedes our understanding: A critique on the persistence of the language of NIMBY. *Transactions - Institute of British Geographers*, *31*(1), 85–91. https://doi.org/10.1111/j.1475-5661.2006.00191.x

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Xue, D., Zhao, X., Dong, J., Ren, R., Xu, Y., & Chen, Z. (2022). Critical Success Factors of Underground Logistics Systems from the Project Life Cycle Perspective. *Buildings*, *12*(11). https://doi.org/10.3390/buildings12111979

Yan, J., Jaw, S., Soon, K., Wieser, A., & Schrotter, G. (2019). Towards an Underground Utilities 3D Data Model for Land Administration. *Remote Sensing*, *11*(17). https://doi.org/10.3390/rs11171957

Yang, L., Zhang, X., & McAlinden, K. J. (2016). The effect of trust on people's acceptance of CCS (carbon capture and storage) technologies: Evidence from a survey in the People's Republic of China. *Energy*, *96*, 69–79. https://doi.org/10.1016/j.energy.2015.12.044

Zhu, Y., Chen, M., Yang, Q., Alshwaikh, M. J., Zhou, H., Li, J., Liu, Z., Zhao, H., Zheng, C., Bartocci, P., & Fantozzi, F. (2021). Life cycle water consumption for oxyfuel combustion power generation with carbon capture and storage. *Journal of Cleaner Production*, *281*. https://doi.org/10.1016/j.jclepro.2020.124419

Ziauddin, S. B. (2017). Superpower Underground: Switzerland's Rise to Global Bunker Expertise in the Atomic Age. *Technology and Culture*, *58*(4), 921–954. https://doi.org/10.1353/tech.2017.0109

Zurich University of Applied Sciences. (n.d.). *Datenbanken*. ZHAW Hochschulbibliothek. https://www.zhaw.ch/de/hochschulbibliothek/suchen-finden/datenbanken/

Zurich University of Applied Sciences. (2022). *Güterverkehr in Städten reduzieren mit smarter Logistik*. Zurich University of Applied Sciences. https://www.zhaw.ch/de/ueber-uns/aktuell/news/detailansicht-news/event-news/gueterverkehr-in-staedten-reduzieren-mit-smarter-logistik/

Appendix

Appendix A

Table 17: Search summary Factiva

Topic	**Filter Criteria**
Text	((Untergrund AND (unterirdisch OR Tiefe OR tief OR Georessourcen OR unter Tage OR Erdkruste OR unter der Erde OR geologisch OR Geologie OR Untertagebau OR unter Tage)) OR (Underground AND (below ground OR depth OR deep OR georesources OR geological OR geology OR underground mining OR earth crust OR unter the earth))) AND WC>500
Date	11/03/2011 to 31/03/2023
Source	All Sources
Author	All Authors
Company	All Companies
Subject	Not Sports Not Religion Not Festivals Not Financial Crime Not Hate Crime Not Illegal Gambling Not Illegal Immigration Not Digital Piracy Not Murder/Manslaughter Not Sex Crimes Not Gangs Not Terrorism Not Whistleblowers
Industry	All Industries
Region	Switzerland
Language	English Or German

Source: own representation

Appendix B

Table 18: Coding scheme underground

Theme	Explanation	Form of use	Explanation
Resource allocation	Extraction of resources from the underground.	Gas	Gas extraction including allocation via fracking procedure
		Salt	Salt extraction
		Gravel	Gravel extraction
		Oil	Oil extraction
		Gemstones	Extraction of gemstones
		Ore	Ore extraction for metal production
		Mineral water	Drinking water purchased in bottles and not distributed as public supply to the population
Pollution & Risk	Discussion about hazards and risks posed by the underground itself. This does not mean pollution by humans. These can be, for example, hazards from earthquakes or toxic soil substances.		
Future use	Future forms of use discussed for the future. These technologies are not yet fully developed or are still in an implementation phase.	DGE	Focus technology
		CCS	Focus technology
		CST	Focus technology
		Nuclear repository	Final repository for nuclear waste
		Energy storage	Storing energy in a battery underground.
		Energy grass grid	Mesh in the underground, which can heat up the grass.
		Compressed air storage power plant	Storage of energy underground.
		Aquaponics	Establishment of a cycle for raising food and fish. The plant will be built underground.
		Asphalt collectors	Collectors under the road that can heat or cool the asphalt.
Community services	Services to the residential population by means of supply of utilities and disposal of things. These services are provided using the underground.	Public supply	Providing the population with water, electricity, etc.
		Geothermal energy	Heating with geothermal technology up to 3,000 meters under the surface.

		Waste disposal	Waste dumping underground.
		Bodies disposal	Cemeteries
Traffic	Traffic that is shifted underground. This includes pedestrian, rail and road traffic.	Tunnelling	The traffic is moved underground by means of a tunnel.
Caving	Exploring and investigating underground cavities.		
Legal situation	Legal provisions or ambiguities concerning the underground and its use.		
Test purposes	The construction of scientific test labs underground specifically pertains to the physical location of the laboratory and does not involve research related to geology.	Test purposes	Construction of test labs in the underground.
Infrastructure	Underground infrastructure construction.	Public infrastructure	Underground infrastructure that is available to the general public. These are buildings in which people physically reside. For example, car parks, railway stations, museums and others.
		Work and residence	Underground spaces where people stay longer. For example, living rooms or workplaces.
		Storage	Using the space underground to store things.
Lake ground	Topics concerning the specific subsurface under lakes.		
Ecosystem		Planting	Plant organisms growing underground. For example mushrooms and truffles.
		Animal habitat	Animals that live underground and use it as a habitat.
Knowledge	Exploring the underground to gain more	Geological Knowledge	Knowledge about geological structures and

	knowledge about it. Additionally, it allows to investigate the past by analyzing subterranean features and materials.		natural processes underground
		Archaeology	Excavations from underground to better understand earlier times.

Source: own representation

Appendix C

Table 19: Coding guideline CST

Category	Definition of category	Coding rules
Environmental friendliness	The impact of CST on the environment - directly through operation and indirectly by decreasing CO_2 emissions of freight transport above ground.	Positive arguments: - Environmentally friendly project - Renewable energy used - Reduction of pollution/ CO_2 above ground Neutral arguments: - No effects on environment Negative arguments: - Electricity from unrenewable sources - More traffic leads to more pollution
Contribution to relaxation of scare space above ground	Congestion on space requirement for roads, railways as well as logistic centers. Whether CST can provide relief for space above ground.	Positive arguments: - More free space Neutral arguments: - No changes / impact on scare space Negative arguments: - Less space available
Impact on traffic congestion	The category questions whether CST has a relieving effect on the congestion situation on Swiss roads.	Positive arguments: - Less trucks - Less traffic jams Neutral arguments: - No changes / impact on space above ground Negative arguments: - Not less transport due to traffic to CST hubs
Transportation costs	How the opening of the CST tunnel affected the	Positive arguments: - Lower costs

	cost for freight transportation.	Neutral arguments: - Similar costs Negative arguments: - Higher costs
Visionariness	To what extend the project or the technology of CST is classified as visionary. It also includes the classification of how the project strengthens Switzerland's innovation capacity.	Positive arguments: - Visionary project - Supporting innovation strength of Switzerland Neutral arguments: - Whether visionary nor not visionary Negative arguments: - Not visionary
Feasibility	To what extent the project is technically feasible.	Positive arguments: - Feasibility is proven - Technically feasible Neutral arguments: - Feasibility is unclear / must be checked Negative arguments: - Concept is not feasible - Reverie, utopia
Impact on logistics sector	Changes that CST brings to the logistics industry. If logistics is being improved through CST compared to road transportation.	Positive arguments: - Faster logistics - 24 hours operation - Flexibility for logistics Neutral arguments: - No changes for logistics Negative arguments: - Disadvantages / competition for traditional logistics companies
Legal structure of ownership	Attitudes about the private ownership of CST (incl. foreign investors).	Positive arguments: - Private ownership is desired

	The government is not supporting and financing at a large scale.	- Private sector takes responsibility Neutral arguments: - Ownership has advantages and disadvantages Negative arguments: - Dependencies on foreign investors - Project should be implemented by government
Funding of the project	Whether funding for the project is secured or seen as a risk to implementation.	Positive arguments: - The funding is secured - Many investors are supporting the project Neutral arguments: - Many investors found but still more needed Negative arguments: - Funding is not given - Funding is impossible to achieve
Investment	The investment concerns the amount of costs incurred until CST is operational.	Positive arguments: - The investment costs are low / moderate Neutral arguments: - The investment costs are similar to comparable projects Negative arguments: - The investment costs are high
Economic operation	This refers to the extent to which the operation of CST can be operated in an economically viable manner.	Positive arguments: - The economically operation is secured Neutral arguments: - It remains open whether it will be economically operated

		Negative arguments: - It's not possible to operate CST economically
Side effects of project	Side effects arising from the construction and operation of CST. E.g. groundwater pollution, vibrations from the construction of the tunnels and noise pollution.	Positive arguments: - There are even positive effects arising Neutral arguments: - No side effects occur Negative arguments: - Undesirable side effects by CST occur
Clearness of legal situation	On what extend laws are regulating the construction and operation of CST.	Positive arguments: - The legal situation is clarified Neutral arguments: - The legal situation must be checked Negative arguments: - Lack of a legal basis
Political support	With political involvement is the support of politicians for the CST project meant. This also includes whether an open discussion regarding the legislative process for underground tunnel systems is held.	Positive arguments: - Positive statements of politicians - Acceptance of votes for CST Neutral arguments: - Disagreement among politicians Negative arguments: - Negative statements of politicians - Rejection of votes for CST
Government involvement	It is about the extent to which the state, cantons and municipalities itself are involved in the project. Whether there is support from the	Positive arguments: - Support from government Neutral arguments: - Support from government is not yet clear Negative arguments:

	government - both financially and conceptually.	- No support from government - Government is supporting but this is seen negatively

Source: own representation

Appendix D

Table 20: Coding guideline DGE

Category	Definition of category	Coding rules
Environmental friendliness	The impact of DGE on the environment. Direct through low number of emissions of DGE plants. But also indirect through replacement of unrenewable power production plants.	Positive arguments: - Environmentally friendly technology - Renewable energy - Substitute to fossil fuels Neutral arguments: - Environmentally friendliness needs to be proven Negative arguments: - Pollution / destruction of the underground (ecosystem) - Fossil fuels are used for drillings
Essentiality for power supply	Weather DGE can contribute an essential contribution to the power supply of Switzerland in the future.	Positive arguments: - Essential contribution to power supply - High energy production possible - Huge potential Neutral arguments: - Effective contribution needs to be evaluated Negative arguments: - No essential power supply in Switzerland - Potential is low
Availability: Continuously and regenerative	This refers to the attitude towards the constant availability (24h/day) of DGE. Whether DGE can thus contribute to the	Positive arguments: - Regenerative technology - 24h a day / permanent energy production Neutral arguments:

	stability of the electricity grid will be assessed.	- Availability is not yet clear Negative arguments: - Not continuously available technology - Not regenerative
Self-sufficiency of power supply	This deals with the dependence or independence of electricity production on foreign countries. It is about what influence DGE can have on this.	Positive arguments: - Independent power supply - Self-distribution with energy Neutral arguments: - Unchanged / unclear dependencies in power supply Negative arguments: - Dependency on power supply from other countries caused by DGE (insufficient production or not applicable in Switzerland)
Geological conditions	Assessment of whether the geological conditions in Switzerland are good for operating DGE plants. This refers to the existing rock formations and layers.	Positive arguments: - Good geological conditions for DGE Neutral arguments: - Better and worse conditions available Negative arguments: - Bad geological conditions for DGE
Conflicts of use	The extent to which drilling for DGE operations conflicts with other uses of the underground. This could be conflicts with e.g. water pipes, electricity grids, nuclear repository etc.	Positive arguments: - DGE will solve other conflicts of use Neutral arguments: - No conflicts of use Negative arguments: - Conflicts of use can be detected

Earthquake risk	Assessment of the probability of an earthquake being triggered by the drilling or operation of DGE plants.	<u>Positive arguments:</u> - Earthquake risk can be fully eliminated <u>Neutral arguments:</u> - Moderate earthquake risk <u>Negative arguments:</u> - There is an earthquake risk
Level of acceptance of habitants	To what extent the residents of DGE plants or test drillings for DGE plants support or reject the projects.	<u>Positive arguments:</u> - Positive voices from habitants - Public votes for DGE accepted <u>Neutral arguments:</u> - Acceptance is unclear - There are positive and negative voices <u>Negative arguments:</u> - Negative voices from habitants - Public votes for DGE rejected
Experiences from previous projects	The influence on attitude of the success or failure of previous projects of DGE.	<u>Positive arguments:</u> - Good experiences from other DGE projects <u>Neutral arguments:</u> - No experiences - Good and bad experiences <u>Negative arguments:</u> - Negative experiences from other DGE projects
Visionariness	To what extend concrete DGE projects or the technology of DGE itself is classified as visionary.	<u>Positive arguments:</u> - Visionary project - Supporting innovation strength of Switzerland <u>Neutral arguments:</u> - Whether visionary nor not visionary <u>Negative arguments:</u> Not visionary

Feasibility of concrete project	To what extent a concrete project is feasible. This is not evaluated on a technical but on an organisational and conceptual basis.	Positive arguments: - Feasibility of project is proven Neutral arguments: - Feasibility of project is unclear / must be checked Negative arguments: - Concept is not feasible
Feasibility of technology	To what extent the DGE technologies are considered as feasible and promising for the future.	Positive arguments: - Technically feasible Neutral arguments: - Technical feasibility is unclear / must be checked Negative arguments: - Technology doesn't work
Economical operation	This refers to the extent to which the operation of DGE can be operated in an economically viable manner.	Positive arguments: - The economically operation is secured Neutral arguments: - It remains open whether it will be economically operated Negative arguments: - It's not possible to operate DGE economically
Investment	The investment concerns the amount of costs incurred until a DGE plants starts the operation.	Positive arguments: - The investment costs are low / moderate Neutral arguments: - The investment costs are similar to comparable projects Negative arguments: - The investment costs are high
Investment risk	This assess the risk and thus financial impact that may occur if DGE test drills are unsuccessful.	Positive arguments: - There are guarantees to completely assure potential losses. Test drillings are

	This means that construction of a DGE plant is not possible due to the conditions found.	actively supported with guarantees Neutral arguments: - There is a moderate investment risk Negative arguments: - The investment risk is high - High potential losses
Impact on energy costs	To what extent the large-scale operation of DGE plants in Switzerland would have an impact on energy costs.	Positive arguments: - The energy costs will be lower through DGE operation Neutral arguments: - The energy costs remain the same Negative arguments: - The energy costs will be increased through DGE
Side effects	Side effects arising from the construction and operation of DGE plants. E.g. groundwater pollution, damages from earthquakes and other collateral damages.	Positive arguments: - There are positive side effects caused by DGE Neutral arguments: - No side effects occur Negative arguments: - There are negative side effects caused by DGE
Clearness of legal situation	On what extend laws are regulating the construction and operation of DGE plants.	Positive arguments: - The legal situation for DGE is clarified Neutral arguments: - The legal situation must be checked Negative arguments: - Lack of a legal basis for DGE
Political support	With political involvement is the	Positive arguments:

	support of politicians for DGE projects meant. This also includes whether an open discussion regarding the legislative process for DGE technology is held.	- Positive statements of politicians - Acceptance of votes for DGE Neutral arguments: - Disagreement among politicians Negative arguments: - Negative statements of politicians - Rejection of votes for DGE
Government involvement	It is about the extent to which the state, cantons and municipalities itself are involved into DGE projects. Whether there is support from the government - both financially and conceptually.	Positive arguments: - Support from government Neutral arguments: - Support from government is not yet clear Negative arguments: - No support from government - Government is supporting but this is seen negatively
Support from science	This denotes support or rejection of DGE from the field of science.	Positive arguments: - Support from science and universities - Positive statements from researchers Neutral when mentioning: - Support from science is not yet clear - Positive and negative statements from research Negative when mentioning: - No support from science and universities - Negative statements from researchers

Data availability	This corresponds to the quality of the existing data that can be used for planning DGE projects.	Positive arguments: - Data availability to plan DGE projects is good Neutral when mentioning: - Data availability to plan DGE projects is unknown / need to be evaluated Negative when mentioning: - Data availability to plan DGE projects is bad

Source: own representation

Appendix E

Table 21: Coding guideline CCS

Category	Definition of category	Coding rules
Contribution to the solution of the climate crisis	Whether and to what extent CCS can make a significant contribution to solving the climate crisis.	Positive arguments: - CCS is an important solution to solve climate crisis - Negative emissions are unavoidable Neutral when mentioning: - CCS is neither the solution nor does it strengthen climate crisis - The impact of CCS is not clear yet Negative when mentioning: - CCS cannot stop climate crisis - CCS is counterproductive, as fewer emissions are thus avoided
Amount of CO_2 reduction	Assessment of whether the amount of CO_2 reduced by CCS is significant for Switzerland.	Positive arguments: - A massive amount of CO_2 can be reduced Neutral when mentioning: - The impact and volumes of CO_2 reductions are unclear Negative when mentioning: - CCS cannot reduce enough CO_2 to have an impact
Risk of CO_2 leakage	The risk that CO_2 already stowed underground could leak back to the surface.	Positive arguments: - The risk of CO_2 leakage is completely eliminated Neutral when mentioning: - The risk of CO_2 leakage is moderate Negative when mentioning: - There is a risk for CO_2 leakage

Earthquake risk	Assessment of the probability of an earthquake being triggered by the drilling or operation of CCS plants.	Positive arguments: - The earthquake risk is completely eliminated Neutral when mentioning: - The earthquake risk is moderate Negative when mentioning: - There is an earthquake risk
Site search Switzerland	This concerns the difficulties that may arise when it comes to the location search for a CCS plant. For example, whether there is local resistance or a lack of space for the construction of the facilities.	Positive arguments: - There are several possible locations - There are communities interested in starting a pilot project Neutral when mentioning: - The site search is an open point Negative when mentioning: - No site can be found - Society / habitants decline CCS projects
Geological conditions	Assessment of whether the geological conditions in Switzerland are good for operating CCS plants and store CO_2 underground. This refers to the existing rock formations and layers.	Positive arguments: - Good geological conditions for CCS Neutral arguments: - Better and worse conditions available Negative arguments: - Bad geological conditions for CCS
Technological evaluation	Evaluation of whether the technology is considered promising or whether gaps in the technology are also highlighted.	Positive arguments: - Promising technology - Progresses in development of the technology Neutral arguments:

		- The technology must be evaluated Negative arguments: - The technology has to many problems - Development of technology is not getting ahead
Time horizon for implementation	Estimates of how long it will take to implement the first CCS plants in Switzerland. Whether this duration is considered too long or suitable.	Positive arguments: - Operation expected within a reasonable time Neutral arguments: - The time horizon is unclear Negative arguments: - It takes to long to develop the technology
Feasibility	To what extent CCS technologies and projects are feasible at all.	Positive arguments: - The technology is feasible - There will be concrete projects in Switzerland Neutral when mentioning: - The feasibility needs to be proven Negative when mentioning: - The technology will never work - CCS projects will never be implemented in Switzerland
Impact on power plant efficiency	The impact that CCS has on the production efficiency of the linked power plants.	Positive arguments: - The power plant can benefit from the operation together with CCS Neutral arguments: - Moderate / unclear efficiency reduction Negative when mentioning:

		- Relevant efficiency reduction
Experiences from previous projects	The influence on attitude of the success or failure of previous projects of CCS.	Positive arguments: - Good experiences from other CCS projects Neutral arguments: - No experiences - Good and bad experiences Negative arguments: - Negative experiences from other CCS projects
Costs for reduction of CO_2	Attitudes towards the cost implications associated with the storage of CO_2 through the operation of CCS.	Positive arguments: - Low costs Neutral arguments: - Moderate costs - Same costs level as for conventional CO_2 certificates Negative arguments: - High costs
Development & construction costs	This targets the costs for the development and construction of CCS plants.	Positive arguments: - The investment costs are low / moderate Neutral arguments: - The investment costs are similar to comparable projects Negative arguments: - The investment costs are high
Space requirement underground	This is about the space required underground to store CO_2.	Positive arguments: - Space underground can be better utilised through CCS Neutral arguments: - Space requirements are moderate Negative arguments: - Huge space requirements underground

Level of acceptance of population	To what extent the population supports or rejects CCS technology.	Positive arguments: - Positive voices from habitants - Public votes for CCS accepted Neutral arguments: - Acceptance is unclear - There are positive and negative voices Negative arguments: - Negative voices from habitants - Public votes for CCS rejected
Clearness of legal situation	On what extend laws are regulating the construction and operation of CCS plants. This includes the legal situation on storage of CO_2 underground.	Positive arguments: - The legal situation for CCS is clarified Neutral arguments: - The legal situation must be checked Negative arguments: - Lack of a legal basis for CCS
Political support	With political involvement is the support of politicians for CCS technologies meant. This also includes whether an open discussion regarding the legislative process for CCS technologies is held.	Positive arguments: - Positive statements of politicians - Acceptance of votes for CCS Neutral arguments: - Disagreement among politicians Negative arguments: - Negative statements of politicians - Rejection of votes for CCS
Government involvement	It is about the extent to which the federal government itself is involved into developing and promoting CCS technologies. Whether	Positive arguments: - Support from government Neutral arguments: - Support from government is not yet clear Negative arguments:

	there is support from the government - both financially and conceptually.	- No support from government Government is supporting but this is seen negatively
Support from science	This denotes support or rejection of CCS from the field of science.	<u>Positive arguments:</u> - Support from science and universities - Positive statements from researchers <u>Neutral arguments:</u> - Support from science is not yet clear - Positive and negative statements from research <u>Negative arguments:</u> - No support from science and universities - Negative statements from researchers
Involvement of environmental groups	This denotes support or rejection of CCS from environmental groups.	<u>Positive arguments:</u> - Positive statements from environmental groups <u>Neutral arguments:</u> - Positive and negative statements from research - Support / Rejection from environmental groups is not yet clear <u>Negative arguments:</u> - Negative statements from environmental groups

Source: own representation

Appendix F

Table 22: Coding guideline underground

Category	**Definition of category**	**Coding rules**
Additional planning resource	Whether the underground is being considered as a suitable planning resource for infrastructure projects.	Positive arguments: - The underground provides relief for scare space over the ground Neutral arguments: - It is unclear whether the underground can be used as planning resource for infrastructure Negative arguments: - No space available underground for planning of infrastructure
Building of tunnels	The attitude towards tunnel construction in Switzerland. Weather additions tunnel building is seen positively or negatively.	Positive arguments: - Tunnel building is part of the Swiss identity - Switzerland's tunnel network should be expanded Neutral arguments: - No attitude towards tunnel construction is represented Negative arguments: - Switzerland's tunnel network should not be expanded - Tunnel construction lead to negative side effects
Innovation and engineering skills	Strong engineering and construction skills are required to develop infrastructure in the underground. It is a	Positive arguments: - Good engineering skills - Good construction skills Neutral arguments: - No rating of the skills

	question of assessing the extent to which these skills are available in Switzerland and are seen as a reason for the further use of the underground.	Negative arguments: - Bad engineering skills - Bad construction skills
Political discussion	For example, this could also include political dependencies on foreign countries for CCS being discussed.	Positive arguments: - Positive statements of politicians - Acceptance of votes for the use of the underground Neutral arguments: - Disagreement among politicians Negative arguments: - Negative statements of politicians - Rejection of votes for the use of the underground
Environmental impacts	This refers to the use of the underground. Whether the use has an impact on the environment and whether this hinders the use.	Positive arguments: - The use has a positive impacts on the environment Neutral arguments: - The use has no / not significant impact on the environment Negative arguments: - The use has a negative impact on the environment
Mythical presentation	This is about the underground being assessed as a mystical, mysterious space.	Positive arguments: - Mythical / mysterious in a positive way presented Neutral arguments: - No rating of the mythical / mysterious presentation Negative arguments:

		- Mythical / mysterious in a positive way presented
Conflicts of use	Many planned projects underground will cause conflicts of use. There is not always space to implement every project.	Positive arguments: - Conflicts of use can be defused Neutral arguments: - There are no conflicts of use occurring while using the underground Negative arguments: - There are conflicts of use occurring while using the underground
Clearness of legal situation	On what extend laws are regulating the use of the underground.	Positive arguments: - The legal situation for the use of the underground is clarified Neutral arguments: - The legal situation must be checked Negative arguments: - Lack of a legal basis for the use of the underground
Government involvement	It is about the extent to which the state, cantons and municipalities itself are involved into the use of the underground. Whether the government is supporting concrete projects or is seen more as a hurdle for projects, for example due to approval procedures.	Positive arguments: - Support from government Neutral arguments: - Support from government is not yet clear Negative arguments: - No support from government - Government is supporting the use of the underground but this is seen negatively
Side-effects (Structural obstructions)	Impacts of forms of use on the population, such as influence on drinking	Positive arguments:

	water water quality or vibrations.	- The use of the underground has positive impacts on the population Neutral arguments: - No structural obstructions from the use of the underground occur Negative arguments: - Structural obstructions from the use of the underground occur
Social factors	How the living underground works and how the living above ground will be affected using the underground.	Positive arguments: - People feeling comfortable being underground Neutral arguments: - Society has no attitude towards being underground Negative arguments: - People do not like to be underground / do not feel comfortable there
Geological structures	Statements on whether Switzerland generally has good geological structures. This can be in relation to the use of the underground, but also to natural conditions. For example, this could be the tectonical conditions and the resulting earthquakes risks.	Positive arguments: - Good geological conditions of the underground Neutral arguments: - Better and worse conditions available Negative arguments: - Bad geological conditions underground
Data availability	This corresponds to the quality of the existing data regarding the	Positive arguments: - Data availability to plan underground projects is good

	conditions of the underground. This includes mapping as well as data of geological structures.	Neutral when mentioning: - Data availability to plan underground projects is unknown / need to be evaluated Negative when mentioning: - Data availability to plan underground projects is bad

Source: own representation

Appendix G

The following article provides an example for the coding. A green mark stands for positive arguments, blue for neutral and pink for negative arguments.

Figure 16: Coding example (1/3)

St. Gallen setzt die Bohrer an; In der Ostschweiz entsteht derzeit das grösste Geothermie-Projekt der Schweiz

Michael Breu, 27 March 2013, Basler Zeitung

bad experiences from previous projects

Am 8. Dezember 2006 bebte Basel. Einen Wert von 3,4 registrierten die Seismologen des Schweizerischen Erdbebendienstes auf der Richterskala. Drei Monate später, am 27. März 2007, folgten vier weitere Erdstösse. Sie waren schwächer und erreichten nur noch eine Stärke von 2,9 Punkten auf der logarithmischen Skala. Aber sie besiegelten das Aus für das ambitionierte Geothermie-Projekt von Basel. Zu forsch waren die Ingenieure, als sie mit hohem Druck Wasser in den Untergrund pressten, um an die im Erdinnern enthaltene Wärme zu gelangen. Seither hat dieses sogenannte petrothermale System einen schweren Stand als Zukunftsverfahren.

Geological conditions

St. Gallen geht einen anderen Weg. Seit Anfang März wird im Osten der Schweiz ebenfalls nach warmem Wasser gebohrt. Anders als in Basel verfügt St. Gallen im Untergrund über tiefliegende Gesteinsschichten, die heisses Wasser führen, sogenannte Aquiferen. Diese Schichten können einfacher angezapft werden. Geht alles nach Plan, so soll in spätestens vier Jahren die Hälfte der Gebäude in der Stadt St. Gallen mit Fernwärme umweltfreundlich geheizt werden, zudem werden zwischen 2000 und 3000 Haushaltungen mit Ökostrom versorgt. «Die Chancen für einen Erfolg stehen gut», sagt Fredy Brunner, FDP-Stadtrat, Direktor der Technischen Betriebe der Stadt St. Gallen und geistiger Vater des Geothermie-Projekts. Und mit Überzeugung fügt er an: «Wir bauen nicht einfach ein Geothermie-Kraftwerk, wir möchten St. Gallen CO2-freie Wärme für Jahrzehnte liefern, zuverlässig, zu einem konstanten Preis, mit lokaler Wertschöpfung und damit einen wichtigen Beitrag zu einer besseren Welt leisten.»

Environmentally friendly

Energy costs from DGE

Die Energiestadt Gold

Das St. Galler Geothermie-Projekt ist derzeit die grösste Tiefenbohrung nach warmem Wasser in der Schweiz. Es ist Teil des städtischen «Energiekonzepts 2050», das ebenfalls als eines der ambitioniertesten der Schweiz gilt und deshalb mit dem

Source: Breu (2013)

Figure 17: Coding example (2/3)

European Energy Award ausgezeichnet wurde. Für die Umsetzung des Konzeptes erhielt St. Gallen 2013 zum zweiten Mal das Label Energiestadt Gold.

Environ mentally

Das monotone Hämmern und Drehen ist schon von Weitem zu hören. Die Rechenwaldstrasse führt uns ins Sittertobel, vorbei am Kehricht-Heizkraftwerk und der Abwasserreinigungsanlage der Stadt. Nach einem überdimensionierten Kreisel – er musste eigens gebaut werden, um den Transport der riesigen Bohranlage zu ermöglichen – erreichen wir den Bohrplatz. Am Montag, 4. März, kurz vor 6 Uhr, wurde der Bohrkopf eingefahren in ein zuvor 20 Meter tief ausgehobenes Loch. Seither dreht er sich senkrecht in die «granitische Molasse»: 24 Stunden am Tag, sieben Tage die Woche.

Geological conditions

In den nächsten Tagen soll die erste Etappe abgeschlossen werden: In einer Tiefe von 1000 Metern wird dann der Winkel angepasst. Nach weiteren 400 Metern erreicht die Bohrung einen Winkel von 20,5 Grad, der bis auf die Tiefe von 2500 Metern beibehalten wird. Nach Erreichen dieser zweiten Bohrsektion wird aufgrund der Messdaten entschieden, ob weitere Seitenarme in Schichten mit höherer Wasserdurchlässigkeit gebohrt werden sollen. Nach weiteren 2000 Metern – also in einer Tiefe von 4000 bis 4500 Metern – ist dann das Zielgebiet erreicht. Dort wird genug 140 Grad heisses Wasser für den Betrieb des Geothermie-Kraftwerkes vermutet. Bereits im Juni sollen diese Schichten angezapft werden (vor dem St. Galler Open-Air-Festival, das am letzten Juni-Wochenende auf dem Nachbargrundstück stattfindet). Das Team um Stadtrat Fredy Brunner ist optimistisch, und Marco Huwiler, Projektleiter bei den St. Galler Stadtwerken, sagt: «Wir treffen bisher auf die Schichten, die wir vor Projektbeginn prognostiziert haben.»

Geological conditions

Auch der Bundesrat hofft

Political support *Public support*

Der Grundstein für das St. Galler Geothermie-Projekt wurde 2009 mit einer Machbarkeitsstudie gelegt. Mit nur einer Gegenstimme passierte es im August 2010 das Stadtparlament, und bereits drei Monate später, am 28. November 2010, bewilligte die Stadtbevölkerung mit über 80 Prozent Ja-Stimmen einen Rahmenkredit über 159 Millionen Franken. 76 Millionen sind für die Tiefenbohrung und den Bau des Kraftwerkes reserviert, 83 Millionen fliessen in den Ausbau des Fernwärmenetzes, das die Stadt vor einem Vierteljahrhundert als Pionierleistung aufbaute.

Development costs

Source: Breu (2013)

Figure 18: Coding example (3/3)

Obwohl der Erfolg der Geothermie noch ungewiss ist, ortet auch der Bundesrat in dieser Technik ein grosses Potenzial für die Wärme- und Stromversorgung der Zukunft. Bereits 2035 sollen Geothermie-Anlagen rund 1,4 Terawattstunden Strom pro Jahr liefern, 2050 sollen es sogar 4,4 Terawattstunden sein, heisst es in der bundesrätlichen Energiestrategie. Um dies zu erreichen, hat die Landesregierung ein Förderprogramm lanciert. Neben der Forschung (acht Millionen Franken) sollen Pilotanlagen (drei Millionen) gefördert werden. Auch will der Bundesrat die Risiken von Grossprojekten teilweise übernehmen; beim Scheitern des St. Galler Projekts würde der Bund maximal 24 Millionen Franken tragen.

Essential power supply

Government support

Financial risk

Vier Standorte in Wartestellung

Inzwischen hat auch die aus der aufgelösten Basler Firma Geopower hervorgegangene Firma Geo-Energie Suisse AG bekannt gegeben, weiterhin Geothermie-Projekte voranzutreiben. Noch in diesem Jahr soll mindestens ein Gesuch für den Bau und Betrieb einer Geothermie-Anlage eingereicht werden. Zur Auswahl stehen vier Standorte in der Schweiz: in Etzwilen (TG), in Avenches (VD), im Jura und in der Region Sursee-Mittelland.

Am fortgeschrittensten ist das Projekt in Etzwilen, wo ein Kraftwerk geplant ist, das 30 Gigawattstunden Strom liefern soll. Weil im Thurgauischen auf das vor sieben Jahren in Basel angewendete petrothermale Verfahren gesetzt wird, hat sich inzwischen eine Protestgruppe formiert. «Wir wollen nicht die Versuchskaninchen für eine neue Methode sein», sagt die Etzwilerin Iris Schilling dem «St. Galler Tagblatt», und Manuela Behr ergänzt: «Wenn es schiefgeht, sind unsere Gesundheit und unsere Häuser kaputt.»

Negative side effects

Source: Breu (2013)