DESTRESS

Demonstration of soft stimulation treatments
of geothermal reservoirs

Deliverable D3.3: Risk governance strategy report

WP 3.3: Risk governance

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Risk governance strategy report

Deliverable 3.3

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Introduction

This public report entitled *Risk Governance Strategy* corresponds to the Deliverable 3.3 of the European DESTRESS project. This comprehensive report is done on the framework of the WP3 dealing with "Risk management workflows for deep geothermal energy". The main objective of this sub-task was to analyze the public uptake of geothermal energy and geothermal projects in various socio-economic conditions in Europe. Several countries and organizations were involved in this study: the University of Strasbourg (UoS) and the company Electricity of Strasbourg (EGS) in France, the Netherlands Organisation for applied scientific research (TNO) in the Netherlands, the University of Glasgow (UoG) in the United Kingdom, the Swiss Federal Institute of Technology in Zurich (ETH) in Switzerland.

The importance of conducting social science research on the development of geothermal energy is apparent on at least two levels. First, the technologies involved in deep geothermal projects, and in particular those implementing the Enhance Geothermal Systems (EGS) approach, require significant human, technical and financial resources for both project development and risk management. Yet, these projects are not always well perceived by local authorities and inhabitants and several controversies have arisen in European countries. In France, the first protests against geothermal projects appeared in 2014/2015, they concerned a project located in Haute-Savoie near the border city of Geneva, and several projects planned in the Eurometropolis of Strasbourg in Alsace. They led to the withdrawal of two projects in Alsace. In Switzerland and Germany, opposition to projects in Haute-Sorne and Neuried blocked all geothermal work for several years. This poor reception of deep geothermal projects by the population can be explained in part by the media coverage of incidents related to several projects, in particular the 3.4 magnitude earthquake in Basel in 2006, which led to the final shutdown of the project, and the 2.7 magnitude earthquake in Landau in 2009. However, a more detailed analysis of the controversies that have arisen from these projects shows that the inhabitants integrate many other aspects, which may be of a political, cultural or economic nature, into their arguments against the project.

Second, social science research related to the field of geothermal energy can provide important insights to answer the need to establish Responsible Research and Innovation (RRI) at the European level. Indeed, RRI requires stakeholders to reflect more about how to develop a project, to facilitate the engagement of local authorities or even inhabitants in the definition of projects, with all the consequences this may have in terms both of communication and of project governance.

The work carried out within the framework of the DESTRESS project is multidisciplinary. The consortium members involved in this work package are geologists, geographers, sociologists, researchers in communication studies. Several approaches are being used. A broad media study was conducted in several countries, including France, Switzerland, the Netherlands and Great Britain, over a period ranging from the early 2000s to the present. It provides a more accurate picture of the media coverage of the development of projects, whether they are pilot projects or projects for heat and electricity production. Work has also been carried out on public engagement strategies as well as on devices fostering reflexive approaches among stakeholders: studies of the engagement of inhabitants in legal public inquiries organized by Prefecture in France; action research related to the governance of the Geneva project in Switzerland; the setting up of a reflexive research approach aiming at evaluating the societal embeddedness of a specific project in the Netherlands. Finally, studies on public perceptions of deep geothermal energy have been conducted in France and Switzerland using different sociological tools (observation, quantitative studies, and focus groups).

All these studies account for the different contextual factors that may impact both the definition of projects and their adoption by different social groups. These may be cultural or social factors. Local culture, tradition, identity, or relationship with the natural or urban environment can influence how people perceive and interpret a project. They may be political factors. Local political action in favor of renewable energies or innovation may play a positive role in the development of a partnership approach

in project definition and implementation. More concretely, the ways in which industrialists or local authorities interact with local elected officials and residents influence social uptake of a project.

These different factors contribute to what we call the embeddedness of a project. Considering the more or less strong embeddedness of a project we distinguish between on the one hand, locally rooted projects that are the result of a mature dialogue between the different actors and, on the other hand, unrooted projects, prompted by economic profits and/or national political programming, often ignoring the specificities of the local territory. The social shaping of a project obviously affects its perception by the general public and may prompt diverse reactions: somewhat consensual support in the case of rooted projects and criticism and resistance in the case of unrooted projects. However, the form and strength of oppositional social movements or support for a project largely depends on the social situation and on the identity of the actors and stakeholders.

This report is structured in six chapters. The first chapter provides a brief overview of the state of the art regarding EGS technologies and the risks involved, followed by a summary of the orientations of social science research on deep geothermal energy. The second chapter presents the different case studies on which the work carried out under WP 3.3 of the DESTRESS program has focused, with references to national contexts. Chapters 3 to 5 present the work and results of the research carried out under the DESTRESS program according to three main subjects, media studies, research on public perception of deep geothermal energy, and work on public engagement. The last chapter discusses different issues - the fate of rooted and unrooted projects, the dynamics of social movements, the role played by the state and local authorities - and ends with a series of recommendations.

Chapter 1. General presentation: Enhanced Geothermal Systems and social studies of geothermal projects implementation and policies

1. From Hot Dry Rock systems (HDR) to Enhanced Geothermal Systems (EGS)

Enhanced geothermal systems (EGS) allow widespread use of the enormous untapped geothermal energy potential. EGS measures are generally intended to improve productivity (or injectivity) of a geothermal reservoir by increasing the overall transmissivity of the reservoir rocks. This goal is achieved through various methods that are dependent on the geological system that comprises the rocks, the rock structures, the tectonic situation as well as the stress field (Huenges et al., 2020).

Enhanced (or Engineered) Geothermal Systems (EGS), previously known as Hot Dry Rock (HDR) systems, arose from a concept initiated in Los Alamos (USA) and Cornwall (UK) to exploit the vast energy resource in the form of heat in the low-permeability rocks that underlie most continental regions at practically drillable depths. The central concept is to engineer hydraulic linkages between two or more boreholes within the target reservoir to enable circulation of fluid through the hot rock at rates of commercial interest. A great deal of work has been conducted in classic HDR settings to learn how to engineer linkages that have the characteristics of a heat exchanger.

In Europe, most geothermal developments have taken place at the Soultz-sous-Forêts site located in northern Alsace, located about 50 km north of Strasbourg. The Soultz reservoir deviates from a classic HDR system inasmuch as it contains permeable structures that host substantial volumes of natural brines (Genter et al., 2010).

Soultz-like EGS projects located in the Upper Rhine Graben (Insheim, Landau, Rittershoffen) are characterized by the occurrence of large volumes of natural brines contained in fractured crystalline rocks, whose natural permeability is very low due to the poor hydraulic connection within the fracture network. To be able to circulate through the rock mass at the rates needed for commercial energy production, the permeability of the rock mass must be increased or “stimulated” by applying various techniques such as thermal, hydraulic or chemical stimulation. Thermal stimulation could generate thermal cracks and thus increase the original permeability, especially in crystalline rocks. This system has been successfully applied at the Rittershoffen site (Baujard et al., 2017). Hydraulic stimulation acts mechanically by shear dilation through the injection of large volumes of water at high pressure but generates nuisances such as induced seismicity. Chemical stimulation using acid treatment dissolves the secondary minerals that seal the natural fractures and can also increase productivity. All these techniques help to the development of reservoirs. In the framework of Destress, treatment consists in soft stimulation to minimize the potential nuisances.

In case of successful stimulation, geothermal wells are then better connected to a far field reservoir which is exploited by hydraulic circulation like in Soultz and Rittershoffen, which is operating today (Baujard et al., 2018; Ravier et al., 2019). Hot natural brine is pumped from the production well, and is then re-injected at lower temperature into the fractured rock mass within the reinjection well. Meanwhile on the surface, the geothermal fluid transfers its energy to the power plant for the production of electricity like in Soultz, or heat like in Rittershoffen. These two operational sites have been exploiting a crystalline fractured reservoir since 2016 with more than 90% a sustainability (Baujard et al., 2018; Mouchot et al. 2019).

The development of EGS technology by deep drilling in the upper crustal lithosphere faces many scientific and technical challenges. Among them, a major issue is to improve the poor hydraulic connections between production/re-injection wells and the fractured reservoirs by optimizing well trajectories, stress field orientation and fracture geometry. What is more, the physical processes and mechanics of induced seismicity in geothermal systems are poorly understood and are consequently another important challenge to overcome. There have been some well-known felt seismic events in the Upper Rhine Graben linked to hydraulic stimulation at Soultz in 2003 (Magnitude 2.9) and Basel in 2006

(Magnitude 3.4), or during geothermal exploitation like in Landau in 2009 (Magnitude 2.7). Finally, felt induced seismicity is the main nuisance that could happen with EGS.

2. Social studies of geothermal energy developments

Geothermal energy for heat and electricity production is an emerging source of renewable energy (RE) that several European countries and regions aim to implement. Thus, several sociological studies on geothermal energy related to national or European research programs were carried out in the 2000s and 2010s aimed at prospecting and assessing, through questionnaire surveys and focus groups, how a population may perceive the installation of a geothermal power plant. Feelings expressed by the populations are generally rather enthusiastic at first glance, geothermal energy being perceived as one of the energy sources that can make it possible to reduce the consumption of fossil fuels (See for instance Pellizone et al., 2013). However, this optimism decreases when a plant is scheduled to be built in the inhabitants immediate vicinity. For instance, a sociological survey conducted in the Italian region of Viterbo revealed that the population was confident about the future role of renewable energies, including geothermal energy (Pellizone et al., 2017). But this corresponded to a general approval of the need for energy transition. When the same researchers organized local discussions in focus groups they singled out potential obstacles to the projects: fears related to arsenic contamination of groundwater (a sensitive subject in the region) and lack of trust in local government.

The discrepancy between an optimistic vision of renewable energy and the expression of misgivings when faced with local projects may have been reinforced by the fact that geothermal projects have not always been environmentally friendly, in either the natural or human environment. In the 2000s and 2010s several events disrupted the expansion of the geothermal sector in France, Switzerland and Germany. In 2003 in Soultz-sous-forêts, a 2.9 magnitude earthquake was caused by hydraulic stimulation aimed at reopening microcracks in the granitic basement. At that time, the hot dry rock technique, which resembles the fracturing method, was still in use. The same phenomenon occurred in Basel in 2006 at a magnitude of 3.4 leading to the final shutdown of the project. Three years later, another earthquake occurred in Landau, Germany at a magnitude of 2.7. In addition, shallow drilling caused soil swelling or subsidence resulting to serious damage to roads and buildings in several cities in France and Germany. This was the case in the villages of Lochwiller and Kircheim in Alsace and at six different locations in Baden-Württemberg in Germany, the best known being the one in Staufen-im-Brisgau.

These local accidents may have huge consequences for national or local political agenda concerning the development of geothermal energy. In this context, media are cited as the main cause of misunderstandings about the risks caused by projects. For instance, Stauffacher et al. (2015) analyzed the role of the media in developing public perceptions of the risks of deep geothermal projects. They argue that the media tended to cover stories related to risks or accidents but payed scant attention to successful projects. Leucht conducted a detailed analysis of project coverage in the German media over the period 2003-2011 (Reith et al., 2013). She showed that during this period the media focused much more on the problems generated by the projects – for instance the 2009 seismic event related to the Landau project – and on the discontent of the populations than on the role that deep geothermal energy may play in the energy transition or economic development of a region. In Leucht's opinion, this situation was due both to the lack of commitment of industrialists in communication and to their lack of foresight.

Until the early 2010s, resistance and opposition to energy-related projects were rarely analyzed as a sociological phenomenon as such. Work on this topic focuses on social acceptability (or its absence) or acceptance by the communities of the projects (Batellier, 2015). However, the use of the term acceptability reflects a rather top-down and normative vision of the development of deep geothermal energy. It considers that projects are now an integral part of the energy policy of a country, region or federation; that governments have taken the necessary steps to facilitate and regulate the involvement of companies involved in the implementation of this policy. People should therefore be convinced or

even enthusiastic about the efforts being made to promote the energy transition. Thus, resistance by local communities or inhabitants is often dismissed as informed by emotional, ignorance-fueled reactions. The most radical conclusions (Gendron, 2014) evoke a NIMBY (not in my backyard) syndrome to account for the alleged selfish attitude of opponents who are unable to grasp the technical dimensions and collective value of a project. This approach is generally associated with a simplistic view of the role and influence of the media in times of controversy: negative when they relay the words of opponents, positive when they talk about the potential societal and environmental benefits of a project.

In his cartography of the concept of acceptability Batelier (2015) analyzed all the postulates on which this reading of the social understanding of energy-related projects is based: opposition is considered as deviant behavior, guided by emotions and ideologies, citizens do not understand or are misinformed; the controversy or conflict is bad and reflects a lack of trust in the project leaders. In this context, it is assumed that more information and greater familiarity with the projects would encourage a positive attitude.

However, this reductive interpretation of the resistance to the implementation of sociotechnical projects rarely stand up to empirical scrutiny. It appears that opponents quickly inform themselves not only about the technical aspects of a controversial project, but also about the environmental, political and economic aspects. It is therefore necessary to go beyond these interpretations that stigmatize opposition and seek to understand all the dimensions of the public responses to projects. In particular, one may ask whether the perception of risk, which is assumed to cause uncertainty and fear, is so central in geothermal controversies.

While the risks issues are important to take into consideration when studying resistance or opposition to geothermal projects, current sociological research shows that other issues matter in the public uptake of a project. In their synthetic text Meller et al. (2018) argued that environmental, but also economic and political concerns are common in public debates on deep geothermal energy. Discussions are often about the risks to the environment or housing, the cost-benefit balance for a community, and matters related to the public's information or public consultation exercises. However, inhabitants do not give equal importance to these aspects in all the case studies. Pellizzone et al. (2017) argue that economic, social and political contexts, the occurrence of seismic episodes in a region, or the degree of commitment of a population to environmental issues are elements that likely influence the way people think about deep geothermal projects. Because they can have a significant impact on project development, addressing these factors must become a crucial issue for stakeholders.

The report on Public acceptance of the Geo-elect consortium (Reith et al., 2013) and the collective book *Geothermal energy and society* (Manzella et al., 2018), endorse the need for Responsible Research and Innovation (RRI) to conduct case study analysis and support the development of deep geothermal projects. Following von Schomberg (2013) they state: "societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable product" (cited in Manzella et al, 2018, p. 57).

According to these authors, the adoption of the RRI principles imposes a radical move with respect to the social acceptability model, particularly in terms of the relationships that stakeholders develop with civil society: "efforts should be made to ensure that society becomes a partner in co-constructing the path of innovation from the initial planning stages and throughout developments as opposed to seeking public approval and social acceptance only in the final phases of developments" (*op. cit*., p. 57). Several principles should be implemented: to include wider society through citizens' participation and public engagement; to be reflexive and take all perspectives into account (instead of imposing a predefined agenda in public deliberations and activities); to anticipate what the future would (could) be in terms of promises and perils.

By presenting the work carried out under WP 3.3 Risk Governance of the H2020 DESTRESS program and of a set of recommendations, this report aims to contribute to the implementation of a Responsible Research and Innovation approach that takes three levels into account. First, the analysis of public consultation and engagement mechanisms, as well as the study of the public perception of deep

geothermal energy, makes it possible to identify what is understood by social desirability. These analyses can also lead to the emergence of a more reflexive approach and enable operators and local institutions to better appreciate the social, cultural and identity contexts with which they interact. Secondly, the action research work carried out with project stakeholders in the Netherlands and Switzerland calls for a form of reflexive engagement on the part of the project actors. For instance, the main objective of the work carried out around the Trias Westland project was to make the project's stakeholders think about the embeddedness of the project. Thirdly, a reflexive approach is also encouraged through the studies conducted on the media. They provide an overview of the media's focus on deep geothermal energy and on the degree of precision provided in the media regarding technical and political issues in project development. In this regard, this report invites promoters to reconsider their approach to media relations.

Chapter 2. Presentation of the case studies

1. National frames: legal context and participatory tradition

1.1. France

Development of high temperature projects[1]

High temperature geothermal energy is emerging in France thanks to the creation of Franco-German consortium[2] which established the pilot project of Soultz-sous-Forêts in 1985[3]. A genuine laboratory for deep geothermal energy, it was intended to exploit the thermal anomaly of the Rhine basin by first developing a Hot Dry Rock type geothermal project. After several exploratory phases, and three boreholes more than 5000 m deep, the group discovered a very saline aquifer located at a depth of 3500 m, in a naturally fractured granitic bedrock and a temperature of 200 °C. The EEIG's activity provided the basis for the Enhanced Geothermal System (EGS) technique. The aim has been to experiment the different types of stimulation (thermal, hydraulic, chemical) that allow better water circulation in micro-cracks. The EEIG was converted into an industrial site in June 2016 following the acquisition by Electricité de Strasbourg (a subsidiary of EDF), which invested 8 million euros in the fracture system. With a capacity of 1.7 MWe, the site can now produce 12,000 MWh of electricity per year, supplying electricity to the equivalent of 5000 homes.

Inspired by the Soultz-Sous-Forêts model, many projects have been launched since 2000 in the German, Swiss and French regions of the Rhine basin. Thus, on the French side, in Alsace, the 24 MW Rittershoffen geothermal thermal plant was inaugurated in 2016. It supplies heat to the Roquette starch factory located about 15k m kilometers away. In Alsace, three cogeneration power plant projects are currently being operated in the Eurometropolis of Strasbourg and two projects are being drawn up in northern Alsace and on the outskirts of Strasbourg. The Rhine basin is not the only area where deep geothermal energy is being developed. The Ministry of Mines has issued a dozen or so research permits regarding high-temperature geothermal energy, to be carried out in Alsace and in areas in the Massif Central and in south-western France. Thus, 23 projects could be completed by 2030, which would generate 211.5 MWe and 245 MWth for an investment of 1,500 million euros.

Legal and participatory aspect

The development of low and high-temperature geothermal energy is backed by various provisions taken within the framework of the national climate plan (2004) and the Grenelle 1 and 2 laws (2009/10). First, the Renewable Heat Fund was created in 2009, which includes a total allocation of 1.12 billion euros and targets renewable energy and energy recovery (EnRR) heat projects. It allows operators to produce heat at a competitive price compared to the use of fossil fuels. The revival of low-temperature geothermal energy in the Paris Basin has been partly achieved thanks to this Fund. It has also encouraged provincial cities to include the development of geothermal energy in their territorial climate plans[4]. This is the case, for example, of the climate plan of the Eurometropolis of Strasbourg, which sets a target of 20% to 30% of renewable energy usage for private and public needs[5]. Secondly, EDF's

[1] A more extended account of the development of geothermal energy in France is given in Chavot et al., 2019.
[2] This consortium took the form of the EEIG (European Economic Interest Grouping) called *exploitation minière de la chaleur* (heat mining) in 2001.
[3]This project is supported by the European Commission, the French Ministry of Research through the AFME (now ADEME), and the German Ministry of the Environment.
[4] http://www.energivie.info/PCET (accessed on 02/26/2018).
[5] http://blog.bio-ressources.com/non-classe/alsace-geothermie-profonde (accessed on 02/26/2018).

electricity purchase tariffs were revalued in 2010, setting the price of kWh from geothermal energy at 20 cents, which also benefited from an 8 cent premium. This measure made it possible to ensure the economic viability of cogeneration projects and led several companies to favor this option rather than heat production alone, despite the limited efficiency of converting heat into electricity. Finally, the establishment of a guarantee fund set up by companies with the support of the Ministry of Ecology allowed companies to obtain financial compensation in the event of unsuccessful drillings.

In France, the development of geothermal energy depends on the mining code, since it is linked to the exploitation of underground resources. Likewise, the granting of research and concession licenses is controlled by the state and by local prefects. For low-temperature geothermal energy (<150 °), all procedures are managed locally. The exclusive license to prospect (*Permis exclusive de recherche* - PER) is granted by the prefect for a period of three years. For high-temperature projects with or without generation of electricity, applications for the PER are processed by the Ministry in charge of mines. In this case, the state or prefect calls on several evaluation and control bodies:

- Analysis of applications for a license, their compliance with the legal framework and the monitoring of drilling operations is carried out by the Regional Directorate for Environment, Development and Housing (DREAL) linked to each prefect.
- Additional expertise can be provided by the French national institute for industrial environment and risks (Ineris), concerning subjects relating to risk management. The Departmental Council of Environment and Sanitary and Technological Risks (CODERST) can also be called on regarding environmental and hygiene issues.

	Low temperature project	High temperature project
	Licence needed for drilling depth over 200 m. < 150 °C	> 150 °C
Application for an Exclusive licence to prospect (PER)	Administered by the prefect. Organization of a public inquiry.	Administered by the Ministry of Mines. European competition. Public consultation via a web platform
Permit is issued	Prefectural decree, valid for 3 years	Ministerial decree, valid for 5 years
Authorization of Exploration	Administered by the prefect. Organization of a public inquiry	
Commissioning of the plant	Administered by the prefect. Registry of public consultation.	
Application for a concession	Administered by the prefect. Organization of a public inquiry. The concession is valid for 50 years, renewable for a period of 25 years	

Figure 1. Mandatory public consultations for low and high temperature geothermal energy

Hence, approval procedures can take a very long time. For example, the procedures that led to the beginning of geothermal drilling in the Eurometropolis of Strasbourg in 2017 began in 2010.

The public is consulted several times during the process. Two different procedures exist depending on the nature of the license: for a low temperature license administered by the local prefect, citizens' opinions are collected through a local public enquiry; for high temperature license controlled by the State, the Ministry of Ecology has set up a web platform to collect citizens' comments. Once the license has been granted, in both cases (low and high temperature projects) a second consultation is carried

out for the exploration authorization request administered by the prefect, which takes the form of a public inquiry. Finally, the public is consulted again before the plant starts operating and during the application for a concession (Chavot et al., 2019).

1.2. Switzerland

Switzerland has the highest density per km2 of heat-pump installations (Rybach, 2013) but does not produce any electricity from geothermal resources as of November 2019. Early developments of Deep Geothermal Energy (DGE) in Switzerland were marked by notorious drawbacks. In Basel (2006), the local energy utility *Industrielle Werke* Basel AG (IWB) and city government strongly supported the Deep Heat Mining project that should have been the first commercially operating petrothermal power plant in the world. This project triggered a 3.6 M earthquake and was consequently halted. In 2013, another, this time hydrothermal, project implemented by the energy utility St.Galler Stadtwerke (SGSW) and city authorities of St.Gallen caused a 3.4 M earthquake after unexpectedly drilling into a natural gas reservoir. Although drilling operations resumed after the earthquake, the project was stopped because the flow of hot water was insufficient.

Despite these two failed flagship projects, there are about 20 projects which are either actively producing or in the planning stage (Ejderyan et al., 2019). Most are hydrothermal systems and do not openly thematize the question of stimulation in their public communication. Among those, the actively producing systems are mostly mid-depth projects with drilling depths ranging from 300 m and 2,371 m. The largest active project is the Erdwärme Projekt in Riehen near Basel with a capacity of 5 MWt heat. All the other projects are very small in comparison, with a capacity of 1.35 MWt or less.

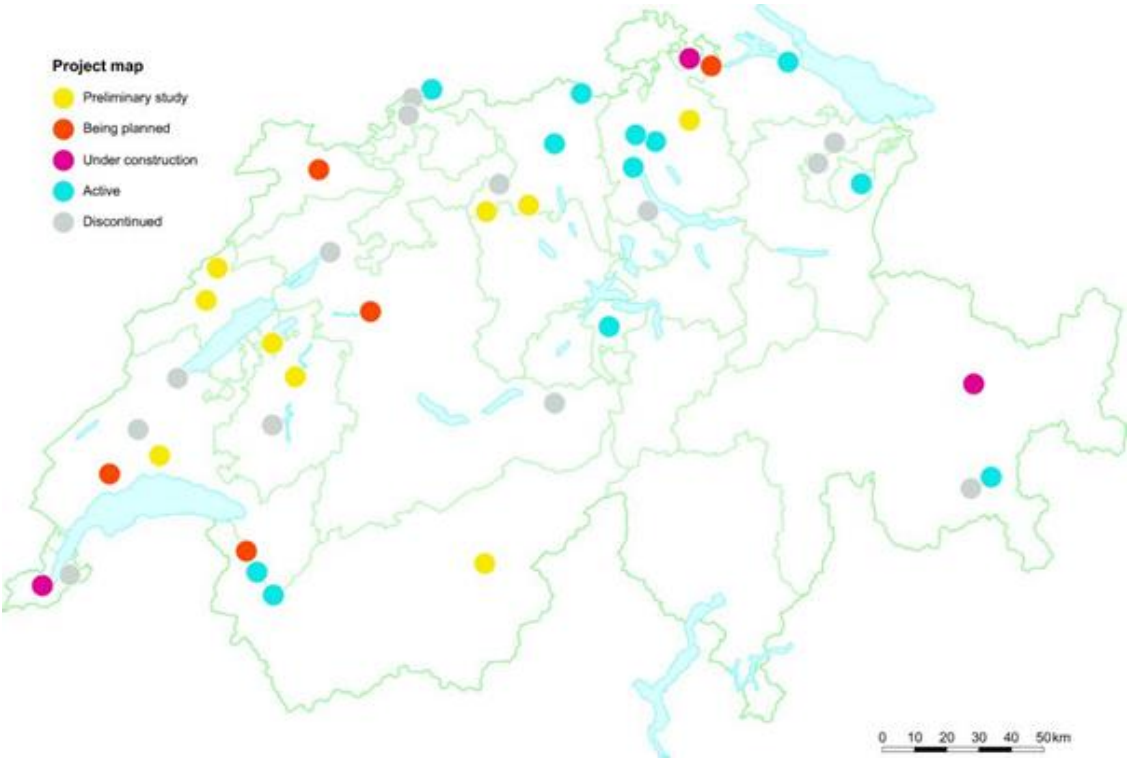


Figure 2. Geothermal projects in Switzerland and their development status (Source: Geothermie-Schweiz.ch, 2018)

Legal context

In Switzerland, the energy transition was formally accepted by citizens in a referendum on a Federal Energy Strategy 2050 (ES2050) in May 2017 and enforced in a new Energy Act (EnA) in 2018. The strategy relies on increasing energy efficiency and promoting the development of renewable energies while phasing-out nuclear power plants. Geothermal energy is one of the new renewables to be promoted. Scenarios for the ES2050 assume geothermal electricity production of 4.4 TWh by 2050 (Prognos AG, 2012), representing approximately 8% of electricity production by then.

The Swiss federal structure and direct democratic system mean a wide range of actors influence the development of DGE. Energy policy in Switzerland is shared among the three federal levels (Thaler et al., 2019). At federal state level, the Swiss Federal Office of Energy (SFOE) is responsible for the development and oversight of energy policies, while cantons and municipalities are responsible for their implementation.

The direct democratic system provides opportunities for citizens and actors from civil society, including non-governmental organizations (NGOs) and professional corporations, to intervene in the planning and implementation of policies and projects, especially ones with a local impact (Kübler, 1999; Linder & Vatter, 2001). Instruments such as national or local referenda and initiatives enable citizens to oppose or propose laws, policies and projects, provided enough signatures are collected. Moreover, several legal and administrative procedures allow stakeholders to contest projects. To avoid lengthy legal or political processes with uncertain outcomes, policy makers and project managers are therefore prone to engage in dialogue with concerned stakeholders and the public in the early stages of a project (Kübler, 1999).

Regarding electricity production, the federal state has wide prerogatives. With the ES2050 the federal government decided to phase out nuclear power and support the development of renewable energies. The federal state can steer such development for instance by setting the level of feed-in tariffs. Furthermore, it supervises the national electricity grid (Thaler et al., 2019). The federal state set the basic law for DGE in the country in the frame of the ES2050.

Until the acceptance of the ES2050, the SFOE supported single geothermal projects based on its own budget and granted an exploration risk guarantee covering 50% of exploration costs for projects aiming to produce geothermal electricity that failed because insufficient resources were found. Since the acceptance of the ES2050, the share guaranteed by the federal state has risen to 60%. In Switzerland, knowledge about the deep underground is low compared to countries that have an oil and gas industry. The presence of deep geothermal resources can only be determined through exploratory drilling (Hirschberg, Wiemer, & Burgherr, 2015). In Switzerland such drillings cost the equivalent of several tens of millions of euros, depending on their depth. Therefore, large deep geothermal projects are usually initiated by public utilities, cantons or big cities. Geo-Energie Suisse, the only private operator for DGE in Switzerland is owned by a consortium of public utilities.

The ES2050 attributes a significant role to DGE in the future Swiss energy mix. The scenarios for the ES2050 assume electricity production of 4.4 TWh by 2050 (Prognos AG, 2012) from DGE. The EnA supports the DGE by setting goals and increasing the federal guarantee to cover 60% of exploration costs. The public vote also gave geothermal energy more legitimacy. As part of the ES2050, geothermal energy infrastructures are now considered of national interest (as is all renewable energy infrastructure), making it more difficult for opponents to contest such infrastructure based on local concerns alone. Moreover, the EnA introduces a preferential price for electricity produced by geothermal energy. Finally, the SFOE supports DGE development through the funding of pilot projects or research programs.

As the ES2050 focuses on electricity, no target has been set for the production of geothermal heat. The federal state has fewer prerogatives for policies regarding heat than for electricity. The main reason is that the largest share of heat consumption is used for heating buildings. According to the federal constitution, the cantons are in charge of regulating the energy consumption of buildings. The federal state has some indirect influence on heat policies through taxing carbon emissions (Thaler et al., 2019).

The 26 cantons are responsible for implementing the EnA. Sovereignty over the underground lies with the cantons, and as such, they are the authorizing bodies for any DGE project. Cantonal legal bases for regulating DGE vary strongly across the country. This diversity in cantonal regulations has been identified by legal experts as an obstacle to the nationwide development of DGE as project developers cannot rely on a standardized workflow (Wiederkehr & Abegg, 2015). Cantonal authorities are generally in charge of granting authorizations for deep geothermal energy projects. In some cantons, the oversight of projects is delegated to the municipalities. Cities that have enough financial capacity might even develop their own projects through their public utilities, as in the case of St.Gallen, or in partnership with private operators.

Contrary to other European countries, Switzerland does not have a longstanding tradition for oil and gas exploration. Therefore, only a few exploratory wells have been drilled and there is a lack of knowledge about the Swiss underground. This adds further uncertainties to the ones originating from the institutional frame.

At national level, geothermal energy is perceived rather positively by the population, however it is still little known compared to other renewable energy sources and many people are unsure about supporting it (Moser & Stauffacher, 2015; Stadelmann-Steffen & Dermont, 2016). In a national survey on the acceptance of renewable energy based on a representative sample, over 55% of respondents indicated support for the expansion of geothermal infrastructures for electricity production (Stadelmann-Steffen & Dermont, 2016). Another more recent study comparing support for hydropower and DGE in Switzerland obtained similar results (Blumer, Braunreiter, Kachi, Lordan-Perret, & Oeri, 2018). National environmental NGOs generally also have a positive attitude toward DGE. They consider geothermal energy as an alternative to fossil fuels for heat and – to a lesser extent given the potential of wind, solar and biomass – as a replacement for nuclear energy in power production.

Public acceptance at the national level is important as in the direct-democratic system, citizens can have a direct influence on policies promoting DGE, through legal procedures or referenda. However public support at the national level does not mean that the implementation of single projects will go smoothly, especially in a federal country. Residents who live near sites of potential geothermal power plants might oppose specific projects, as has been the case with some of the DGE projects. Particularly the special character of a low probability-high consequence risk associated with DGE influence their perception of the technology (Knoblauch, Stauffacher, & Trutnevyte, 2018).

1.3. Netherlands

National playing field.

In the Netherlands, Geothermal energy is mainly used for heating (direct use). In total, 20 geothermal projects have been implemented in the Netherlands (2019). Most projects concern the greenhouse horticultural industry; two projects are operational for heating supply in the built environment. In the future, geothermal energy might also be used for electricity production or industrial processes. Geothermal energy is seen as an important source of renewable energy that is needed to achieve the goals of the Paris Agreement. According to the Dutch National Climate Agreement, geothermal energy will play an important role in the transition towards a more sustainable energy system in the Netherlands.

In order to accelerate the development of geothermal energy projects in the Netherlands, more knowledge about the characteristics of the (deeper) subsurface is required. Therefore, several research programs have been initiated in the Netherlands. One of these programs is the so-called ‘Netherlands Seismic Campaign for Geothermal Energy’ (Seismische Campagne Aardwarmte Nederland) or ‘SCAN’ program for short. This program was initiated by the Dutch government. Its purpose is to complete the map of the Dutch deep subsurface by researching the areas that were historically left ‘blank’ because of their lack of oil and or gas potential. By openly sharing these data, SCAN will help support future

determination of geothermal potential in these areas. A second research program is the so-called Green Deal Ultra Deep Geothermal Energy (UDG). This collaborative research program is focused on gaining more insight into the feasibility of developing ultra-deep geothermal energy projects. By producing more knowledge about the characteristics of the deeper subsurface (more than 3-4 kilometers depth), the participants aim to get more insight into whether geothermal energy deep in the subsurface could be produced in a safe and responsible way. Participants in the Green Deal UDG come from national authorities, research institutes as well as engineering, industrial and energy companies.

Regional playing field.

Within the EU project DESTRESS, the Trias Westland project in the Westland region has served as a case study for evaluating the societal embeddedness of the project in its local environment. As part of the Trias Westland project, drilling was planned down to the Trias formation, a geological formation at a depth of more than 4 km in the subsurface. This was the first time the Netherlands had drilled to a depth of 4 kilometers. The aim of the exploratory drilling was to determine the feasibility of geothermal systems in the Triassic Sandstones in the West Netherlands Basin.

Originally, the Trias Westland project appeared to be useful as a test site for (soft) stimulation techniques. However, drilling revealed that the Trias Formation was too impermeable for geothermal energy production at a depth of 4 kilometers. Despite the fact the Trias Westland could not be used for testing and validating stimulation techniques, it still was an interesting project for evaluating the societal embeddedness of the project.

After a few fiascos with developing and implementing innovative energy projects in the subsurface – like shale gas in Boxtel and CO2 geological storage in Barendrecht – as well as the current problems with seismicity as a consequence of the natural gas production in the Groningen field, the use of the subsurface has become controversial in the Netherlands. National, regional and local governments as well as industrial and energy companies are worried that geothermal energy could also become controversial. The Trias Westland project was therefore perceived as an ideal opportunity to evaluate the stakeholder management and communication strategy of the Trias Westland project and to derive best practices for improving the societal embeddedness of geothermal energy projects.

2. Presentation of the case studies

2.1. France, Northern Alsace and Eurometropolis of Strasbourg projects

In Alsace, the two functioning geothermal power plants are located in the north part of Alsace, at Soultz-sous-Forêts and Rittershoffen. Six applications for exploratory drilling were submitted to the prefect in 2013, five of which concerned the Eurometropolis of Strasbourg (EMS) region. Three of these projects had been strongly contested in the public space during the legal public inquiries organized in spring 2015 (Figure 4). The Robertsau project was contested by residents' associations, and the Eckbolsheim and Mittelhausbergen projects were contested by the municipalities affected by the projects. Mobilization was less significant in Illkirch-Graffenstaden and in Vendenheim. The two projects planned in northern Alsace have not provoked any hostile reaction up to now.

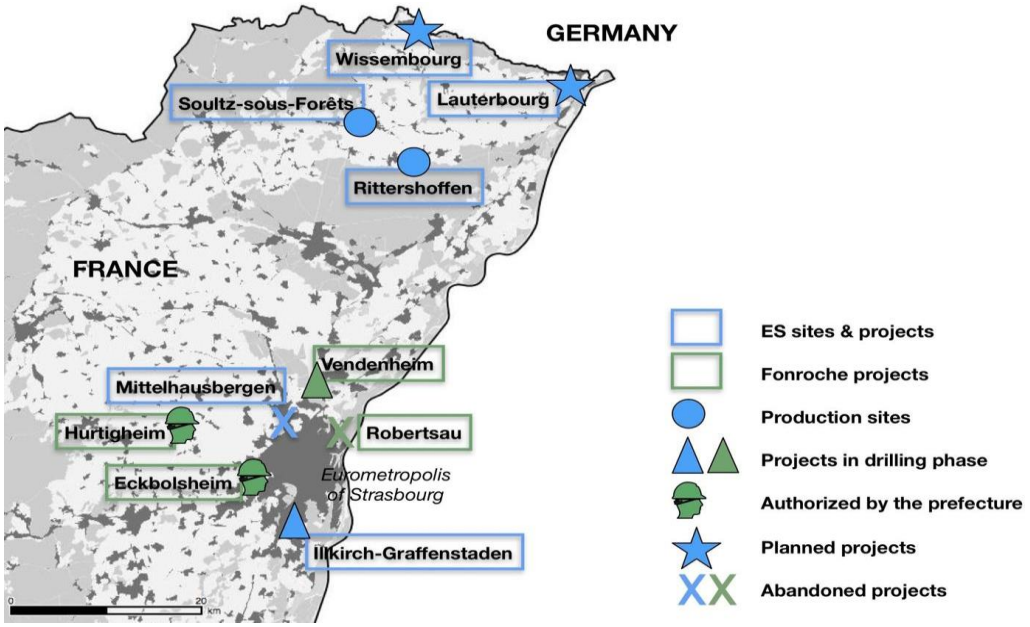


Figure 3. Locations of the deep geothermal projects in northern Alsace and in the outskirts of Strasbourg (Background, IGN land cover map).

Sites and operators (ÉS: Electricité de Strasbourg)	**Prof.: Temp: Flow**	**Production**	**Status**
Projects and plants in northern Alsace			
Wissembourg and Lauterbourg area, ÉS	Not defined	Power (+heat)	Planned project. No apparent opposition.
Soultz-sous-Forêts, ÉS	5 000 m: 150°C: 100 m^3/h	Power (+heat)	No opposition. In production.
Rittershoffen, ÉS	2600 m: 170°C: 300 m^3/h	Heat	No opposition. In production.
Strasbourg Eurometropolis projects			
Illkirch-Graff., ÉS	2900-3300 m: 150-160°C: 200 m^3/h	Heat + power	No opposition. Approved by prefecture. Drilling began in June 2018.
Mittelhausbergen, ÉS	3800 m: 140-150°: 180 m^3/h	Heat	Opposed, then abandoned (due to obsolete license).
La Robertsau (Strasbourg neighb.) Fonroche	4300-4800 m: >150°C: 350 m^3/h	Power (+heat)	Opposed, then abandoned.
Eckbolsheim Fonroche	4300-4800 m: >150°C: 350 m^3/h	Power (+heat)	Opposed. Approved by prefecture.
Vendenheim Fonroche	4000-4200 m: >150°C: 350 m^3/h	Power (+heat)	Opposed. Approved by prefecture. Drilling began in June 2017.
Other projects			
Hurtigheim Fonroche	4300-4800 m: >150°C: 350 m^3/h	Power (+heat)	Opposed. Approved by prefecture.

Figure 4. Main geothermal projects in Alsace
(Heat between brackets means that the target of producing heat has not been decided).

After the organization of legal public inquiries, the prefect authorized four projects, three located within the territory of the EMS (Illkirch-Graffenstaden, Eckbolsheim, Vendenheim), and one on the western outskirts of the EMS (Hurtigheim). Up to now, drilling has started only at the Vendenheim and Illkirch-Graffenstaden sites.

All the projects use - or intend to use – a similar approach: to target an aquifer trapped in the granitic basement at 3,000 m or deeper, and make use of the EGS (enhanced geothermal system) stimulation initiated in Soultz-sous-Forêts. With the exception of the Mittelhausbergen and Rittershoffen projects, all aim to produce both heat and electricity.

2.2. Switzerland: Haute-Sorne and Geneva cases

Haute Sorne

The Haute-Sorne project led by the operator *Geo-Energie Suisse*, a national geothermal operator, plans to build a 5 MW petrothermal power plant to capture heat from an artificial reservoir created in a crystalline bedrock at a depth of 5,000 m (GES, 2017). The project was presented to local authorities and to the population in 2013. The government of Jura supports the project and delivered the building authorization in 2015. To ensure local support, Geo-Energy Suisse informed the population early on after the company had selected the Haute-Sorne site.

Although cantonal and municipal authorities support the project, significant opposition from the local population has delayed its implementation. A group of inhabitants of Haute-Sorne is contesting the planning process and took the matter to the federal court. They argue that the project will cause nuisance such as noise and will have an impact on the landscape, and that it will also create risk for groundwater resources and seismicity. Moreover, the opponents argue that there is little benefit for the population, as it is placed in a rural area where the additional heat benefit cannot be exploited economically (Knoblauch and Trutnevyte, 2018).

In December 2018, the federal administrative court ruled in favor of the Cantonal government, stating that the planning process had been conducted correctly and that it addressed all issues. In parallel, citizens in the Canton of Jura opposed to the project launched an initiative and collected enough signatures to call for a vote on a complete ban of DGE in the canton. However, the initiative was declared void by the cantonal constitutional court on the ground that it went against the federal EnA that mentions renewable energy infrastructures to be of national interest. Such a ruling was made possible by the acceptance of the ES2050 through federal referendum.

However as of January 2019, the completion of the project remains uncertain. After a project in South Korea using a similar technique was declared likely to have triggered a magnitude 5.5 earthquake (Grigoli et al., 2018), the Cantonal government put the authorization on hold until an expert commission returns a full evaluation report of the event.

Geneva

The second Swiss case study is on the GEothermie 2020 program jointly led by the canton of Geneva and the local public utility SIG. The program launched in 2014 includes several projects.

It has avoided the pitfall of single geothermal projects that stand and fall very much depending on one project outcome. When looking for hydrothermal uses of geothermal energy the location is of crucial importance, as projects will only be developed at sites with suitable underground conditions. However, program managers realized that it is crucial to combine underground potentials with surface needs. The program needed to involve interested stakeholders, seek collaboration with universities, promote transnational agreements due to proximity to the border with France, and finally to develop new industrial know-how, as geothermal activity was new for for SIG.

The geothermal program in Geneva is mostly focused on geothermal exploration for heat, as heat accounts for the biggest share of energy use in the canton. This approach was chosen by the program managers despite the earlier focus on the federal level on geothermal electricity production. However, in discussions with the SFOE, the Geneva program management team was able to make a case for geothermal heat projects, by emphasizing that it would help reduce fuel oil consumption.

GEothermie 2020 gained visibility and traction within the SFOE through direct contact between cantonal and federal officers, who discussed the benefits of the program and options to support it from a technical point of view. Moreover, the program managers are also deeply involved in the organization Geothermie-Schweiz, an organization ich which professionals who are active in geothermal energy convene and which promotes and lobbies for DGE. Being part of the board of this organization, the program managers of the Geneva program have considerable influence on the agenda of the organization and on the communication materials developed. In the bi-annual conferences organized by Geothermie-Schweiz, there are talks and inputs on the Geneva perspective on a regular basis and increased interest in geothermal heat projects can be observed.

	Haute-Sorne	Geneva
Type of technology	Petrothermal	Hydrothermal
Purpose of project	Electricity production	Heat production
Project carriers	Project developed by a private operator owned by public operators, with political support from the cantonal government.	Geothermal program carried jointly by the cantonal government and the local public utility.
Project frame	Pilot project to develop petrothermal technology for electricity production to support DGE at national level. Opportunity for local development through tax income and visibility.	Decarbonize heat production to meet CO_2 reduction goals and become less dependent on oil and gas imports. Develop a new local economic value-chain around geothermal energy.
Status	On hold	Ongoing
Public reaction	The project started with strong support from the cantonal government, political parties and NGOs. A group of residents of Haute-Sorne started a campaign criticizing the authorization procedure, emphasizing potential risks and underlining the lack of local benefits. The project is now questioned by a growing number of local politicians and business.	Apart from localities where projects have been completed or are planned there is little public awareness of DGE. Stakeholders such as NGOs or potential collective end users are rather positive. In areas where projects are completed or ongoing, public reactions are favorable.

Figure 5. Summary of the Swiss case studies.

Although GEothermie 2020 is focused on hydrothermal DGE, opponents to fracking in the Lake Geneva region were concerned that the geothermal program might eventually need hydraulic stimulation. Indeed, the Geneva geothermal program does not exclude the use of petrothermal technologies in the long term. The opponents to fracking argued that this might also open the way to the use of fracking for shale oil and gas. Although several members of the federal government have made public statements against fracking for fossil fuels, there is currently no ban or moratorium against the technology at the federal level. In order to avoid opposition to the geothermal program based on a

mistaken assimilation to fracking, the Genevan government introduced an article banning the exploitation of fossil fuels in the cantonal law for the use of underground resources, revised in 2017. The strategy has so far been successful, as two exploratory wells were drilled and the program has not been the subject of any significant opposition at the time of writing, November 2019.

2.3. Netherlands: the Trias Westland project

The Trias Westland project is situated in the Westland region in the Netherlands, the center of the horticultural greenhouse industry of the Netherlands.

Figure 6. Geographical location of the Trias Westland project.

In this region, several other geothermal energy projects have been successfully developed, at depths of 2 to 2.5 kilometers.

The goal of the Trias Westland project was to determine the suitability of the Deep Triassic Aquifer at a depth of ~4 kilometers for deep geothermal energy production in the Westland area. This project would be the first geothermal energy project in the Netherlands at this depth. Gaining more knowledge about the characteristics of the Triassic Sandstones at for kilometers depth was useful both for the participants of the Trias Westland project and for national stakeholders, like the Dutch government and several research institutes.

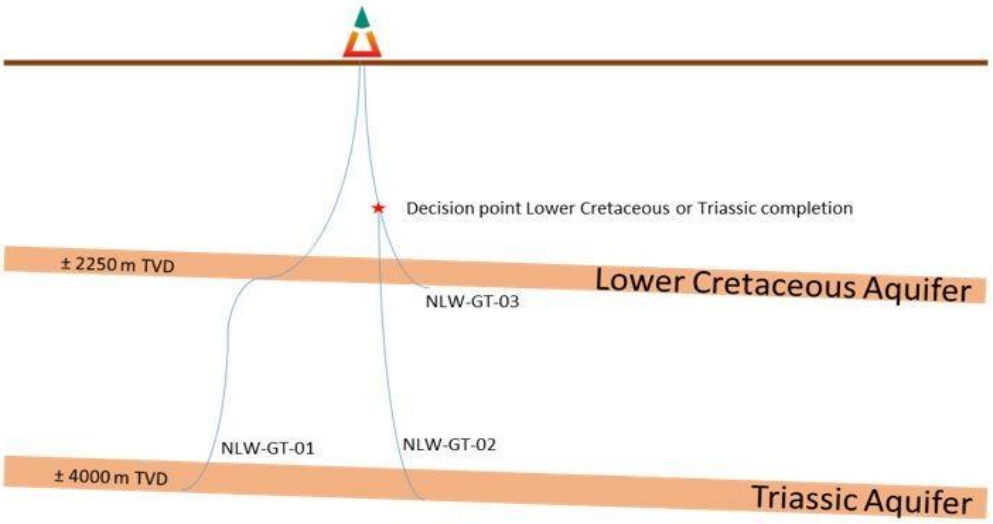


Figure 7. Schematic of the Trias and Lower Cretaceous aquifer
(Source: project team Trias Westland)

An interesting element of the Trias Westland project was that previous geological feasibility studies suggested that the potential for geothermal energy in the Lower Cretaceous Aquifer at ~2,5 kilometers depth was much safer. This led to an unusual design of the project and drilling plan: a first drilling was planned to a depth of 4 kilometers to identify the geological characteristics of the Triassic Aquifer. If the Triassic Aquifer turned out to be unsuitable for deep geothermal energy production, the same bore hole would be used to drill to the Lower Cretaceous Aquifer at a depth of ~2-2.5 kilometers, in order to assess the potential for geothermal energy production at that depth. Depending on the outcomes of the test phase and the permeability of both aquifers, the decision would be made for a deep geothermal energy project (Trias) or a 'normal' geothermal energy project (Lower Cretaceous).

Three local companies started the Trias Westland project: HVC – a local waste management company; Capturam – a local engineering company for energy infrastructure; and Royal FloraHolland – the cooperative international marketplace for flowers and plants for growers and buyers. The local municipality and two Dutch financiers played an important role in developing and implementing the project. The national government provided a risk assurance *(garantiefonds*) for the drilling to 4 kilometers depth, because of the value of this drilling for the knowledge about the geology of the Triassic Aquifer. Additionally, nearly 50 horticultural greenhouse entrepreneurs participated in the development of the project. These horticultural companies will be the future end users of the geothermal heat; and, they will become the owners of the heat company after a period of 15 years.

2.4. Summary

Country	Area	Heat/ electricity	Geology	Urban/ rural	Brief description
F	Northern Alsace	Both	Fractured granite	Rural	3 EGS projects carried by a regional public operator; Acceptability is not an issue. The projects are fairly well accepted
F	Euro-metropolis Strasbourg (EMS)	Both	Fractured granite	Urban	5 EGS projects in the metropolitan area; Different operators (local public & private operators); Major variation in acceptance (2 projects have been abandoned due to strong opposition)
CH	Haute-Sorne, Jura	Power	Granite	Rural	EGS project carried by private company owned by utilities; On hold because of local opposition
CH	Geneva	Heat	Sediment	Urban	Program carried by the state and local public utility; Multiple project planning from shallow to mid-depth. Strong acceptance. Ij November 2019, two 650 m and 1,130 m exploratory wells have been successfully drilled
NL	Trias Westland	Heat	Sediment	Rural	Geothermal project under development. Project is characterized by close cooperation with and support from local stakeholders.

Figure 8. Presentation of the French, Swiss and Dutch case studies

Chapter 3. Media studies

Mass media could be one of the ways to communicate about geothermal energy. Media discourses are intermediaries between scientists / heads of industry and citizens. Some journalists may be specialized in the environment or in scientific topics, but they are not necessarily experts in the field of geothermal energy. In fact, journalists select sources and then frame local authorities', industrialists', experts' or associations' discourses in order to produce reports that meet media standards and match their audience: images are chosen, metaphors could be used to make scientific information understandable, etc. As a consequence, scientific discourse is simplified and may be even distorted.

1. France: National and Alsatian press coverage: 2002-2018

In what follows we examine the importance given to certain topics concerning geothermal energy and discuss how this "press agenda" (McCombs and Shaw, 1972; Scheufele and Tewksbury, 2007) has helped construct a particular representation of geothermal energy. More specifically, we drew up the following research questions (RQ):

- RQ1: What kinds of events have attracted the attention of the French national and Alsatian newspapers to geothermal energy since France began promoting the energy transition in the early 2000s?
- RQ2: To what extent do the French and Alsatian press distinguish between different kinds of geothermal energy? Is there any difference between the national and Alsatian regional press in this regard?
- RQ3: When French and Alsatian news press reports mention geothermal energy, what angle do they take?
- RQ4: Which are the main kinds of geothermal energy covered by news reports?

1.1. Corpuses and methodologies

We analyzed all six French national daily (non-tabloid) newspapers and both Alsatian daily newspapers. All are owned by private groups. In the *Europresse* database for national press and in a private database for Alsatian newspapers, we selected all articles published between January 2002 and July 2018 that mentioned the keyword "*géothermie*" (geothermal energy) at least once. The final sample used for analysis comprised 3 219 news items. Figure 9 shows that Alsatian newspapers paid more attention to geothermal energy projects (n = 2,340) than the national press (n = 879).

Newspaper		Number of articles analyzed
National press	*Les Échos*	302
	Le Monde	181
	Libération	127
	Le Figaro	110
	La Croix	86
	L'Humanité	63
Alsatian press	*DNA Dernières Nouvelles d'Alsace*	1.562
	L'Alsace	778

Figure 9. Presentation of the French media corpus.

We chose to start in 2002 to cover the period since France began promoting the energy transition. We were also interested in two particular events: a micro-seism (magnitude 2.9) in the pilot deep geothermal project in Soultz-sous-Forêts, which occurred in 2003, and the National Climate Plan established in 2004.

The corpus was collected in original PDF format (when available[6]) in order to retrieve the accompanying images, captions, headlines, titles and subtitles in bold bigger or colored characters, which are important to attract readers' attention. Coding was performed by five coders using the software *Atlas.ti v.8* and developed iteratively. The research team set up a coding scheme based on our previous analysis and in in-situ observations (Chavot, Heimlich, et al., 2018a; Serrano et al., 2019). The coding team then conducted a pilot test to train themselves and to adjust the scheme where necessary. The final coding consisted in classifying all 3,219 news items on the basis of the variables listed in table 2:

	Codes
Date	Year / Month
Journalistic angle[7]	Rather in favor of geothermal energy / Rather against / Rather balanced
Geothermal energy project location	Worldwide / International / National / Alsatian or Upper Rhine Graben project / Other local project / Projects submitted to Public inquiries in 2015: Robertsau, Mittelhausbergen, Eckbolsheim, Ilkirch,
Type of geothermal energy[8]	Heat production / Electricity production / Cogeneration (both) / Not specified

Figure 10. Coding scheme used for content analysis

1.2. Results

When and why national and Alsatian newspapers talk about geothermal energy

Geothermal energy was covered throughout the period analyzed (2002-2018). However, Alsatian newspapers paid much more attention to this renewable energy than did the national press. While *DNA* and *L'Alsace* published an average of respectively 90 and 80 articles per year, barely 15-20 articles were published per year in national newspapers (figure 11). Only the financial newspaper *Les Échos* published an average of 34 articles per year, suggesting the importance given to economic factors at national level[9]. As shown in figure 1, the increased attention paid by Alsatian newspapers to geothermal energy was linked to induced seismic events. Thus, the first peak in the number of articles published by *DNA* and *L'Alsace* was directly linked to the earthquake in Basel (Swiss city in the Upper Rhine Graben) in December 2006. The second peak in *L'Alsace* coincided with the earthquake in St. Gallen (also a Swiss

[6] Original print format was not available in PDF for Alsatian newspapers (*DNA*, *L'Alsace*) between 2002 and 2008. Only text format in html was accessible and images were sometimes included.
[7] This code was chosen by the coder based on the extent to which the article: a) only or mostly mentions benefits or positives aspects of geothermal energy (positive angle), b) only or mostly mentions risks or problems of geothermal energy, c) proposes a balanced account mentioning benefits and risks at the same level or does not mention benefits or risks about geothermal energy. Sources cited (promoters, opponents) and title's angle were also taken into account.
[8] Among the different classifications mentioned in the introduction, we chose the one based on the use of geothermal energy (heat or electricity production). Even if a coder was able to infer the kind of geothermal energy the article was talking about (heat, electricity or both), coding was based on explicit mention. An article talking about "deep geothermal energy" but which did not specify if they meant heat or electricity production (or both) was coded as "not specified".
[9] This observation is investigated in more detail in the second phase of coding, when we analyze arguments, themes and sources quoted in articles.

city) in July 2013. In the first case, almost a hundred news reports were published between December 2006 and July 2007. This kind of media coverage, consisting in covering an issue more frequently when problems or unexpected events occur, may suggest to audiences that the issue is problematic *per se*.

Figure 11. Articles published by Alsatian newspapers per year and main events related.

Regarding Alsatian newspapers, it should also be noted that the public inquiries conducted in 2015 in the Eurometropolis of Strasbourg mainly attracted the attention of *DNA* and barely that of *L'Alsace*. This result suggests that the attention paid by newspapers to geothermal energy projects is determined by proximity, which is consistent with one of journalists' standards for news selection (agenda). As a matter of fact, the criteria used by journalists to select facts include proximity between facts and audiences. Deep geothermal energy projects submitted to public inquiries were planned in the region mostly covered by *DNA*. This conclusion is also supported by the fact that, except for *Les Échos*, more than 80% of articles published by national press did not treat this renewable energy as the main topic. In most cases, geothermal energy was mentioned only once, for instance, in a list of different kinds of renewable energies. In contrast, Alsatian newspapers published articles in which geothermal energy was the main topic more frequently. This was particularly true for *DNA*: geothermal energy was the main topic or an important topic in 32% of 1,562 news items analyzed: geothermal energy was mentioned in the headings or in the legend of the images.

In contrast to what we observed in the Alsatian press, the interest in geothermal energy by the national press seemed to be less associated with risks or problematic events and more with the energy transition (figure 12). The attention paid by the national press' to geothermal energy was related to projects worldwide, particularly those in Iceland, which is seen as an example to be emulated.

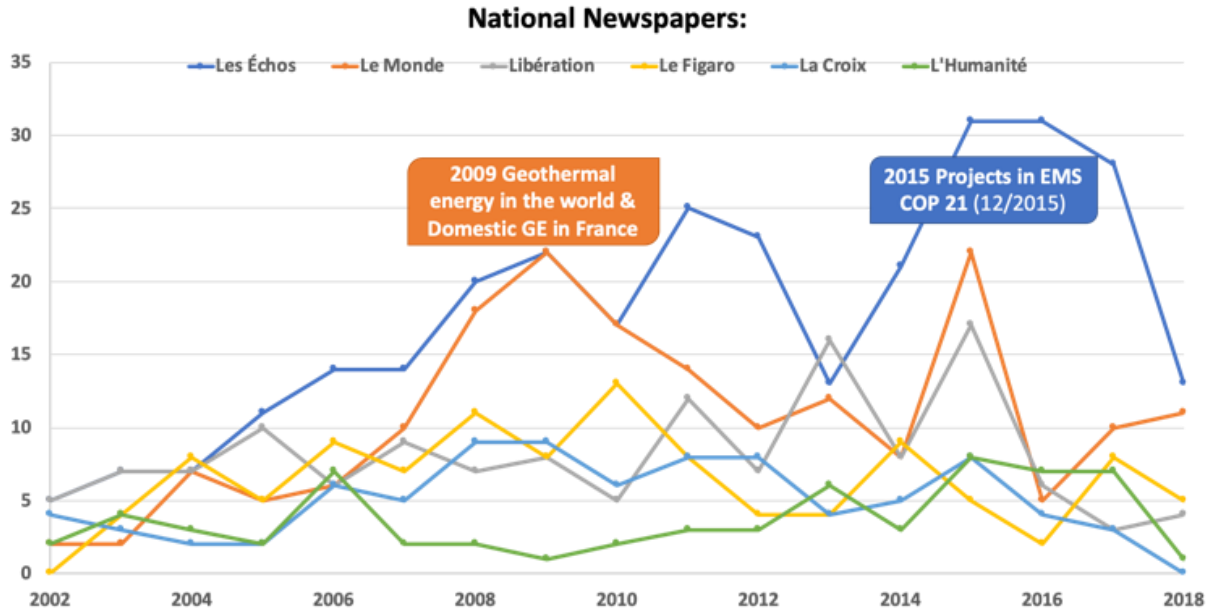


Figure 12. Articles published by national newspapers per year and the related main events.

Global coverage of geothermal energy: mostly positive

This first result is consistent with the angle favored by national press. Except for the right-wing newspaper *Le Figaro*, all national newspapers covered geothermal energy from a positive angle in more than 80% of their articles. This means news reports are not balanced but focus on positive aspects, such as the contribution to energy transition. This kind of article does not mention risks associated with geothermal energy or the problems caused by a particular project. In fact, no national newspaper provided even 10% negative coverage. Despite the fact that to be objective, journalists should present balanced and neutral reports (which means mentioning both positive and negative aspects or having all sides express their opinion on the subject), the percentage of balanced news reports was less than 30%.

Nevertheless, and interestingly, it should be noted that press coverage of geothermal energy in Alsatian newspapers between 2002 and 2018 was also mainly positive. Positively biased news reports on geothermal energy also highlighted the fact that it is a continuously available energy resource, i.e. it does not depend on weather conditions (as is the case of solar or wind energy).

News reports mentioning risks, accidents or problems with this renewable energy (for instance the cost of installation) represented a small proportion of the corpus and were concentrated around particular events. Alsatian newspapers (*DNA*, *L'Alsace*) published a higher proportion of articles mentioning both positive (i.e. continuously renewable energy) and negative aspects (i.e. risks, cost). This result may be explained by the fact that these regional newspapers more frequently covered the geothermal energy projects in Basel (earthquake in 2006) and legal public inquiries in the Eurometropolis of Strasbourg in 2015, which occurred near their readers. In addition, the positive coverage of geothermal energy over time was regular. There was a peak in positive coverage in 2007-2008; it seemed to be linked to municipal elections. In fact, the press cited the candidates' discourses defending renewable energies including (but not exclusively) geothermal energy.

Knowing that negative coverage of geothermal energy was specifically associated with deep geothermal energy projects in the Eurometropolis of Strasbourg and earthquakes in the Upper Rhine Graben, we wanted to find out if all geothermal energy projects in the Eurometropolis of Strasbourg benefited from the same media coverage. In fact, projects in Robertsau, Vendenheim and Eckbolsheim concentrated most of negative news reports while the Soultz-sous-Forêts project barely received any negative coverage. This result confirms our previous conclusion: opposition to deep geothermal energy projects is more likely to happen when projects are not discussed and agreed on in advance with local authorities and residents (Chavot, Heimlich, et al., 2018a; Chavot, Masseran, et al., 2018b).

Geothermal energy… how is it used?

In the Eurometropolis of Strasbourg, operators and politicians promoting deep geothermal energy projects criticized the fact that these projects were lumped together with other geothermal energy projects (Lochwiller, Basel, Landau) using non-industrial technologies or technologies that were not included in the Eurometropolis of Strasbourg projects. Could press coverage on geothermal energy contribute to this kind of misunderstanding? Analysis showed that most news reports do not specify what kind of geothermal energy is concerned. On average, half the articles did not explicitly mention whether the target is heat or electricity production. When they did, the main use explicitly mentioned in the Alsatian and national press was heat production, mostly domestic heat production (geothermal heat pumps).

In addition, it appeared that different expressions are used to refer to geothermal energy. Among such expressions, e.g. "high temperature geothermal energy", the most frequent one was "deep geothermal energy" (*géothermie profonde* = 766[10]). This term merits particular attention because of the different meanings that can be associated with the concept of depth: risks, something hidden, obscure and even dangerous or not well controlled events. Journalists or sources cited by the journalists sometimes explain deep geothermal energy as a technology consisting in penetrating "into the bowels of the Earth". For example, statements made by an ecologist politician were reported by DNA on December 10, 2014. He associates the fact of going into "the bowels of the Earth" with the damage to land and houses in Landau and with the earthquake in Basel: "On the other hand, I fully understand the citizens' concerns. In these subjects, we are working in the bowels of the Earth, and serious incidents have already made headlines in Landau or Basel, among others".

1.3. Conclusions

Promoters of renewable energies may hold the media responsible for opposition to particular projects. By analyzing media coverage on renewable energies, other authors expect to find a public opinion indicator (Romanach, Carr-Cornish, et al., 2015). Our research focused on deep geothermal energy and more specifically on projects planned in the Eurometropolis of Strasbourg. Four deep geothermal energy projects submitted to public consultation in 2015 were faced with serious opposition despite the fact that geothermal energy has had a good image in daily newspapers since the early 2000s, as confirmed by the study reported here.

Results also confirmed our previous findings (quantitative survey, focus groups, in-depth interviews): opposition to geothermal energy is related to specific local projects and less to renewable energy in general. The way in which a particular project is conceived by the operator and the authorities and also involves the local authorities and the residents, may influence residents support.

Over the period 2002 to 2018, the Alsatian and national press tended to focus on the positive aspects of geothermal energy (contribution to energy transition and mitigating climate change) and avoided referring to negative ones (high cost of geothermal projects, risks associated with different geothermal energy technologies). Negative media coverage of geothermal energy was correlated with specific events: an earthquake in Basel or St. Gallen for instance. More specifically, in the Alsatian press, negative coverage concerned the public inquiries held in 2015. In these cases, press coverage on geothermal energy increased significantly.

Confirming some of our expectations based on analysis of participation in public inquiries held in 2015, our results suggest that media coverage of geothermal energy had little influence on opposition, given that press coverage was globally positive before the public inquiries. However, our results also show

[10] This qualitative discursive analysis is still in progress. Here we present our first observations.

that media discourses are not always clear about the kind of geothermal energy they are talking about; in addition, there is a significant increase in the number of reports on geothermal energy whenever problems arise. Could this focus on the negative aspects contribute to confusion regarding the different kinds of geothermal energy? This point will be explored in depth in the next stage of coding our corpus, when we will focus on news reports whose main topic is geothermal energy and exclude reports that only mentioning the word "geothermal" once.

2. United Kingdom Media study

2.1. Corpuses and methodologies

The UK media analysis concerned national and local newspapers in the UK. Although the coding scheme between the two studies was harmonized, the corpus could not be merged because of differences in the article collection criteria.

We searched for articles from national newspapers in the UK about geothermal energy in the database LexisNexis® and reviewed literature in media analyses to choose the corpus in this study. We focused on *The Guardian* and *The Independent* as these titles fall under the category of "quality newsbrands" and appear to be the most trusted (Press Gazette 2017). We used the searchword "Geothermal" which returned 955 hits for both titles. We screened the articles to filter out those not relevant (mainly those mentioning geothermal hot springs or not referring to any use). We kept 192 articles in *The Guardian* and 97 articles in *The Independent*. The coverage for *The Guardian* is from February 12, 1975, to December 31, 2017, and the coverage time of *The Independent* is from September 19, 1988, to December 31, 2017.

Region	Local News Journals
Scotland (Sc)	Aberdeen Press and Journal
	Aberdeen Evening Express
	The Herald (Glasgow)
	Haymarket
	Scotsman
	Donside Piper & Herald
	Paisley Daily Express
	Scottish Daily Mail
Southwest (SW)	Western Morning News (Plymouth)
	Western Daily Press
	Evening Herald (Plymouth)
	West Briton
	Cornish Guardian
	Falmouth Packet
	The Cornishman
	Bournemouth Echo
West Midlands (WM)	The Stoke Sentinel
	Worcester News
	Coventry Evening Telegraph
Northwest (NW)	(England)
	Leyland Guardian
	Crewe Guardian
Northeast (NE)	The Journal (Newcastle, UK)
	The Northern Echo
Yorkshire (Y)	The Huddersfield Daily Examiner
East Midlands (EM)	Grimsby Telegraph
	Nottingham Evening Post
	Lincolnshire Echo
East (E)	North Norfolk News
	East Kent Mercury
Southeast (SE)	Oxford Mail
Northern Ireland/Irish Republic (NI)	Belfast Telegraph
	Irish Examiner
	Ballymena Times
	Belfast News
Greater London	London Lite

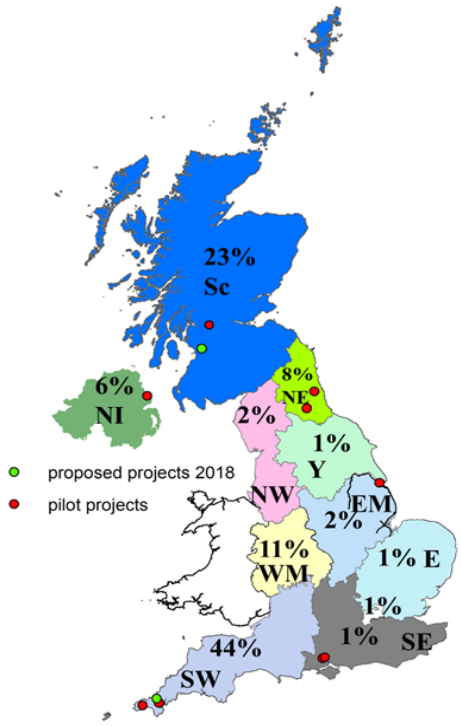


Figure 13. Overview of the journals and associated regions and where most of local news publications in our collection originated.

For the analysis of local newspapers in the UK regional press, articles were searched from the Nexis database using a combination of the keywords "geothermal energy" and "geothermal heat", and the

condition of three or more occurrences per article. The time period for the analysis was 1980 to 2013. No articles on geothermal energy from before 2001 were found in the database. We found 137 articles from 11 regions in the UK and Ireland and 35 different local newspapers (Figure 13). The majority of these articles were published in the Southwest England region, where two exploration wells were drilled in the 1980s and two new pilot projects were developed in 2018. Local newspapers in Scotland published the second most articles on geothermal energy. This could also be explained by the numerous exploration and feasibility studies in this region, as well as two proposed pilot projects in Kilmarnock (now cancelled) and the UKGEOS site in Glasgow that is being developed at the time of this writing. Surprisingly few articles in our collection originate from Northeast England, where three exploration wells were drilled between 2004 and 2011. Also, very few articles originate from Southeast England where the Southampton project has been the only active geothermal district heating scheme for decades.

2.2. Coding in UK media analysis

The articles were analyzed using thematic coding. The goal was to identify salient themes under which geothermal energy is reported in the UK. The articles in NVivo, a qualitative data analysis (QDA) software. The articles were first organized and classified by year, sections, and bylines. Then the articles were read carefully, and statements were coded. The coded statements can have the length of articles, paragraphs, single sentences, or words. Each statement can be assigned to more than one code as long as it matches the shared attributes of the categories. For instance, one statement asserting that geothermal energy is *not intermittent and has little carbon dioxide emissio*n can be coded as "environmentally friendly" and by the code "efficiency."

For the analysis of the national press statements were also assigned functional codes that do not correspond to themes: these codes were actors (to identify which actors were mentioned or given a voice in the articles), area (to identify which areas were mentioned in relationship to geothermal energy) as well as general attitude to assess whether a statement was positive, neutral or negative towards geothermal energy.

For the general attitude code statements are coded as positive attitude when they contain words pointing towards potential merits and benefits of geothermal energy such as "huge potential" and "not intermittent," and any description about supporting geothermal development, for instance, increasing funds in geothermal projects. Arguments are coded as neutral attitude when they only describe facts without emotional words such as the number of capacity and the explanation of working principles of the technology. Arguments are coded by negative attitude when they express any risks or nuisance associated with geothermal energy, as well as descriptions about impeded development of geothermal energy (for instance absence of investors, or cancelation of subsidies).

The thematic analysis was conducted in an inductive way. While reading the text all statements saying something about geothermal were coded according to their content. Codes about similar topics or pointing to similar attributes were then grouped and merged into categories that correspond to the most frequent themes.

In the regional media analysis, after a first screening round, four main themes were identified: Economy, Environment, Project Finance, and Technology. References to energy security, job generation, or future energy demand are classified as Economy sub-themes. If references relate to costs or profitability of specific projects, they were related to the Finance theme. References to pollution, climate change and renewable energy are classified as Environmental sub-themes. Statements about the capacity of a geothermal project, explanations of the technical concept of exploiting a geothermal resource, description of risks, advantages or challenges for geothermal were all considered as Technology related references. An overview of this scheme is listed in figure 14, including examples of categorized sentences. In addition to the themes, we identified and counted references to UK pilot projects or feasibility studies as well as references to examples from abroad. Finally, we evaluated the frequency of references to different types of resources, e.g. granites, disused mines, Deep Geothermal Single Well

heat exchangers (DGSW), Ground Source Heat Pumps (GSHP), and Hot Sedimentary Aquifers (HSA), and the frequency of references to different applications of geothermal energy, such as electricity generation, heating and cooling.

Theme	Sub-theme	Examples
Economy		
	UK energy independence	"Second, for our energy security - this energy is under our feet here in Britain, so we don't have to rely on other countries for it". Western Morning News, 15 May 2009.
	Future low-carbon energy mix	"Mr Law added: "Geothermal energy is a renewable, green and economical power source we must develop to meet the energy needs of the future." The West Briton, 29 October 2009.
	local economy stimulation	"There is significant potential for geothermal energy to encourage investment into the region and re-empower the local community." The West Briton, 4 February 2010.
Environment		
	Landscape or air pollution	"In the long term it certainly seems a good way of providing heat, obviously at no cost to the environment." Aberdeen Press and Journal, 7 July 2015.
	Sustainability/CO_2 reduction/ climate change	"The study explores how natural heat from the Earth could be used to meet demand more sustainably across the county especially for growers." Worcester News, 7 February 2017.
Finance		
	Financial advantages	"In Germany the geothermal industry is worth in excess of 4 billion and more than 150 geothermal projects are in development." Irish Examiner, 24 September 2010.
	Funding allocation	"Keele University has landed a £500,000 grant to help further plans to generate its own power." The Stoke Sentinel, 28 December 2010.
	Financial disadvantages/ need for legislation	- "The legislative and planning permission framework needs to be adapted effectively. So there are huge obstacles to overcome." The Herald (Glasgow), 17 March 2015. - A recent report for the UK Government by Atkins said heat wells - typically several miles down - are too deep to be exploited commercially. Aberdeen Evening Express, 16 November 2013.
	Development costs	"Mr Hanly said the estimated construction cost of the facility is 30m:". Irish Examiner, 24 September 2010.

Technology	
Concept	"In very basic terms we are talking about pumping hot water, turning that into steam and using it to heat anything." Grimsby Telegraph, 16 December 2010
Capacity	“If the test site proves a success, a power plant could be operational by 2020, and could produce enough electricity to fully supply up to 1,500 homes.” Cornish Guardian, 21 December 2017.
Technological/geological challenges	“But it is a difficult and expensive process, and today's mechanical drilling technology has limitations, despite considerable advances in recent years in the context of oil & gas resource exploitation.” Aberdeen Press and Journal, 1 August 2016
Advantages of geothermal vs other renewables	"The great thing about geothermal is it's not intermittent. It's constant energy that goes on going." Evening Herald (Plymouth), 26 October 2009.
Fracking	“One of the benefits of the proposed system is that it does not require hydraulic fracturing or "fracking" to deliver which means that it is unlikely to cause earthquakes.” Aberdeen Press and Journal, 28 March 2016.
Risks	“Hazardous gases and minerals may also come up from underground.” The Herald (Glasgow), 4 July 2011.
Comparison of geothermal and hydrocarbons	“But it is a difficult and expensive process, and today's mechanical drilling technology has limitations, despite considerable advances in recent years in the context of oil & gas resource exploitation.” Aberdeen Press and Journal, 1 August 2016.

Figure 14. Overview of themes, sub-themes and examples of references to these themes.

2.3. Results

National media analysis

Figure 15 presents the number of articles in each year, namely the frequency. Generally, the number of articles increases with time. After 2000, the number of articles has increased significantly, and peaks appeared in 2006, 2009, 2012, and 2015. The highest peak is at 2015 with 32 articles.

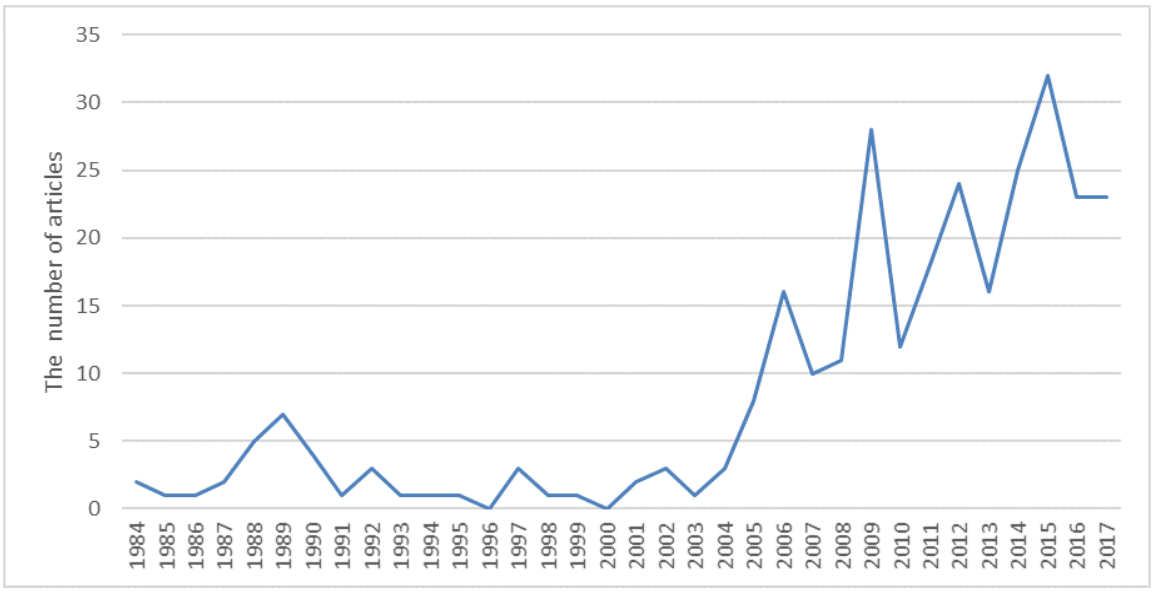


Figure 15. Frequency of news articles discussing geothermal energy

Figure 16 shows the number of articles in each newspaper in each year. The number of articles in each newspaper increases with time, and the increasing trend has become predominant after 2000. The two newspapers have different peaks in the number of articles. The peaks in *The Independent* appeared in the year 2006, 2007, 2010, 2012, and 2017 while the peaks in *The Guardian* occurred in the year 2006, 2009, 2012, and 2015. After 2006, the distance between lines in Figure 15 is bigger, with the number of articles in *The Guardian* increasing faster than the one in *The Independent*.

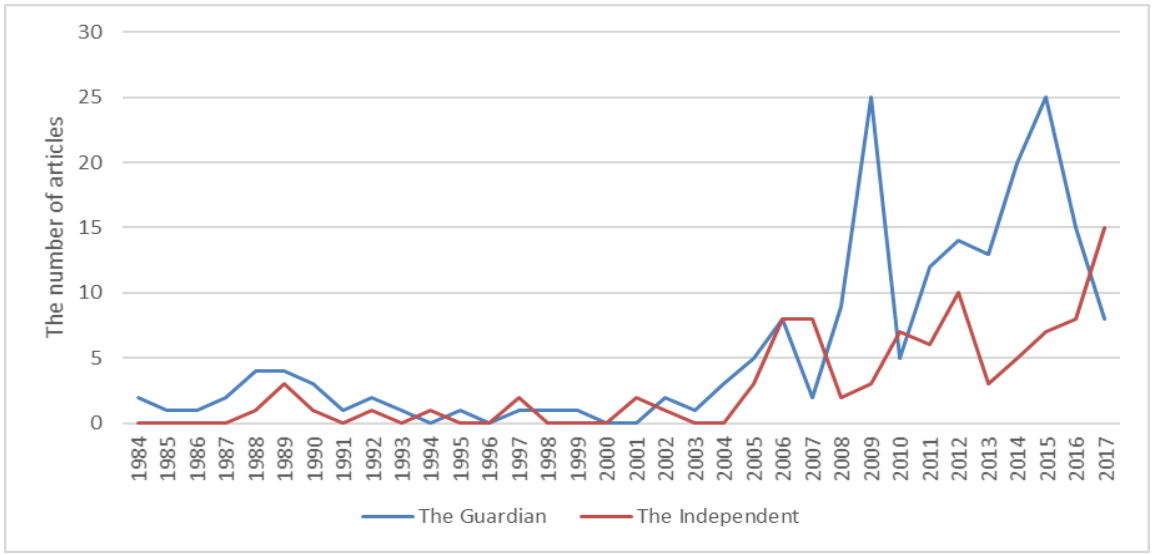


Figure 16. frequencies of newspaper articles in each newspaper

Frequency and origin of the UK geothermal local news articles

The majority of the 137 articles in our collection were published between 2007 and 2018 (Figure 17). A possible explanation is that interest in renewable energy increased only in the past decade. In addition, digitalization of local news articles might have been limited between 1980 to 2000, reducing the number of articles that we retrieved from the database from this period. Some ten to twenty articles were published per year covering geothermal energy between 2010 and 2018, with a peak in media attention in 2011. This indicates that there is no apparent relation between the frequency of geothermal

publications and the timing of realization of pilot projects. Most likely this is because many articles cover feasibility studies instead of only pilot projects.

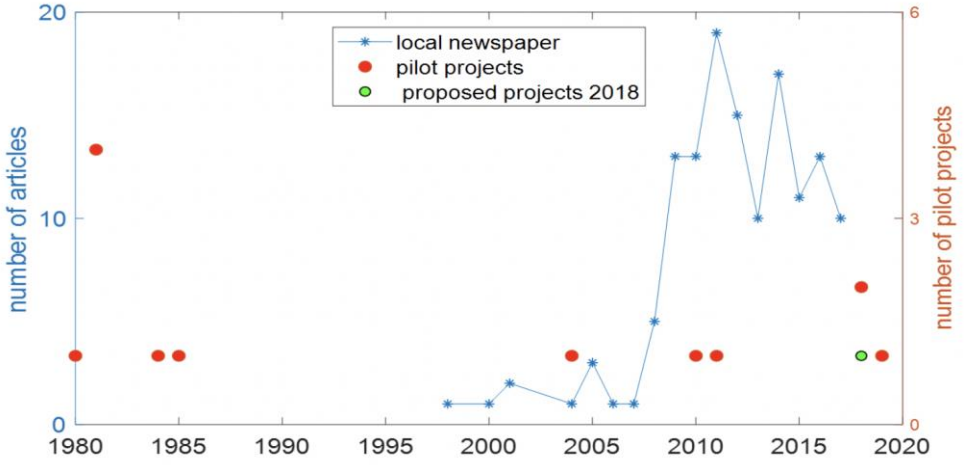


Figure 17. Frequency of local news publications on geothermal energy over time related to the realisation of the pilot projects.

UK geographical regions to which geothermal energy is associated

Almost 40% of the articles mention geothermal activity outside of the UK, often as part of an explanation of what geothermal is (Figure 18-A). The USA, Germany and Iceland are amongst the most frequently mentioned countries. This highlights that geothermal energy is often associated to other countries and considered as a new feature for the UK by local journalists in the UK. Some seventy percent of the articles have references to projects within the UK (Figure 18-B). Most of these references relate to a pilot project or feasibility studies in the Southwest, such as the Rosemanowes or United Downs. Pilot projects in the Northeast, Scotland, Northwest and West Midlands are referenced in some 10% of the articles.

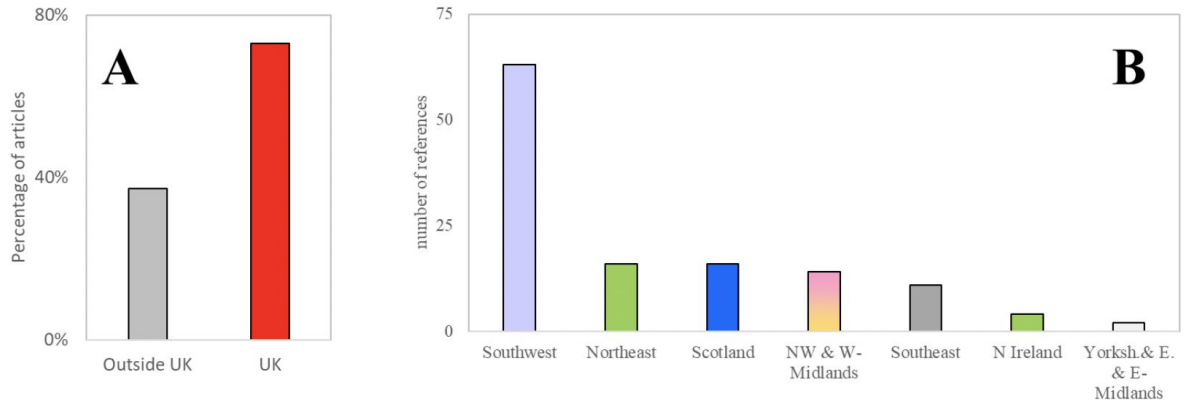


Figure 18. (A) percentage of the local news articles that have a reference to a UK feasibility study or pilot project, and or a reference to geothermal activity abroad. (B) overview of the references to the different regions in the UK, the Northwest (NW) and West Midlands are merged into one group is this figure as well as Yorkshire, the Southeast, East and East Midlands.

Themes in UK Media Analysis

National Press

The thematic analysis on the national press highlighted 6 main themes, out of which 5 were particularly salient.

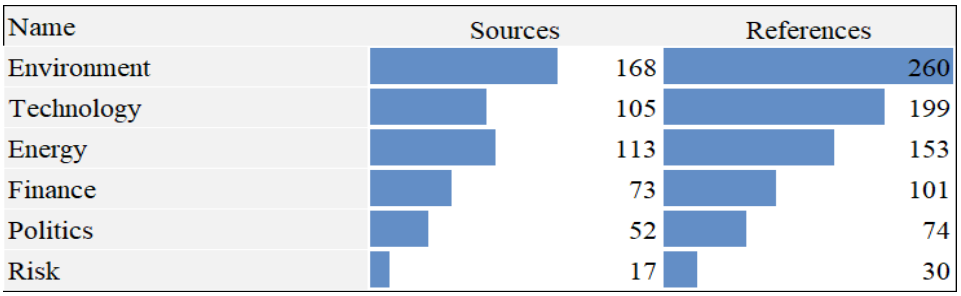


Figure 19. Main themes identified with ranking. Sources correspond to the number of articles in which the theme appears, and reference to the number of statements coded for each theme.

Our study found six frames in the discourse. Organized roughly by discussing intensity from high to low, they are Environment, Technology, Energy, Finance, Politics, and Risk. Environment is the most dominating one, which is very different from the geothermal energy case in Switzerland (Stauffacher et al., 2015) but similar to the other media analysis of biofuels (Sengers et al., 2010). In both the environmental and technological topics, the pro arguments of geothermal energy are overwhelming to the con arguments. The focuses in the media press are the sustainability, cleanness, low carbon footprint and huge potential of geothermal energy. Con arguments hit points such as tampering the beauty of nature, pollution from the fracking process, but they take a small share. As an emerging energy technology also involving fracking, geothermal energy has drawn much less attention of the UK media than shale gas has, which has been discussed in-depth in the mass media about its environmental impact both inside and outside the UK (Jaspal and Nerlich, 2014; Jaspal et al., 2014; Davis and Hoffer, 2012). So we could conclude that the mass media in the UK has focused on the positive environmental impacts of geothermal energy while has discussed its technological part not in detail.

In the frame Energy, geothermal energy is highly appreciated for its role in energy security and energy revolution. It is frequently mentioned in the mass media as an ideal alternative to fossil fuels and nuclear power. Moreover, its advantages are emphasized in the comparisons with other energy types. A particular category in the topic energy is the controversy, which is counted as a negative attitude part but not directly against geothermal energy itself. Because an amendment in infrastructure law was passed in 2014 stating that fracking can be operated without asking residents for permission, the controversy between fracking operators and residents was quoted many times in that relatively short time. It is likely that the negative public impression to the amendment might extend to the geothermal. Nevertheless, geothermal energy, in this case, is just an edge topic after the main role shale gas or enhanced oil and gas recovery. So the overall voice in the topic energy is very positive.

We also found that the media reported inactive actions of the UK's government in the topic finance although the UK's government were quoted in many positive arguments stating that the government acknowledged geothermal energy could increase the share of renewable and combat climate change. For instance, geothermal energy is framed as not so important as other renewables, nuclear or even fossil fuels; policy tools and subsidies are in favor of other energy technologies; the newly planned geothermal energy plants lack funds. Although these arguments do not state any drawbacks of geothermal energy, they might deliver passive signals to the public to some extent.

The topic Risk in our study is not dominating with only a few arguments. However, risk is an important and dominating frame in most of the public perception studies in emerging technologies because whether society accepts a technology is mostly dependent on how the risks associated with it are perceived (Shackley et al., 2004; Stauffacher et al., 2015; Dowd et al., 2011; Kunze and Hertel, 2017).

In our study, environmental risk and seismic risk have almost equal arguments, but both are not very significant. The financial risk is mentioned in fewer arguments. In comparison, Stauffacher et al. (2015) identified that risk is the most dominant frame in the discourse of deep geothermal energy in Switzerland. In the study of Kunze and Hertel (2017), they focused directly on the risk perception as the central part of the public perception of deep geothermal energy in Germany. Dowd et al. (2011) investigated the public risk perception of the geothermal energy in Australia and compared it with the

scientific risk assessment. Hence, our study is different from those studies about the public perception of geothermal energy either in focus or results.

Regional Press

Technology is the most frequent occurring theme in the UK local news media, 72% of the articles containing references to one or more of the Technology sub-themes (Figure 20). In 50% of the articles the technological concept of producing geothermal heat is explained and in 42% of the articles the potential output of a geothermal system or the recoverable energy from a resource is mentioned. This indicates that authors think the audience is unfamiliar with the subject and therefore explanations are required of how geothermal exploitation works and what it could deliver. Technological advantages, such as the non-intermittent nature, and challenges, such as geological uncertainty, are both mentioned in 18% of the articles. Nevertheless, the overall tone of the articles is positive. This is derived from the limited recognition of references to risks and fracking, while advantages, such as revival of the local economy and reduction of UK dependence on fossil fuel imports, are more frequently mentioned. This suggests that the increased media attention after 2011 (Figure 17) is not or at most in-directly related to a series of earthquakes occurred in the Blackpool area following hydraulic fracturing operations (Green et al., 2012; Westaway 2016) and the resulting stirred-up public debate on shale gas safety in UK. Although these seismic events might have increased media attention for geo-energy subjects in general, the authors of the articles only rarely related shale gas induced seismicity to geothermal energy.

Geothermal is not only disassociated from fracking in the media, this is also the case for legislation. In the UK, following government acceptance of a proposal by Green et al. (2012), induced seismicity caused by 'fracking' for hydrocarbons is very tightly regulated, while, induced seismicity caused by hydraulic fracturing for other purposes, such as EGS development, is exempt from this regulation. it is covered in the UK only by default regulations affecting all forms of vibration nuisance caused by industrial activity; as Westaway and Younger (2013) have discussed, the regulations for this, expressed in terms of thresholds of peak ground velocity, probably equate to magnitudes of ≥3 for typical depths of injection. This apparent anomaly has been raised in the media, a notable article being that by Lyons (2019). In this, a representative of the shale gas industry is quoted as saying he was 'disappointed by the blatant double standards being applied to the shale gas industry with no scientific basis or credible research' and an environmental critic noting that 'you would assume, given the similarity of the processes, that there would be similar regulatory oversight for both'. This article also addressed the United Downs project, which involves development of a deep geothermal reservoir exploiting flow through a natural fracture in granite in Cornwall (GEL, 2019). It quoted a spokesman for this project denying that the development process for this project has any similarity with 'fracking' for shale gas, stating that 'the geothermal concept we are trialling in Cornwall relies on pre-existing natural fractures, not on creating new artificial fractures like the fracking process. The pressures, flow rates and volumes of any well treatments we carry out will be much lower than stimulations carried out in shale exploration. We will be circulating water, not complex chemical mixtures.'.

The perception of the financial competitiveness remains ambiguous because in 28% of the articles a statement is made that suggests financial competitiveness or financial gain of geothermal projects, while in 20% contrasting references are made to financial disadvantages such as higher associated costs, the need for subsidies or lack of investor interest (Figure 20). The other financial sub-themes where more neutral: notifications of development costs or the allocation of a grant or funding for a feasibility study or pilot project.

References to environmental themes were present in 66% percent of the articles, highlighting that geothermal energy is generally discussed in relation to renewable energy, as a measure to combat climate change. The absence of references to this theme in 34% of the articles indicates that in a significant number of articles no references are made to environmental merits (or otherwise) of

particular projects. A case in point is the HALO project in Kilmarnock, which has been publicized through many favourable articles in the Scottish media.

In 46% a statement is present that relates a new geothermal project to generation of jobs and cheap energy, stimulating the economy at a local level, which is clearly a major theme in the geothermal energy discourse in the UK. Often not only stimulation but also revival of economically deprived areas is mentioned. Slightly fewer articles link geothermal energy to economic benefits at the national level, for example relating it to a reduction in dependence on imported fossil fuel or identifying geothermal energy as one of the ways to meet future growing demand for (low-carbon) energy. Overall, the broad range of recurrence of all four themes indicates that no single specific theme or sub-theme is dominant in the media discourse. Authors tend to describe a broad range of aspects, aiming to inform the audience about this new technology.

Theme	Sub-theme	Present in % of articles
Technology		72%
	Concept	50%
	Capacity	42%
	Technological/geological challenges	18%
	Advantages of geothermal vs other renewables	18%
	Fracking	7%
	Risks	6%
	Comparison of geothermal and hydrocarbons	5%
Environment		66%
	Sustainability/CO_2 reduction/climate change	64%
	Landscape or air pollution	23%
Finance		62%
	Financially advantage	28%
	Funding allocation	22%
	Financially disadvantage	20%
	Development costs	19%
Economy		61%
	Local economy stimulation	46%
	Future low-carbon energy mix	22%
	UK energy independence	17%

Figure 20. Frequency of references to themes and sub-themes in local news media.

Geothermal energy is linked to electricity generation in 49% of the articles (Figure 21). Slightly fewer references are made to geothermal heat production, either in combination with the production of electricity or as stand-alone direct use. Only 4% of the articles link geothermal energy to cooling. Specific extraction methods, such as Ground Source Heat Pumps, Deep Geothermal Single Well heat exchangers or doublets are rarely specifically mentioned. The most frequently mentioned type of resource is

granites, even though successful exploitation of this type of resource has not yet been demonstrated in the UK. Very few articles mention disused mines as geothermal resources. All these observations cast doubt on whether the public understands the different forms of technology and geology, the readiness levels of different kinds of exploitation and their applicability to particular types geological resources.

Application	**Present in % of articles**
Electricity production	49%
Heat production	41%
Cooling	4%
Extraction scheme/method	
GSHP	10%
DGSW	7%
Doublet	1%
Type of resource	
Disused Mines	7%
Granite	31%
Sedimentary aquifer	3%

Figure 21. Frequency of references to different methods of exploitation, type pf resource and applications in local news media.

2.4. Conclusions

To sum up, analysis of the UK local media showed that:

- Geothermal energy is a new subject to the UK public. This conclusion is inferred from the frequent references to geothermal projects abroad, the frequent explanation of the technological concept of extracting geothermal heat and the broad range of subjects that are discussed.
- The authors seem to mainly aim to introduce the concept to their audience rather than discussung or mentioning specific issues.
- The tone of the articles is predominantly positive with frequent references to:
    - The huge potential capacity of geothermal projects.
    - Low levels of CO_2 emissions.
    - Potential stimulation of the local economy.

  Very few references are made to risks and fracking.
- Geothermal energy is most often linked to the production of electricity. This is surprising because so far, only one heat production project and several shallow heating and cooling applications are active, and no pilot project for geothermal electricity production has proved to be successful so far.

These results have several implications for practice and project development with regard to public engagement strategies. First, geothermal energy is clearly associated with other renewable energies as well as to CO2 reduction. Such topics are currently positively connotated and should be used as a basis to communicate about geothermal energy projects. Furthermore, the purpose of geothermal energy projects planned in the UK should be carefully explained. While the media often reports on geothermal energy abroad and talks about electricity production, many local projects will likely focus on heat production, so unrealistic (positive) expectations also need to be managed. Finally, although is not a salient topic right now, it should be included in public engagement strategies, as information about potential risks is present in the media and might be picked up by the public.

3. Swiss media study

The Swiss media analyses focus on the way DGE is framed in national and regional print media. In a media analysis, framing refers to the way information is presented by the media, including the storyline, aspects that are emphasized and the vocabulary used. The way media frame information influences the way the information is processed by the audience (Scheufele 2014). In the absence of national debates and social mobilization over DGE, analysis of media discourse is a suitable proxy to understand changes in public discourse concerning DGE (Moser & Stauffacher, 2015). Reports on geothermal energy in Swiss daily newspapers has displayed different trends in the past 20 years, offering clues to how expert and policy discourses on DGE evolve over time, as well as on the expectations associated with it. Analyzing the way DGE is framed in the media can help to predict public debates on DGE.

A media analysis of the Swiss German language press from 1997 to 2013 showed that geothermal energy is mainly discussed in terms of risk, strongly impacted by the induced seismic events in Basel and St.Gallen (Stauffacher, Muggli, Scolobig, & Moser, 2015). A similar pattern was found in a media analysis of the Swiss French language press covering the 1997 -2017 period.

3.1. General trends in Swiss media reporting

Reporting on DGE over the time period analyzed followed similar patterns in both studies, with initially little interest, but that increased rapidly after the 2006 Basel earthquake, and then fluctuated depending on the occurrence of newsworthy events (see figures 22 & 23).

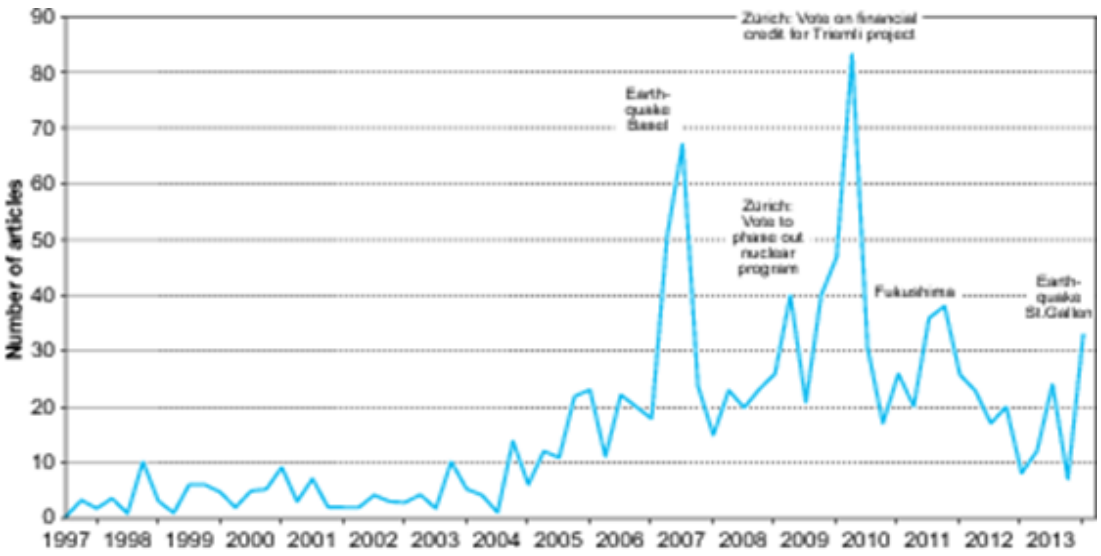


Figure 22. Frequency of newspaper articles containing the keywords 'Geothermie' (geothermal) or 'Erdwärme' (terrestrial heat) in TA and NZZ over time (N = 1091 articles).

Prior to 2006, the main narrative in the Swiss press was to present DGE with the potential to cover a large share of the country's energy need (both electricity and heat) while reducing GHG emissions. During this period, very few negative arguments about DGE appeared in the press, the main ones that did were the high investment costs and the fact that the technology was still in the development phase. There were no mentions of seismic risk.

This changed drastically with the occurrence of the Basel earthquake in 2006. The event attracted the attention of all the media and became a recurring reference in all subsequent reports on DGE. During the period 2006-2009, most articles reporting on DGE in Switzerland focused on seismic risk, questioning the possibility to develop any further project in Switzerland.

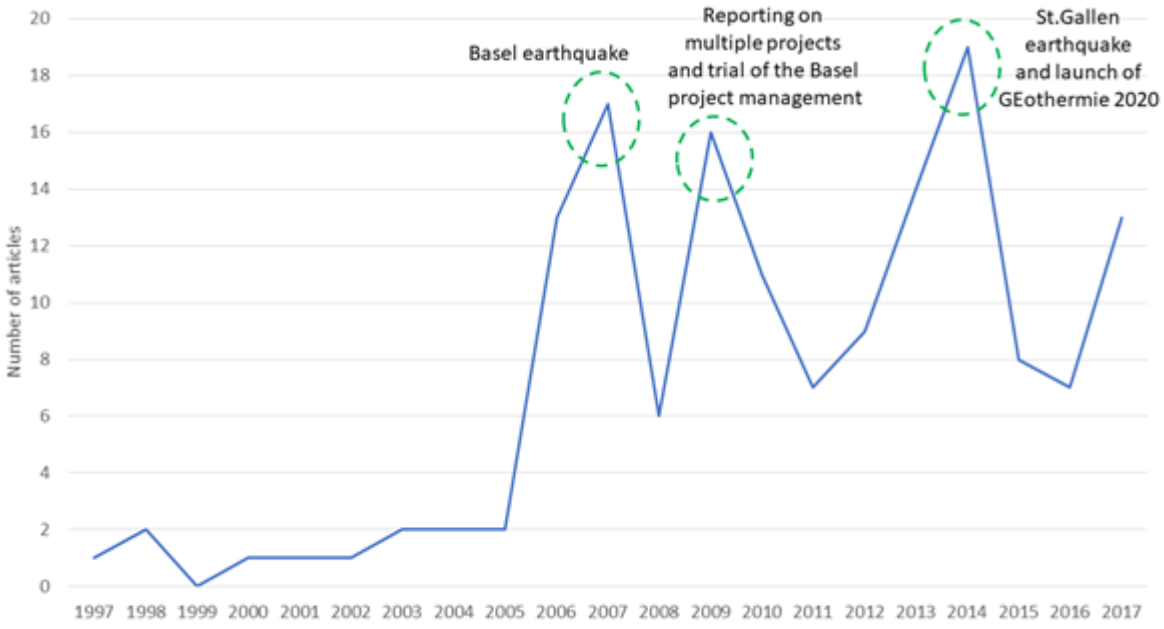


Figure 23. Frequency of newspaper articles with a least a paragraph on geothermal energy in *Le Temps* and *Tribune de Genève* over time (N = 152 articles).

Several plans to develop DGE projects were immediately put on hold after the Basel earthquake, but they eventually resumed. In the Swiss-German language part of the country these were mainly reports on the Triemli project in the city of Zurich and the St.Gallen project. In the French language part, reports about these projects also appeared along with reports about small projects in the Canton of Vaud and about the planned Genevan geothermal program, GEothermie 2020. At the time, most of the projects were hydrothermal and the promoters took care to emphasize that they were using a different "less risky" technology than in Basel. A recurrent narrative in the Swiss press was thus the distinction between hydrothermal and petrothermal projects. However, because of constant reference to Basel, all geothermal projects remained clearly associated with seismic risk.

The 2013 earthquake in St.Gallen triggered an increase in reporting in both the French and German language press. In the French language press, the peak in reporting was reached in 2014, corresponding to the stopping of the St. Gallen project as well as the first stage of exploration of the Geneva geothermal program. In connection with the St. Gallen earthquake and the project ending when it was discovered that geothermal water resources were not sufficient, media reporting continued to highlight the seismic risks associated with geothermal energy. However, in the French language press, the end of the project was not associated with statements about the potential end of DGE, in contrast to what happened in the case of the Basel earthquake.

In the Swiss press, DGE has mainly been discussed in relationship to specific projects, rather than in terms of national policy goals. However, in 2011, DGE was increasingly mentioned as an alternative to nuclear energy in articles reporting on the decision of the Federal government to phase out nuclear power following the Fukushima accident. Subsequently DGE was also discussed in reports about the ES2050.

The study on the German language press by Stauffacher et al. (2015) found that negative arguments about DGE in Swiss newspapers were more frequent in articles reporting about specific events or projects. This suggests that project related dynamics could play the main role in influencing the development of geothermal energy in Switzerland. This is in line with previous studies on the acceptance of DGE and DGE project development in Switzerland that concluded contextual factors play an important role (Blumer et al., 2018; Ejderyan et al., 2019).

3.2. Main frames in German language newspapers

Articles from the two core daily newspapers Neue Zürcher Zeitung (NZZ) and Tages-Anzeiger (TA), which have broad coverage in the German-speaking part of Switzerland, were analyzed. The time frame for the analysis was 1997 to 2013. The results of this study were published prior to the DESTRESS project (Stauffacher, Muggli, Scolobig, & Moser, 2015).

The first analysis focused on the frequency of articles mentioning geothermal energy (see Figure 22). The results show that the geothermal debate in the Swiss newspapers is largely driven by newsworthy events. To be precise, seismic events linked to the projects in Basel and St. Gallen; the public vote on the Triemli geothermal project in Zurich; and global events, including the Fukushima accident, play key roles in capturing journalists' attention. Regarding DGE in Switzerland, the seismic events in Basel and St. Gallen triggered a significant increase in media attention; the adverse reactions in Basel in particular led to an increase in negative arguments. Geothermal energy has thus been broadly discussed in the media, which is assumed to inform societal discourse.

Arguments that share a specific perspective on the issue of DGE were aggregated in the following frames: energy transition, risks, technology and costs. In each frame, we also differentiated between an arguments for and against DGE. The framing strategies of the different groups of actors can be characterized as follows: industrial actors mainly frame DGE as an opportunity for the upcoming energy transition in Switzerland. Scientists clearly favor the risks frame in the debate. However, the media has rarely reported on existing risk mitigation mechanisms to inform readers about increased seismicity, as well as proposals to stop drilling and/or the injection of water. In both cases (risk mitigation and the energy transition), scientists could play a valuable role by providing relevant information for future energy policy decisions. In contrast, politicians in general rarely support a specific frame; instead, they use different frames while talking about DGE, probably in accordance with their respective political standpoints. Public authorities do not emphasize one particular frame as oppose to another, either; their arguments more or less proportionally resemble those of the politicians. Policy makers and public authorities argue strongly in favor geothermal energy as an opportunity for energy transition, but also refer to the uncertainties and risks around geothermal projects.

3.3. Main frames in French language newspapers

The media analysis of the French-speaking part of Switzerland was conducted on a filtered sample of 193 articles from the following newspapers: Le Temps, La Tribune de Genève (TDG) from 1997-2017 and Le Quotidien jurassien (LQJ) 2010-2017. An inductive qualitative content analysis revealed that six main frames are used in the French-speaking press (technology, risks, governance, energy transition, knowledge and costs). These frames are consistent with the four frames identified in the study on the Swiss-German media. This clearly shows that public discourse on DGE takes place at the national level, and as such, might influence policy making at the federal level. However, the media analysis also

revealed the prevalence of a governance frame that is specific to the French-speaking press. In this frame, DGE is discussed as an issue in need of governance. The main topics addressed in the governance frame are the following: the most suitable legal-institutional framework needed to govern DGE at different administrative levels (often referred to as lacking), the importance of public engagement (often discussed in terms of sufficient/insufficient information and participation) and whether DGE is legitimized by popular support (often based on statements asserting or questioning the level of support). The governance frame is most prevalent in LQJ, which is the local newspaper of the canton of Jura, which is explained by regular reporting on the Geo-Energie Suisse project in Haute-Sorne, which is a local issue for this newspaper.

A closer look at the risk frame in the French-speaking press reveals that by far the most frequently discussed type of risk is seismic risk (208 statements in 67 articles). This is followed by exploration risk (33 statements in 25 articles) and environmental risks, which groups the risk of pollution of groundwater or soil and the potential impact on health/well-being (29 statements in 22 articles).

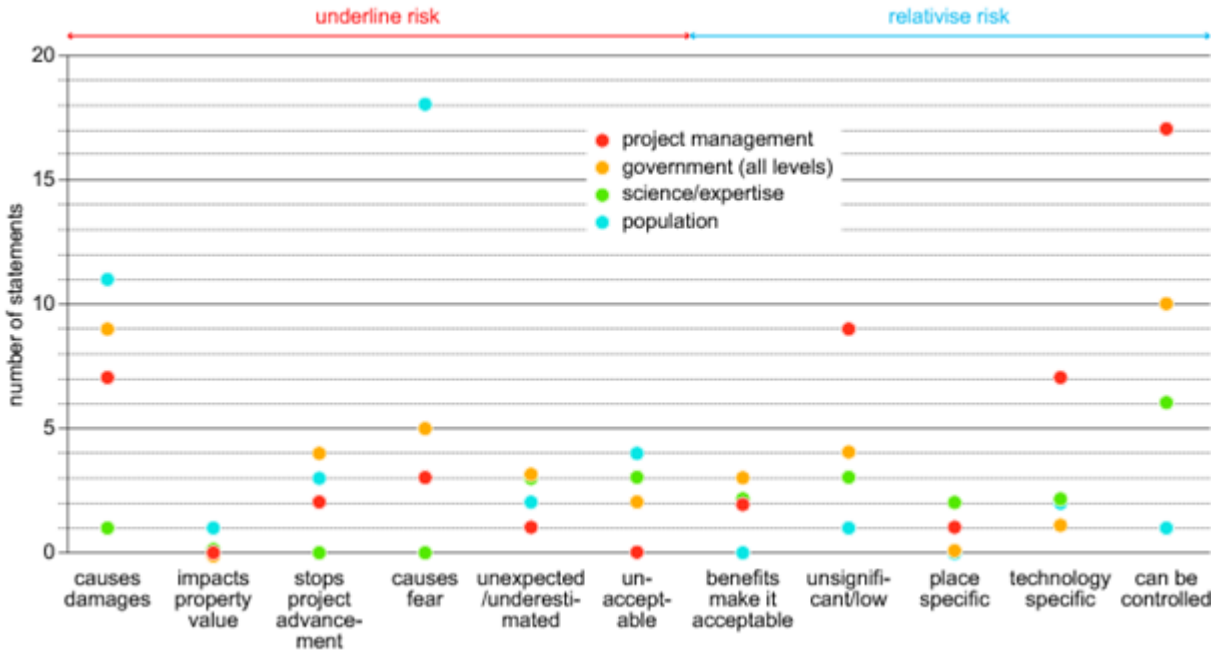


Figure 24. Statements on seismic risk within the risk frame of DGE in the French-speaking newspapers of Switzerland (n=193)

An important finding is that the media is framing seismic risk as a polarized issue (Figure 24). One category of statements underlines seismic risk, mentioning that it can cause damage, affect property values, be unpredictable or cause fear. Therefore, seismic activity can affect the acceptance of a project. This is further supported by statements that induced earthquakes related to DGE can damage buildings. In the media, such statements are predominantly attributed to the population. In opposition to these views, other statements relativize seismic risk; they do so either by presenting seismic risk as something negligible (low magnitude, not causing harm, etc.) or asserting some control over seismic risk (through traffic light systems, forecasting, etc.). Another way is to present risk as something that has to be accepted when balanced with possible benefits. Finally, some statements suggest that risks are linked to a specific place. The statements that put risks into perspective are mainly associated with project managers, political authorities, scientists and experts. In this connection, one issue is that polarization crystallizes images of an 'irrational public' versus images of promoters who only seek to address public concerns about risk by increased technological control. This points to a problem that will have to be addressed in public engagement procedures to avoid misunderstandings that could lead to conflict.

Chapter 4. Public perception of geothermal energy and projects

1. Methods

1.1. Quantitative survey

We conducted a survey using questionnaires to assess the opinions and perceptions of deep geothermal energy in urban and rural areas. This was complemented by the creation of focus groups with local residents. Four areas were investigated (Figure 25), three within the EMS and one in northern Alsace. Each is at a location where deep geothermal projects are at various stages of development.

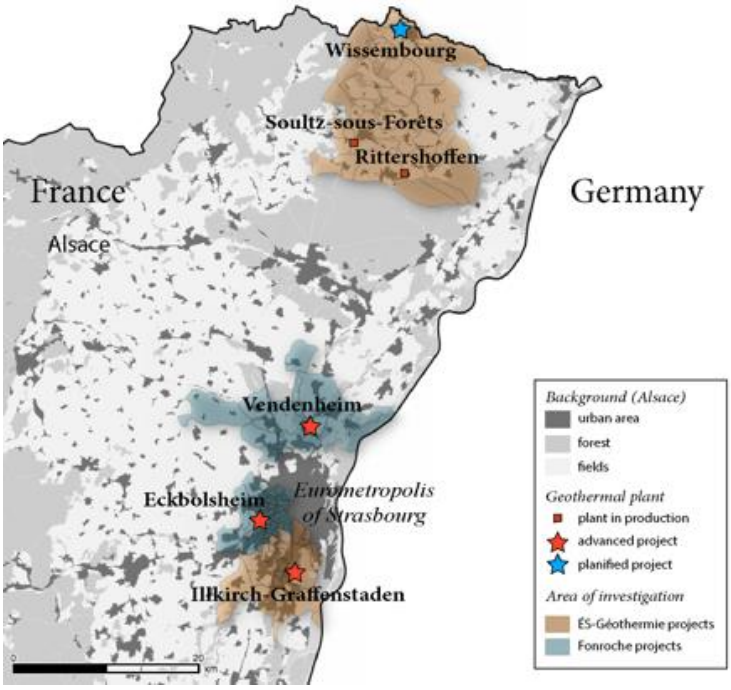


Figure 25. Location of the survey areas and the four deep geothermal projects in Alsace (source: IGN, INSEE). The survey areas were chosen to account for people living in the host and neighboring municipalities. The quota method was applied to each area and interviews were conducted face to face interviewers were conducted based on questionnaires (n = 881).

Two 'rooted' projects (the Vendenheim and the Eckbolsheim projects) are being run by the operator Fonroche. The other two projects (the Illkirch and the Wissembourg projects) are better rooted in the local territory.

To conduct this quantitative study, we sampled potential respondents using the quota method. To this end, we used the statistics from the last French population census conducted by INSEE in 2013. This database allowed us to determine the main socio-demographic characteristics of the populations residing in the four areas and to implement quota sampling.

To be able to analyze the general question of the social representations of deep geothermal energy in local living environments, we divided our questionnaire into six distinct parts (Figure 26): 1) initial contact with filter questions (village/town of residence, socio-demographic criteria), 2) knowledge and perception of deep geothermal energy in general and its main characteristics (economic, energy, environmental), 3) the perception of information concerning the local project and its debate (sources of information and their ranking, participation in public inquiries, acceptance of the local project), 4) knowledge and perception of deep geothermal energy within the local project (energy and geographical characteristics of specific projects), 5) perception of risks (risks related to drilling and exploitation of deep geothermal energy, potential technical control of risks), and 6) further sociographic details on the individuals interviewed.

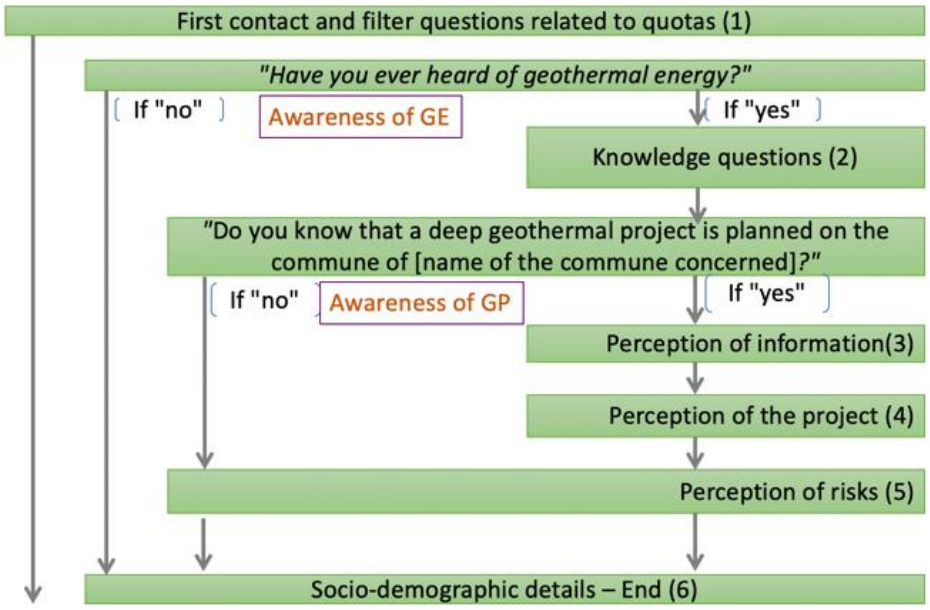


Figure 26. Structure of the questionnaire

This organization and prioritization of the themes addressed gives the questionnaire a 'funnel' type structure: when the respondent show they have more specific knowledge of deep geothermal energy and possibly of its local development, more precise questions and/or questions that are more relevant to the territory can be asked.

1.2. Organization of the Focus groups

Six focus group sessions were held in January-February 2018. Participants were recruited from the respondents in the quantitative survey who had volunteered to participate in this second phase of the study. These sessions were organized in two distinct geographical areas, four sessions were held in the Eurometropolis of Strasbourg (EMS), and two in Wissembourg in the north of Alsace.

The focus groups lasted between one and a half and two hours and the discussions were organized around five themes with scenarios on local energy production, project governance, project risks and the role of citizens. Each topic was introduced by a rather broad question (see table below). Several follow-up questions were then used to relaunch the exchanges.

Topics	**Scenarios / Introductory questions**
Region and energy production.	Imagine that the government decides not to renew the ageing nuclear fleet and asks the regions to organize their energy mix by limiting the use of fossil fuels as much as possible. What do you think would be the most appropriate energy sources for your living spaces?

Project governance	An industrialist from northern France has decided to invest in renewable energies. With the agreement of the ministry, he or she takes the necessary steps to drill a borehole in your municipality to produce electricity. In exchanges with local elected officials, the company proposes to use residual heat to supply the local heating network. You have just read this information in a local media. How would you react?
Induced risks	In your opinion, what are the risks and benefits of deep geothermal energy? What are the minimum conditions that need to be met for the implementation of a deep geothermal project?
Citizen's role in the decision-making process	Imagine you have the possibility to define the energy policy of your territory. What do you consider to be the conditions required for citizen participation in local politics?
Conclusions	What does deep geothermal energy mean to you personally?

All the exchanges were audio and video recorded and fully transcribed.

2. Results

2.1 Quantitative survey

Awareness of deep geothermal energy (DGE) and projects

Awareness of DGE is relatively high in all four territories: 57.3% of respondents had heard of it (Table 1). However, in many cases the fact that people are aware of deep geothermal energy does not always mean they know about projects underway in the vicinity of their home town or village. In fact, only 30.8% of respondents said that they were aware of a local project.

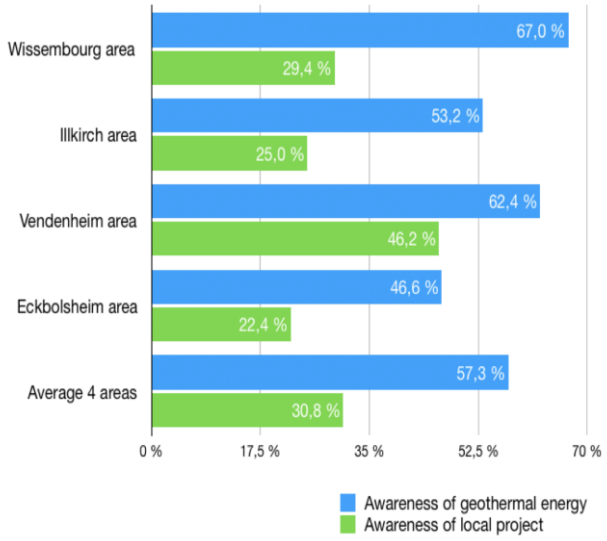


Figure 27. Awareness of DGE in general and of specific DGE projects in the four study areas (n=881). Awareness of DGE was measured using the rate of positive responses to the question, 'Have you heard of deep geothermal energy?', while awareness of the specific projects was based on the question, 'Do you know that a DGE project is planned for the town/village of [name of town or village for which the local project is planned]'?

In addition, awareness varied significantly from one area to another. Awareness of DGE was very high in the Wissembourg area (around 67%), perhaps linked to the long-established presence of two power plants at Soultz-sous-Forêts and Rittershoffen, and regular media coverage of their activities. However, knowledge of a project does not necessarily depend on its local 'roots'. Somewhat paradoxically, the Illkirch project was characterized by a very low level of awareness (25%) compared to the Vendenheim project (46.2%). Even though the Illkirch project was subject to upstream consultation, consultation does not seem to have affected a large part of the population. Conversely, the high level of awareness (62.4%) of DGE in the Vendenheim area seems to be directly linked to knowledge of the project (46.2%). This project was widely discussed and criticized in the public arena in 2015-2016, resulting in the operator rolling out a number of strategies to improve acceptability (media relations, setting up a local monitoring committee, public meetings, etc.).[11]

Finally, age and degree of connection with their place of residence quite naturally appear to have a positive impact on knowledge of DGE. Only 27% of respondents aged under 30 knew what DGE refers to and only 6.4% of them were aware of local projects. However, in the next age group up, awareness of DGE exceeded 50%, and reached more than 80% among respondents aged over 60. DGE and the local projects were the subject of greater awareness among executives and senior professionals (80%) and retirees (79%), and among people who own their own home (75% versus 45% of people who rent).

Knowledge and representation of geothermal energy

As we have seen, the results concerning awareness of geothermal energy and knowledge of local projects varied among themselves and from one area to another. A project may benefit from high visibility either because it is rooted in the history of the area (like in the Wissembourg area) or because the project is the subject of discussion and controversy in the public arena (like in the Vendenheim area). It is therefore important to understand what exactly contributes to awareness.

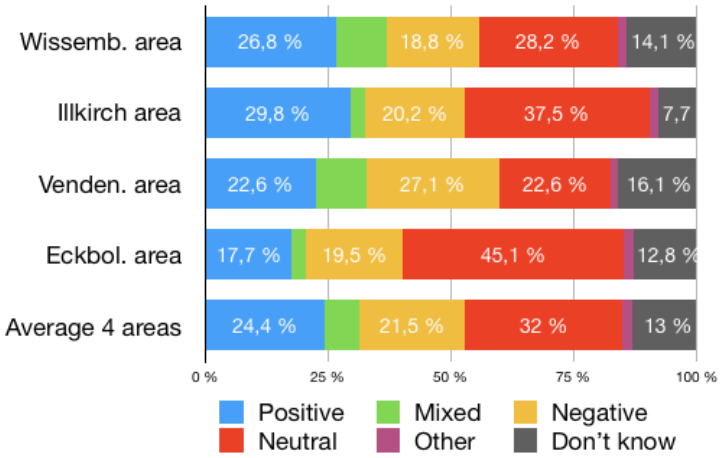


Figure 28. Perception of geothermal energy. Answers to the question, 'In three words or qualifiers, what does the geothermal energy mean to you?' were coded to account for the neutral, positive, negative, or mixed character of all the words and qualifiers proposed (n=492).

When asked, 'What does geothermal energy mean to you (in three words or qualifiers)?', one third of respondents (32.1%) made neutral comments, referring to technical aspects or the principle of geothermal energy (Figure 28). The others expressed positive (for 24.4%), negative (21.5%) or mixed (7.1%) opinions. There was a higher rate of positive remarks in the Illkirch and Wissembourg areas: there, for example, geothermal technology is seen as a step forward that would enable savings while offering a more environmentally friendly alternative, limiting the use of fossil fuels and so on. In

[11] It should be noted that we conducted our survey in this area shortly after drilling began, an event that received extensive press coverage.

contrast, the most negative reactions were recorded in the Vendenheim area. For example, respondents considered that the technology is not yet mature and pointed to certain risks that come with this type of project (e.g. ground movement, seismicity, damage to buildings). In this case, criticism of geothermal energy was multifaceted, echoing our observations during the 2015 public inquiries (Chavot et al., 2016).

Alongside these diverse views of geothermal energy, it was clear that residents are not always aware of the power-generating potential of geothermal energy or of the additional costs incurred by the production process (Figure 29).

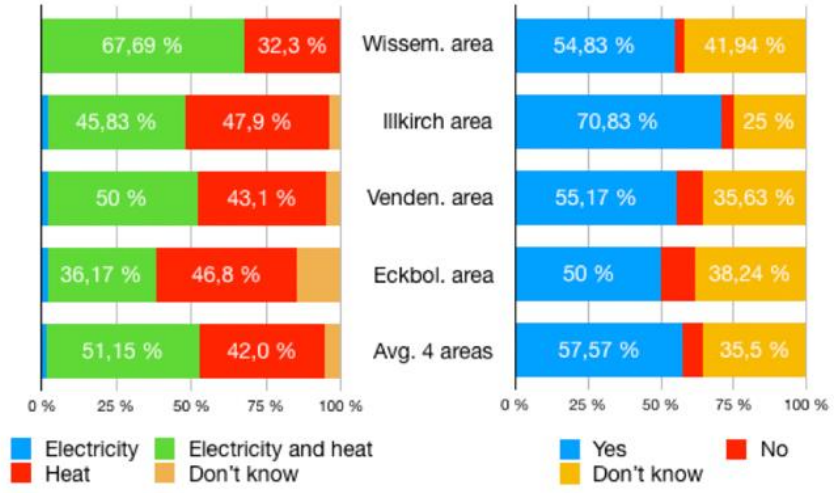


Figure 29. Comparison of responses to two questions about the use of geothermal energy. Left side, answers to the question (from people knowing about the project): 'Is geothermal energy used to produce heat (Yes/No/Don't know) /electricity (Yes/No/Don't know)' (n=262). Right side, answers to the question 'Will the energy produced by the geothermal plant will be used to generate electricity?' (Yes/No/Don't know)' (n=231).

When we addressed geothermal energy in general in the question, 'Geothermal energy is used to produce heat (Yes/No/Don't know), electricity (Yes/No/Don't know)', residents who knew about the local project were not always aware of the power-generating potential. The answers that can be deemed 'correct' ranged from 36% (Eckbolsheim area) to 68% (Wissembourg area). However, when participants answered a question concerning the local project, depending on the area, 50% to 71% of them thought that the energy produced by the geothermal plant would be used to generate electricity. The gap between the relative lack of awareness about this potential use of geothermal energy in a general sense, and knowledge of a local project can be explained by the fact that respondents draw on more specific knowledge, reflecting the communication efforts made by the operators. It is also conceivable that respondents feel more concerned by a local project and are thus more open to information circulating in the public arena.

Finally, a small proportion of respondents believed that it will be more expensive to generate electricity (13.7% of respondents) and heat (9.7%) using geothermal energy than using other means (nuclear or fossil fuels), and a quarter of respondents had no opinion on the subject. This suggests limited awareness of the cost of the energy transition and of the existence of state subsidies. Moreover, there was little public discussion on this point in France before 2018.

Risk perception

Several questions in our survey concerned risks. A first open-ended question, 'What are the risks associated with the exploitation of deep geothermal energy?', triggered some fairly spontaneous comments about risks. The residents mentioned cracks in homes (14.5%), seismic activity or earthquakes (11.1%) and slow ground deformation (10.5%). They also referred to incidents that occur during drilling (8.7%). Finally, and to a lesser extent, they mentioned potential groundwater pollution (7.5%) or other types of pollution (4%). These risks were most often mentioned in Wissembourg (where projects are fairly well accepted) and Vendenheim (where the local project is controversial). Opposition to geothermal energy is not therefore necessarily connected to a knowledge of risks, although this is sometimes the case.

We then asked respondents a set of closed-ended questions to find out whether they believed that deep geothermal energy can cause 'seismicity' (seismic activity), 'ground deformation', 'noise' and different types of pollution (groundwater pollution, soil pollution, radioactive pollution). The majority of local residents responded positively to 'Surface deformation' (62%–84% depending on the area), 'seismicity' (50%–69%) and 'groundwater pollution' (47%–62%). It should be noted that 'seismicity' were most often mentioned in the Wissembourg region (69%).

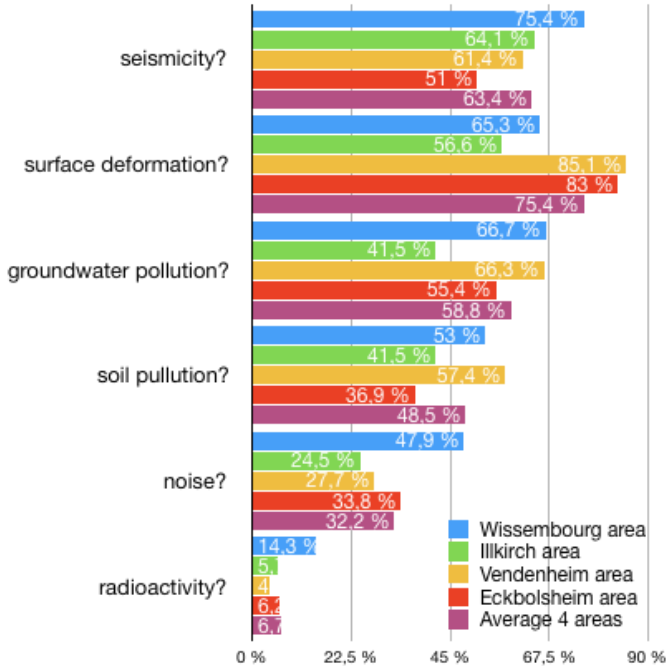


Figure 30. Risk perception among people who were aware of local projects. Question: 'In your opinion, can exploitation of geothermal energy cause… ?' (n=268).

The importance given to a particular risk varied significantly from one area to another in some cases. In addition, people who were aware of the projects considered certain risks to be more important than others (Figure 30). For example, ground deformation was mentioned more often by these people in the Vendenheim and Eckbolsheim areas (85.1% and 83% of respondents respectively mentioned the risk), and seismic activity in Wissembourg (75.4%). As can be seen, these variations do not appear to depend on whether or not a project has local roots. This may be explained by information circulated locally or by people's own experience of geothermal drilling (some inhabitants of the Wissembourg area may have experienced micro-seismic events linked to activities carried out in Soultz-sous-Forêts).

Information and opinions on the project

As mentioned above, only one third of respondents were aware that a project was set to go ahead in their vicinity. We used a set of questions to identify the channels through which this segment of the population was informed about the projects. The traditional media were the main source of

information: 41% of respondents said they had learned about the project via traditional local media (newspapers, radio and local TV); 28% via municipal information, 15% via associations and 23% in discussions with friends or colleagues. In this respect, Illkirch area stood out, as 72% of respondents said that they were informed by the municipality (among other sources of information). Despite these diverse sources, respondents often felt inadequately informed (61%, compared to 22.7% who felt sufficiently informed). In addition, a majority (59.2%) would have liked to have been consulted. It should be noted that only ten or so people among those interviewed in our study had taken part in the 2015 public inquiries.

With the exception of Illkirch, where the municipality appears to play a significant role in communicating about the project, no significant variation from one area to another could be correlated with the fact that a project had local roots or not.

This was not the case when we asked for their opinion about the project (Figure 31). While an average of 45% of respondents were generally in favor of the project (compared to 18.8% against it), we found clear variations from one study area to another. The attitude was the most positive in the two areas concerned by locally rooted projects, (with a rate of 75% of favourable opinions in the Wissembourg area and very few negative ones). However, somewhat paradoxically, almost a quarter of the people who answered this question in Illkirch said they opposed the project, although few of the inhabitants of this area rallied against it when the public inquiries were held in 2015.

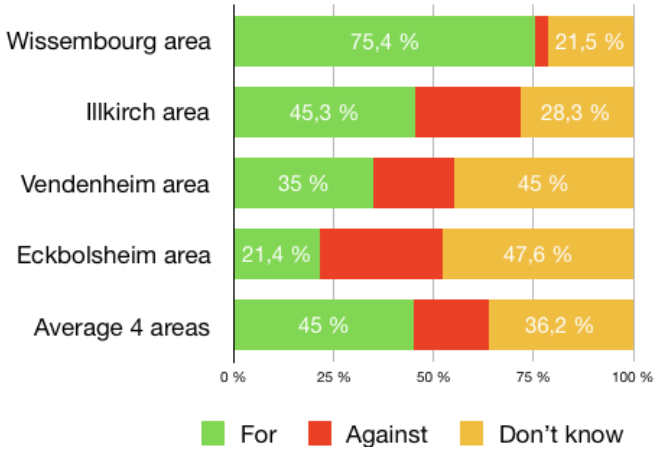


Figure 31. Opinion on local projects according to study area. Question: 'Are you for or against the geothermal power plant project?' (n=195).

Some correlations were quite striking when the answers to this question about opinions on the project were crossed with other questions, especially those concerning the wish to be consulted on projects or on risk perception. For example, 82.1% of those opposed to the projects would have liked to have been consulted (compared to 46.4% of those in favor of the project). Concerning risks, while there were no remarkable differences regarding the risks of seismic activity or ground deformation, the people opposed to the project mentioned the risk of pollution (noise pollution, soil or groundwater pollution) much more frequently.

Perception of information sources

We used a series of questions to assess the credibility of the different stakeholders. We asked people who lived near the projects to rank the three sources of information they would trust most when it comes to the technical aspects, risks and benefits of deep geothermal energy.

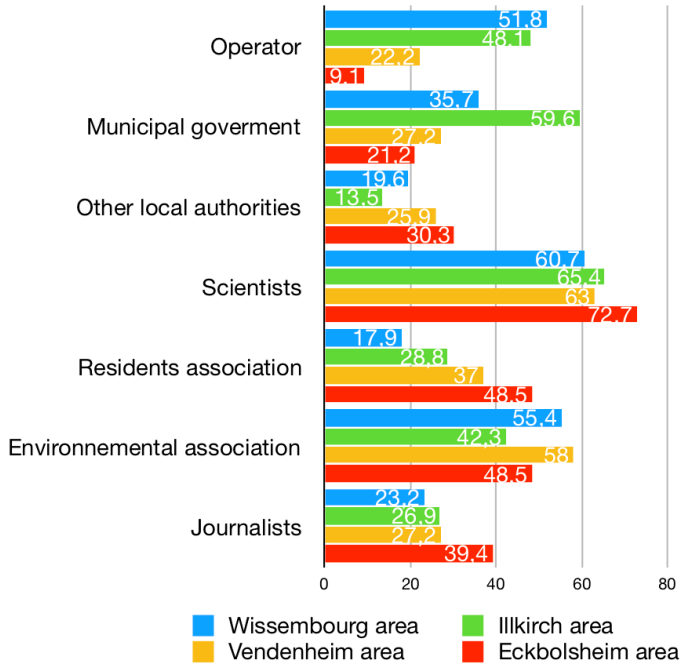


Figure 32. Variation in respondents' opinions on information sources, depending on whether the project is locally rooted or not. Question: '*W*ho do you trust you most to inform you about the technical aspects of geothermal energy? (Choose the top three)' (n=221). Locally rooted projects: Wissembourg and Illkirch; projects with fewer local roots: Vendenheim and Eckbolsheim.

On the subject of technical information (Figure 32), the responses were quite mixed, and varied considerably from one area to another. Although scientists were considered by the population to be the most trustworthy, in the case of the two locally rooted projects, we can see that industrial stakeholders and municipalities were also widely trusted because they had established a long-term dialog on the topic of deep geothermal energy with local residents: the presence of the Soultz-sous-Forêts power plant in the Wissembourg area and communication efforts made by the municipality of Illkirch since 2010 have contributed to this trend.

2.2. Focus groups

Composition of focus groups and motivation to participate.

For the organization of focus groups, we sought to recruit panels of people with the most diversified profiles. Despite these precautions, rather elderly men were best represented. Most of the participants work or have worked in professions requiring a higher education qualification (engineers, technicians, scientists working in the public or private sector, bank executives, business leaders, etc.). However, this did not mean they were experts in geothermal energy. Two participants were listened to attentively in their respective focus group because of their involvement in an association opposed to the project, in one case, and in the other, a committee of experts working on energy problems.

Participants reported different reasons for taking part in the focus groups. Some referred to an attraction, often of a professional nature, for technological innovation, particularly in environment or ecology. Others said they knew about a project located near their home. They were also interested in participating in exchanges on the risks and benefits related to geothermal energy. A relatively large number of participants said they wanted to participate because they or one of their relatives wanted to install a conventional geothermal heating system in their home. Finally, others (among the older participants) mentioned the need to collectively fight climate change.

Whatever their motives, all the participants were active in the discussions and stated their point of view and argument on the energy transition, the risks induced by geothermal energy, and project governance.

Participants supported the principle of energy transition

The majority of participants largely supported the principle behind the energy transition. In their opinion, the transition cannot be achieved through a single solution or technology, but rather through the multiplication of "small" solutions combined and adapted to the local context:

> FG4-H-62-7 "I think it will be a mix of everything: wind, solar, etc., but it depends on the region. For example, if we take wind power, in the Alsace plain, it doesn't make much sense because there is almost no wind. On the other hand, in the Vosges, it would be interesting. It is not quite the same as the Alsace plain. I think it will be necessary to study a little by region, depending on the geography of the region.

Thus, the success of an energy transition policy must be achieved through the territorialization of energy production and consumption. And according to the participants, this territorialization would reduce the size or depth of production units, making it possible to better distribute and reduce the risks and constraints to the environment:

> FG5-F-60-7 - That's why, in my opinion, small structures would make it possible to inject less, to have fewer environmental impacts. We're in the shallow depths, yes. And here, in my opinion, the environmental impact is less than when you dig down to 5,000 m and inject a large quantity of water and cool down, not much, but after 20 years, what would it look like?

This territorial approach was associated with a critique of the centralization of decision-making structures in France. This point was raised several times during the sessions, with different participants. Comparisons were made with Germany and federal structures that were considered more flexible to apply local policies.

> FG5-H-63-7 - Yes, don't centralize because when we talk about nuclear power today, it's centralized.
> FG5-F-61-3. - Absolutely. […]
> FG5-H-63-7 - You can produce partly for your own needs to avoid the monopoly of distribution.
> FG5-H-63-7. - That's clear.
> FG5-H-52-3 - I think we agree that the solution will certainly be mixed. We should study what we have on site. There are certainly places where wind farms would be a good idea. There are certainly places where it wouldn't be a good idea.

Risks perception

The main risks that emerged from the discussions resembled those most often mentioned in the quantitative study: first, issues related to induced seismicity or to the slower change in soil structure, and second, the risk of damage to groundwater (and/or surface water) through their modification or pollution.

Other sources of risk were rarely mentioned. The risk of "awakening" natural Alsatian seismicity during drilling, the risk of a return of a deep bacterial or viral life, the risk of causing a local volcanic phenomenon, the risk of rising oil, or the risk of a fall in property values in an area where the geothermal plants are located, etc. Although some of the risks mentioned during the discussions may seem "exotic" or "baroque" to a specialist, participants often demonstrated in-depth knowledge of deep geothermal techniques, sometimes acquired in a professional environment.

On the other hand, the benefits mentioned during the discussions were just as numerous. These included personal interest, for example, allowing residents to benefit from low-cost individual heating. But they were most often linked with several kinds of collective interests, primarily environmental: geothermal energy is a way of implementing the energy transition and offers an alternative to wind and photovoltaic energy. In addition, it produces uninterrupted energy all year round. Second, from an economic point of view, geothermal energy makes it possible to develop the territory by exploiting local resources.

However, this favorable collective evaluation of geothermal energy was conditional. Frequently, participants brought up the need to build production units at a safe distance from cities or populated areas (reflecting a high level of awareness of the induced risks). Indeed, during the 2015 public surveys,

it was the fact that the plant was built at some distance from the areas where the heat would be used that was problematic for some residents. They included the cost of building the conduits to transport the heat.

What are the sources of information used to form an opinion?

When justifying their perception of geothermal energy, participants referred to a very diverse range of experiences and information, often based on their personal experience. For example, in a focus group held in the Eurometropolis of Strasbourg, two participants expressed concern about the risks by referring to the presence of signs hostile to geothermal energy that are visible when crossing the border into Germany. A participant of Italian origin pointed out that geothermal energy is very advanced in Italy, this is an example, and that we must think about the future of our children.

The media were rarely mentioned in discussions about geothermal energy, but when they were, it was negatively. Their ability to simplify, translate or popularize technical or scientific data was questioned, as commented by a scientist in a focus group:

> FG2-H-74-3 - How should the media be informed? [...] In the end, it's up to us to inform the media because they come to us and ask how it works. We have to be able to inform the media in the same way as we would inform citizens. Otherwise, they'll be the ones who will take the information they want.

In this context, participants emphasized the need for transparency and availability of information. The criticism here concerned the "fait accompli" policy and the preeminence of industrial actors in public decision-making:

> FG2-H-74-3 - I would say that often, some drilling companies – like in the case of Vendenheim - we were not informed, we saw that next to the Reichstett power station... [...] We saw a tower, a chimney, things... and next to it, a little farther away from the boreholes. Later we learned it was a borehole for geothermal energy. So it's still... How should we react? Once it's done, it's done. The industrialists are there, they have the power to do anything, they have the power...

The lack of public information was cited as the first reason for blocking a local geothermal energy project:

> FG5-H-63-7 – I'd like to come back to the fact that communication is needed beforehand. And this is not good. This approach isn't good, because I always assume that, if you don't know a subject, if you don't have enough knowledge or information on a subject, there will be a blockage, whether or not it's justified.

In this context, some participants highlighted the lack of training in technology. School education should be reformed so that everyone can address technical issues.

Who can decide?

In the participants' opinions, in a controversial situation, no information is neutral. Examples of industrial actors using pressure that could affect the quality or independence of expertise were mentioned during the focus groups. In the participants' opinions, the question arises of including actors who can provide territorial expertise in the decision-making processes. They considered this point to be all the more important because the nature of the soil and the conditions for drilling and exploitation greatly vary from one region to another.

> FG1-H-63-7.-[...] the first condition is to have studies that can stand up to the test, that the contracting authority is not the only one on board. That means that there is an outside opinion, a controlling body for everything we want, with reports, etc., so we know what is going on.
> [...]
> FG1-H-70-7-[If you] drill a geothermal well here in Strasbourg, then drill another in Wasselonne, the conditions and chemical environment of the product you are assembling will not necessarily be the same. So, in my opinion, you can't transpose a geothermal power plant made in Eckbolsheim to another one made in Rouen, because the conditions won't be the same.

In all the focus groups, we frequently observed a certain degree of trust in public institutions and administrations, particularly higher education and research organizations. Similarly, some participants called for more involvement of municipalities or local authorities in particular.

> FG6-F-57-2.- So we really need municipalities or communities of municipalities, I don't know, to be part of the project and... That would benefit people and information. This is indispensable. And that the industries in question should assume their responsibilities upstream in the event of risks.
> FG6-F-32-3. - I agree. The municipalities too, the mayors, but us too[...]. Communities should think “community” and not just "I want my name on a plaque". There you go. It would be nice if we could have a role to play too.

Greater involvement of local and regional authorities would make it possible to take the long-term aspects into account and build a collective responsibility for energy production and consumption.

> FG6-H-49-1.- I think it would be a step in the right direction if the government said that it was the regions or territories that should be a little more involved in the production of energy that concerns them. This would change the way we think about energy consumption. As a result, we would automatically be more responsible for what we do. It wouldn't increase the solutions that much, but the attitude would be different.

The involvement of local authorities, or even citizens, would also solve the problem of the impossible "neutrality" of expertise. In the participants’ opinions, this involvement would make it possible to overcome some of the difficulties inherent in decision-making in complex situations or uncertainty. This conception of expertise could take concrete form through the creation of a "citizens' commission".

> FG6-H-49-1.- We should be able to define the territory's energy policy. I need to know what is being consumed, what the territory in question is consuming. If we are informed, I wouldn't like it much. The fact is that we, as citizens, should be sure we know what we are talking about, elected officials too, so everyone is aware of it and that we are talking about the same thing. And only then should we think about it, make choices concerning it.

Chapter 5. Participatory devices and action research approaches

1. Analysis of French legal public inquiries

1.1. Methods and corpuses

Four public inquiries (PI) on deep geothermal projects in the Eurometropolis of Strasbourg were organized by the prefect in spring 2015: in Strasbourg's Robertsau district near the oil port industrial site and in Mittelhausbergen, Eckbolsheim, and Illkirch-Gaffenstaden, three towns that are member of the Eurometropolis. The public inquiries are legally binding when major projects related to urban planning are envisaged, concerning environmentally-sensitive facilities or that may affect the quality of life of local residents. Public inquiries are hosted by the town hall and are under the responsibility of an investigating commissioner (IC) mandated by the administrative court. Participation is open to all citizens: it is possible to express one's opinion in a register available in the town hall, to send it to the IC by mail, email, or to present it orally.

These consultation exercises were carried out in a context of public controversy over the risk related to deep drilling. Residents' associations have been deeply involved along with elected representatives of towns concerned by the projects that are members of the Eurometropolis. The media also widely covered the issue.

The aim of our approach was to better understand the functioning and role played by public inquiries in the processes of appropriation, negotiation and rejection of a technoscientific project and, at the same time, to understand how the different public perceptions of geothermal energy develop.

Three distinct corpuses were thus created and explored.

The first corpus comprises the different documents produced during public inquiries. We took into account all French written opinions submitted during the four public inquiries. The Illkirch-Graffenstaden project attracted the least participation (19 written opinions) and criticism, whereas In all three other sites, local residents contributed a lot to the PI: 86 contributions in Eckbolsheim, 138 in Mittelhausbergen and 135 French contributions in Strasbourg and Robertsau (related to the oil port project), to which must be added 756 contributions from Germany.

We also included in our corpus the descriptions of the projects and their impacts as presented by the industrialists; the summary documents and conclusions made by the investigating commissioners; and, finally, the answers provided by the industrialists. In addition, several observations were made during the public inquiries, in particular during the presence of the investigating commissioners in town halls but also during public meetings organized in parallel to the public inquiries.

The second corpus includes articles published in the local press (the regional daily *Les Dernières Nouvelles d'Alsace*), in the community press and in information blogs (*Le blog de la Robertsau* and *Rue 89*) in the period from September 2014 to December 2015. A total of 173 articles were identified and analyzed.

Finally, we conducted 20 interviews, on the one hand with the investigating commissioners involved in these investigations and, on the other hand, with stakeholders (representatives of local residents associations, associations for environmental protection, scientists, operators, elected officials, representatives and experts from the Prefecture

The data were processed using ATLAS.ti software, which enables analysis of texts through the implementation of precise coding. It is thus possible to examine the way in which geothermal projects are treated by the media, in particular the viewpoint chosen, the sources most often cited by journalists, and the topics covered (technical aspects, risks, links with the economy or local politics). Citizens'

contributions to public inquiries were analyzed taking into account the richness of the arguments, the types of arguments and references used, as well as judgments concerning operators and policies.

1.2. Results

The public inquiries organized in 2015 in the Eurometropolis of Strasbourg are a good opportunity to understand citizen mobilization. These inquiries may simultaneously be understood as a machine to produce expression and a place of for the crystallization of the controversies. The dynamics of mobilization appeared to differ considerably from one site to another, due to the different kinds of leadership provided by either associations or municipal councils. Rather than generalization there was a broad diversification of arguments, each contributor proposing their own interpretation of the problem. These movements are thus very different from the German citizens movements (Bürgerinitiatives) where people share arguments against a project.

We conducted our observations in town halls where citizens can consult information documents and interact with the commissioner in charge of the inquiry. These observations revealed a real dynamic in the exchange and sharing of knowledge. We observed commissioners invite people to debate in a large room, which was transformed into a forum where everyone could express their feelings about the project. During the period of the public inquiries the commissioners collected about 400 French citizens' contributions written in registers or sent by mail, plus 750 letters related to the German Bürgerinitative "petition" (Figure 33). Analyzing French citizens' contributions revealed that everyone had their own opinion, felt free to use the arguments presented by the proto / counter-experts, or to add their own brick to the critical edifice. As a result, each expression was unique and had to be recorded by the investigating commissioner (whereas the 750 German letters were recorded as a single opinion). The rule in French public inquiries being that what counts is not the number of claimers but the arguments they put forward.

Sites, operators, dates of public inquiries	Total	Negative/ positive opinions	Investigating commissioners' conclusions
Illkirch-Graffenstaden (ES) April-May 2015	19	12/7	Positive with reservations
Mittelhausbergen (ES) April-May 2015	138	134/4	Negative
La Robertsau (Fonroche) April-May 2015	135 (Fr) [+756 Ger]	130/5	Negative
Eckbolsheim (Fonroche) April-May 2015	86	130/5	Negative
Vendenheim (Fonroche) Sept-Oct 2015	40	34/6	Positive

Figure 33. Participation in public inquiries held in Alsace in 2015. Most opinions were negative. Although the subsequent Vendenheim PIs had fewer contributions, the councils of the municipalities affected by the project produced negative deliberations. Nonetheless, the IC offered a positive conclusion, meaning that they found enough evidence in the operators' files to remove criticisms and remarks from municipalities and residents

Most citizens who submit their opinions to the PI are informed, some have acquired the necessary proto-expertise (Nowotny, 1993) to deal with highly technical data. Nearly a third of them presented structured arguments, referring to different sources of information (Figure 34). Their proto-expert identity contrasts with the unrealistic image of the naïve and common-sense citizen which still prevails in the philosophy of French culture (for an example of this philosophy, see Hermitte, 2013). Another

third of contributors presented a set of arguments similar to those presented by community groups or municipalities. The remaining third simply expressed their opposition to the presence of a geothermal plant near their homes.

Sources of information	Number
Operators' files	84
Geothermal projects (Basel 21, Soultz-sous-Forêts 17, Lochwiller 17, Landau 16, to name only the biggest)	79
Municipal council deliberations (Oberhausbergen 18, EMS 16, Strasbourg 11, Eckbolsheim 2)	47
Prefect (SPPPI 21, Autorité environnementale 7, DREAL 6)	38
Politicians	18
Media	18
Scientific experts (Scientists 13, BRGM 2, ADEME 2)	17

Figure 34. Main sources used by citizens during the four spring 2015 PIs (Geothermal projects: the main examples referred to in citizens' opinions. Prefecture: instances of opinions or reports connected to the prefecture. n = 376).

Arguments put forward: from a wide range of risks...

What are the main arguments used in the citizens' opinions? Residents criticize deep geothermal energy primarily because of the consequences that drilling and stimulation techniques can have on the surrounding environment: induced seismicity or earthquakes, groundwater pollution, radioactive upwelling, and even explosion risks (related to the use of isobutane when converting heat into electricity) (Figure 35). At La Robertsau, a significant wave of hostility arose against the drilling project because it is located in an industrial area classified as Seveso (the Port aux Pétroles) where large quantities of hydrocarbons and chemicals are stored.

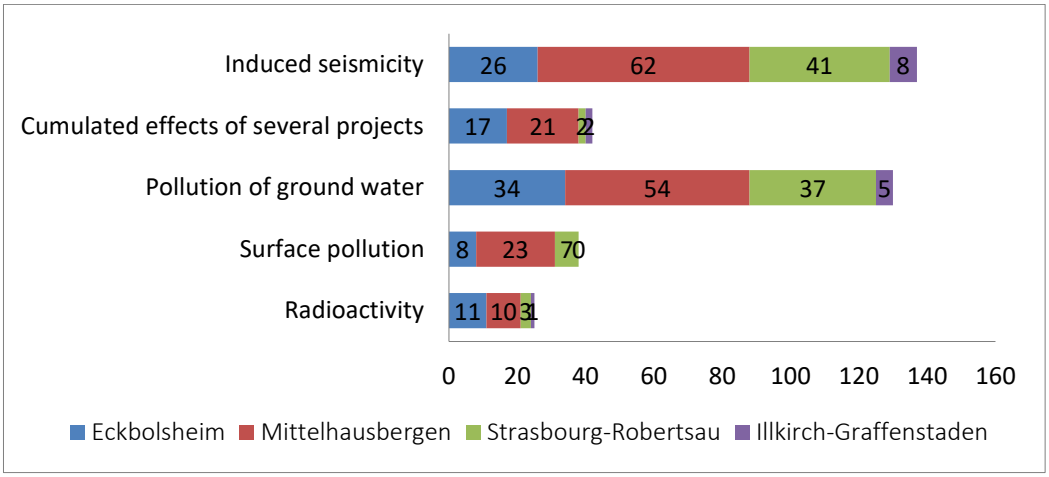


Figure 35. Risks induced by the projects mentioned in the citizens' contributions to the public inquiries organized in spring 2015. (Eckbolsheim inquiry, n = 86; Illkirch-Graffenstaden inquiry, n = 17; Mittelhausebergen inquiry, n = 138; La Robertsau inquiry, n = 135)

Thus, it looks as though the "official" declaration of the measures taken to control the risks, which appears in the documents the operators submit to the public inquiry, did not meet the citizens' expectations. In fact, the measures were mentioned in several opinions expressed by residents. Thus, when industrialists claim to control risks, local residents interpret it as proof that these risks do exist and call for a strict application of the precautionary principle. Finally, citizens point to the existence of risks - real or not - that are not mentioned in operators' files: radon pollution, the cumulative effects of the various boreholes planned within the EMS. In this way, citizens identify problems that have been ignored by industrialists, and that are also absent from the reports published in the general media.

The location of drilling sites is also subject to diverging interpretation. While operators and partners stressed the opportunities linked to new industries in the oil port, La Robertsau residents found it absurd that a "risky" project could be implanted in an industrial site whose access and development is regulated by a Plan for the Prevention of Technological Risks (PPTR). Another example, the operators emphasized the value of drilling for the urban heating system in the Strasbourg district of Hautepierre, whereas the citizens noted that the site is located near shops, a high school and a research centre. In addition, residents questioning the fact that many projects are emerging with only few kilometers between them. Does this imply accumulated risks ? They point out that the impact studies submitted by the operators have not addressed this issue.

The lack of reflexion concerning deep geothermal systems was highlighted in many citizens' opinions. Indeed, the projects to be launched within the EMS are among the first projects of this type in France. The precautionary principle is therefore often opposed to this project due to uncertainty. This argument acquired a special dimension in Alsace, a local scientist having stressed that further research is needed to better understand the behavior of naturally fissured rocks during the exploitation of deep aquifers. Also, geothermal energy was often described in public opinions as "immature" technology and project promotors as "sorcerer's apprentices" (Serrano et al., 2019).

In addition, environmental organizations criticized the very principle of geothermal heat-based electricity production. Alsace Nature, which federates the main Alsatian environmental associations, points to the low expected returns (a 10% rate is often advanced). Finally, more generally, it is the underlying economic model of the project that was criticized. According to opponents, electricity production aims to enrich operators rather than contribute to the evolution of local energy mixes with increased use of renewable resources

… to more political criticism of the projects

Many citizens' opinions questioned the status of the companies involved, particularly the private Aquitaine company Fonroche: its youth and lack of experience, its inability to present clear files at the time of public inquiries, the search for profits, etc., were all emphasized. Many opponents argued that it would be dangerous to put potentially risky projects into the hands of unknown companies. In this context, local companies, such as the local operator *Electricité de Strasbourg,* seemed to be more protected from criticism.

EMS pollical actors were also disqualified because of their inconsistency. Indeed, shortly before the public inquiries, some EMS elected officials affirmed they would not buy electricity or heat from the Port aux Pétroles geothermal site, even though in its information journal, the EMS indicated that geothermal energy could become an important source of energy for the metropolis. Moreover, this institution has not campaigned - or too late - in favor of geothermal energy, preferring to wait for the conclusions of the public inquiries before taking a clear position. [12]

[12] On the other hand, when the EMS took a stand in favor of the projects in 2016, it gave little space to the implementation of a pluralist and contradictory public debate, thus exposing itself to social criticism.

Different forms of mobilization from one inquiry site to another.

These criticisms were voiced by organized collectives. Leadership sometimes falls to residents' associations or to elected officials who mobilize citizens in different ways: public meetings, use of various media (blogs, local press, community press and local government press). Their arguments demonstrated technical, economic and political expertise in relation to the projects.

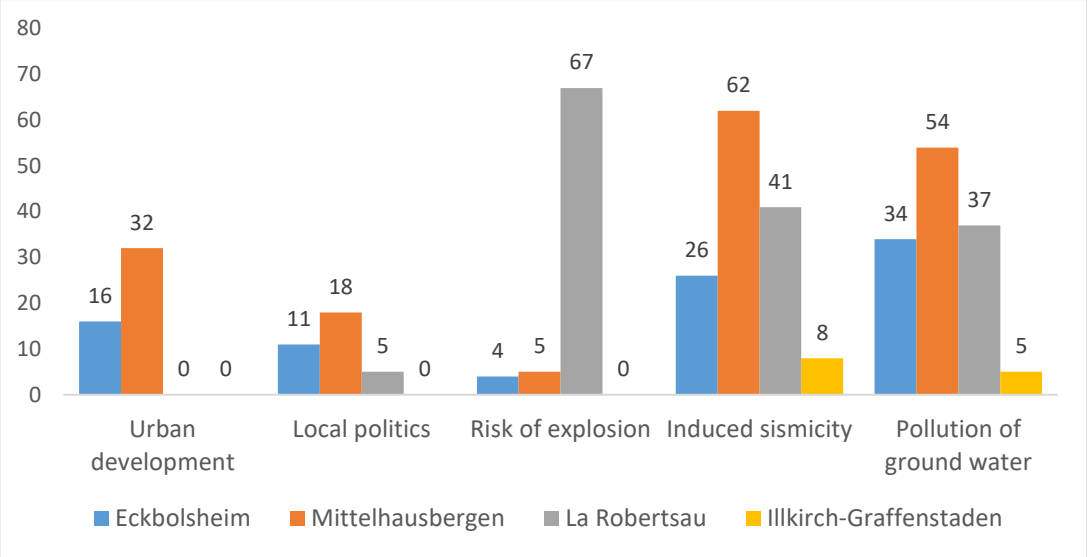


Figure 36. Different concerns expressed by citizens during the spring 2015 public inquiries (Eckbolsheim inquiry, n = 86; Illkirch-Graffenstaden inquiry, n = 17; Mittelhausebergen inquiry, n = 138; La Robertsau inquiry, n = 135).

However, arguments against geothermal projects vared significantly from one site to another. The risk of explosion were mentioned most frequently at La Robertsau (Figure 36). Here, opposition was the result of strong mobilization of local residents' groups. In the past, these groups and La Robertsau's inhabitants had been involved in many governance conflicts and the reduction of risks within the industrial zone of the *Port aux Pétroles*. This contrasted with the recurrent pattern of criticism focusing on issues of urban planning or local politics in the western communes of the EMS, which was due to a significant mobilization of municipal councils against the projects.

To sum up, residents did not object to the general principle of geothermal energy or energy transition. Rather, they argued against specific geothermal projects where they lived. The citizens were thus able to distance themselves from the collective refusal of the energy transition, and to exercise reflexivity concerning a concrete situation. In this sense, the opinions of the citizens revealed the unrooted nature of the projects, notably those of La Robertsau and Eckbolsheim.

The role of the investigating commissioner

The 2015 public inquiries played a decisive role in the dynamics of the controversies. They represent the crystallization of opposition to projects. However, these enquiries did not allow for a real renegotiation of projects. Indeed, the files prepared by the operators and which were presented during the public inquiries presented well-defined and quasi-ordered projects. They specified the location of boreholes, the measures taken to control risks, and the possible impacts on the natural and human environment. As a result, the files, which contained a great deal of technical information that was often difficult to grasp, were not the appropriate basis for constructive exchanges. The citizens could only agree or reject (with varying arguments) proposals that were often felt to be imposed. What is more,

with the notable exception of those written by environmental protection associations, few citizen contributions were intended to make the projects evolve.

In this context, the role of the investigating commissioners can be compared to that of a 'gatekeeper' (White, 1964): they selected, retained, rejected the elements which came in from different spheres (documents and responses from industrialists, citizens' opinions, etc.) and then wrote an opinion. The Mittelhausbergen and La Robertsau investigating commissioners applied the precautionary principle. The implantation site, they wrote, was poorly chosen in both cases: located near homes and a water catchment area, or in a Seveso zone. The investigating commissioners also noted weaknesses in the companies' case files: about the cumulative effects of several drillings, the lack of precise information concerning the fault lines explored and drilling direction, for example.

In their reports, all the investigating commissioners raised the issue of information. In their opinion, richer, more transparent information and a serious consultation would have allowed local residents to consider deep geothermal energy projects in a more constructive way. In this context, the commissioners attributed three functions to the informational issue:

- According to the Mittelhausbergen investigator, "good" information would lead to the acceptability of projects.
- The oil port investigating commissioner defined the information: it must both answer citizens' questions and reassure. However, he considered that the documents provided by the promoter did not make it possible to conclude that all risks would be avoided. The information was neither able to reassure nor to answer.
- Finally, the Eckbolsheim investigator attributed a more noble mission to information: if it was honest and thorough, it would allow for social appropriation of the issues related to geothermal energy, be they technological, political or social. However, these issues were not sufficiently addressed – or had even been omitted - by the promoters and the EMS.

In brief, different visions of what the public actually is and how it should be taken into account by the project promoters were emerging.

The organization of these public inquiries had a real impact on project development. Following these public consultations, two projects were abandoned by the operators. However, it should be noted that the public inquiry has only a consultative value. At the end of the process, the Prefecture issued orders authorizing drilling work at Illkirch, where the rooted project faced no resistance and at Eckbolsheim, against the opinion of the investigating commissioner. According to the Prefecture, in this case the precautions taken were sufficient to limit the environmental impact. So, the Prefecture did not take the criticisms expressed into account. Instead, it considered that they were the expression of individual egoism or of fears that could be overcome through the right communication. To quote the Secretary General of the Prefecture: "Citizens now feel entitled to obtain increasingly complete information and never feel sufficiently informed about the projects that affect them. [...] The decision-making process must integrate this new reality, while making sure that the audience understands that public interest comes first. General interest is not the sum of particular interests. [...] Opinions are then often expressed vehemently, sometimes irrationally. It would therefore be advisable to apply information work upstream." A few months later, it authorized a third project at Vendenheim in the industrial wasteland of a former refinery that will be transformed into an industrial eco-park.

However, not all citizen criticisms and demands remained unanswered. Institutions, local authorities and operators have learned lessons from the opposition movement. In fact, these stakeholders are revising their way of communicating with local populations, particularly through the establishment of monitoring committees open to the public or their representatives.

2. Swiss action research approach

2.1. Methods

The case study on the project in Haute-Sorne is based on a content analysis of project-related written sources, interviews with the operator, the cantonal authorities and local stakeholders, as well as observations made during an information event targeting the local population. The reconstruction of the planning process highlighted that in addition to geological conditions, institutional willingness to host a geothermal project was a key factor in choosing the site of the Haute-Sorne project.

The case study in Geneva started in 2017. It relies on document analysis, participant observation of meetings of the program managers (a total of 35 meetings with 33 different participants) and focus groups with residents of municipalities in the canton of Geneva (6 focus groups with a total of 52 participants).

2.2. Results

Haute-Sorne

The Haute-Sorne case is illustrative of the difficulties of implementing Federal policies that imply the construction of contested infrastructure. The project is considered as a pilot for the type of geothermal power plants that would be needed to reach federal targets in terms of geothermal electricity production. Thus, from the beginning it was an integral element of the national research and development program on renewable energies. However, local opposition to the project emerged. Inhabitants from Haute-Sorne opposed the project out of fear of earthquakes and environmental consequences. In reaction, the operator produced a guarantee that would cover damages caused by the project. He also agreed to organize further information events. Most of the opponents retracted, except for six citizens who took the project to the federal court. In addition, a committee of concerned citizens from the canton of Jura launched an initiative that called for a vote to forbid DGE within the canton.

The results give the impression, shared by many, that the population of Haute-Sorne was not adequately informed. Several interviewees expressed this view, even though the promoters organized several information events and sent newsletters informing citizens about the activities of the accompanying group and the advance of the project. One possible explanation could be the timing of the information. Information was sent in the early phase of the project before the project had attracted public scrutiny and was covered in the media. Because deep geothermal energy is still a relatively unknown form of energy in Switzerland, it is possible that a significant share of the recipients were not aware of this early information.

Another shared impression among the interviewees is that the project lacked political legitimacy. Even though it received support from parties across the political spectrum and was carried by a cantonal councilor, this view was widely shared among the interviewees, as well as by participants in the observed information event. Two explanations are possible. First, the cantonal authorization procedure was regarded by some actors as bypassing local political debate. Residents in Haute-Sorne could oppose the project. But this was an administrative procedure based on individual oppositions with decisions taken at the cantonal level. This impression of the absence of room for political debate was shared by supporters of the project. Some supporters even stressed that although they hoped that the initiative would not be subject to a vote, they nevertheless considered it to be a necessary step to ensure the project's legitimacy. A second explanation that emerged from our analysis of the document is that even if the government backed the project, it predominantly framed the project as a local economic development project, stressing potential benefits in terms of employment and tax revenues. As such, the project was not anchored in a visionary narrative like in the case of St. Gallen where citizens had been enrolled in supporting the project through continuous communication as well as a public vote on it.

Geneva

Communication and stakeholder inclusion are an integral part of the GEothermie 2020 program. In this research project, we analyzed the institutional context, the population's perceptions, as well as the participatory models that, together, guide the implementation of such a program. To work on the perception of the population, we organized six focus groups in five municipalities and one district in Geneva on the topic of energy transition and geothermal energy. This method provides a better understanding of how participants view the energy transition and their acceptance of geothermal energy.

We were able to identify several collectively shared opinions in the different locations: the nature of the information related to geothermal energy, its connection to everyday issues, and the risks associated with it. There were also some differences, in this case concerning the dynamics of discussion and by association, in the topics dealt with by the different groups and at the different localities.

The quality of the information was therefore a recurring theme. Several participants wanted more studies and more information before expressing their opinion. Others asked for elements of comparison with shale gas or other examples of geothermal energy projects elsewhere in Switzerland or in the world. Even if in each focus group there was always at least a person who profiled themselves as an "expert" in geothermal energy or renewable energy, lack of information was mentioned several times in all the focus groups. Because the Geneva geothermal program does not include many concrete interventions within the canton, the lack of information rarely referred directly to the communication strategy of the program, but rather to general knowledge about geothermal energy.

Even if the discussions were focused on geothermal energy, participants preferred to link it to subjects with which they felt more comfortable. This phenomenon is often observed and is important for projects aimed at including the population: if the topic is complex and unknown, it is easier and more effective for sustained participation to find another entry point based on concrete experiences.

Concerning the risks related to the geothermal energy, several participants at different localities mentioned that "zero risk does not exist". Here again, information is necessary, the participants did not know enough about the technology to give an opinion on the level of risk involved in geothermal energy, but they wondered about risks to groundwater and risks of earthquakes. On the other hand, in the Geneva context, most of the participants had confidence in the Canton of Geneva and GIS' ability to properly evaluate these risks.

The focus groups revealed differences between municipalities and neighborhoods. The existence of major infrastructure or renewable energy projects on the municipal territory such as that of a biomass power plant located on public land, may explain why the project was brought up several times in the discussions. It was mentioned either to illustrate a poor example of governance of a renewable energy project, or to demonstrate the municipality's commitment to this sector, etc. In another context, the construction of a major infrastructure project was a key topic. It thus spawned other topics such as mobility or noise pollution. A second difference was due to the balance between individual interests and interests at the community level between municipalities and urban districts.

As this brief overview of the results shows, the group method of discussion is an essential tool to understand the different perceptions of a project and its associations as perceived by the inhabitants. As part of a transdisciplinary study with practitioners, it is possible to share this information in order to make the stakes around a technology immediately visible and to develop it through direct relationships with local actors.

To summarize, the focus groups showed us that the inhabitants' opinions concerning geothermal energy are not set in stone. There's nothing to hide, but everything to gain by revealing how it works. A thoughtful information strategy that is adapted to the context is always desirable for a project originating from a technology like this, to minimize blockages. Knowing that shared values and questions are recurrent, it is possible to produce a clear message that directly addresses the citizens' needs.

3. Netherlands reflective research approach

3.1. Methods

The technical possibilities of innovative sustainable energy solutions, like (enhanced) geothermal energy systems, are impressive. However, many of these energy innovations have not yet produced concrete results or encounter difficulties achieving social acceptability, despite the fact the successful implementation of energy innovations is crucial to speed up the energy transition. Improving and applying energy innovations not only relies on technological improvements, but also on taking social, economic and legal challenges into account. To prevent such setbacks, a multidisciplinary approach is required that provides insights into the main technical and social challenges involved in implementing the technology, and the design of an inclusive implementation strategy for optimal societal embedding of the planned project.

However, current practices for developing geo-energy projects usually only assess the technical, spatial and economic (business case) characteristics of a new geo-energy project. Assessing the social and local characteristics, like the historical or cultural background, the stakeholder network including stakeholder interests, and the balance between (perceived) costs of benefits of the initiative is far less common. For these reasons, the EU FP7 project GEISER developed a socio-spatial assessment to obtain insights into the societal challenges of a new project. The main recommendation of the GEISER project was to develop a project strategy based on both techno-spatial and social-economic assessment, to be able to better deal with possible challenges regarding the societal embeddedness of the project (Figure 37).

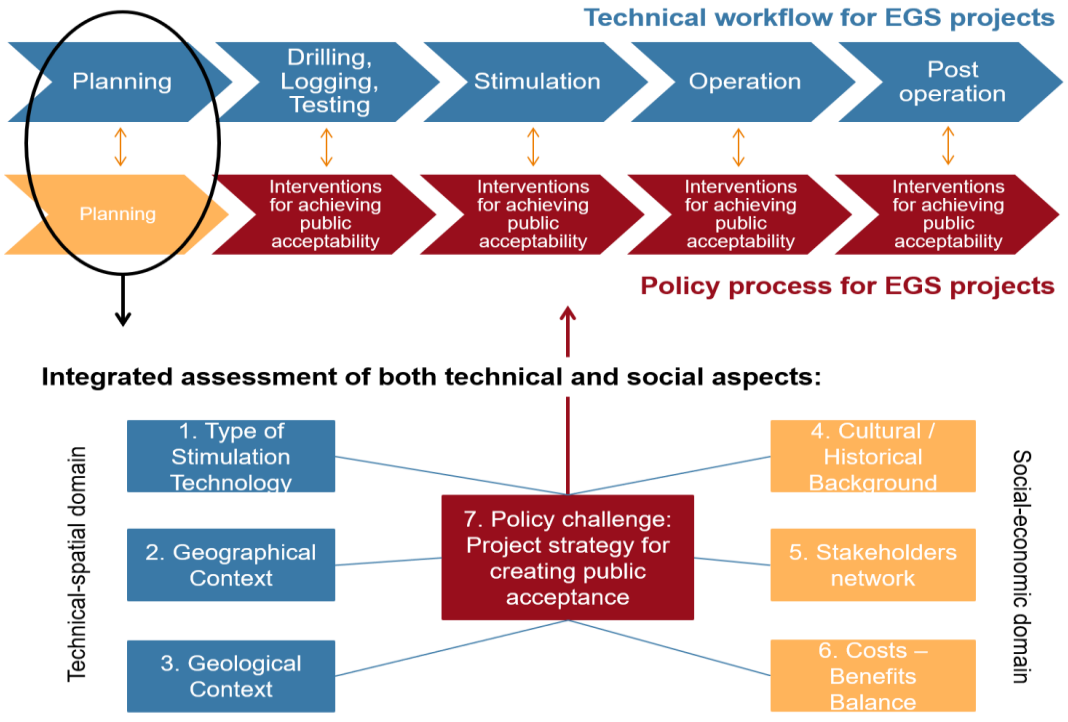


Figure 37. Integrated assessment of both technical-spatial and social-economic aspects in order to define the project strategies for creating public acceptance of EGS at a specific location (TNO, 2013). Based on the combined assessment dedicated interventions could be defined in the different stages of project development in order to deal with the most important challenges regarding societal embeddedness of an EGS project.

The GEISER approach was used as the main research perspective for the evaluation of the stakeholder and communication strategy of the Dutch Trias Westland project. In addition, we used the evaluation of the Trias Westland project to further improve the GEISER approach.

The main objectives of the reflective research approach for evaluating the societal embeddedness strategy of the Trias Westland project were:

- To learn from the approach how to embed the Trias Westland project in its societal environment.
- To learn from the approach and experiences of the stakeholder management team of the Trias Westland project.
- To learn about the feasibility of using an existing evaluation framework to lay the groundwork for creating acceptability of enhanced geothermal energy projects.
- To translate the lessons learned by the Trias Westland project team into generic recommendations for the societal embeddedness of (enhanced) geothermal energy projects.

The reflective research approach consisted of the following research activities:

- Interviews: we interviewed several members of the Trias Westland project team to get insights into the project development process as well as stakeholder management and the communication strategy.
- Desk research: we analyzed many documents on development, progress, stakeholder participation and communication.
- Reflection sessions: We organized several meetings with the stakeholder management and communication team to think about and discuss their activities and experiences.
- Observations: we attended several meetings with owners of houses located near the drilling site.
- Timeline: we drafted a timeline of the project development phases and key communication moments.
- Societal Embeddedness Strategy: we analyzed the societal embeddedness strategy of the project using the GEISER approach as an evaluation framework.

Based on these activities, we drafted general recommendations on how to improve the societal embeddedness of enhanced geothermal energy projects.

3.2. Results

The following paragraph describes three types of results. We provide an overview of:

- the main development stages of the Trias Westland project
- the key reflections of the stakeholder and communication manager
- the (ex-post) evaluation of the societal embeddedness strategy of the Trias Westland Project.

The section closes with a few general conclusions regarding the societal embeddedness of the Trias Westland project.

3.2.1. The Trias Westland project – an overview

In 2016, the Trias Westland Project became a formal case study for the social research in DESTRESS. At that stage, the project was in the ‘project design and business case development’ stage. Collaboration between the Trias Westland stakeholder management team and the ‘social science’ researchers within DESTRESS lasted from spring 2016 to summer 2018. Through desk study and several interviews with key

members of the Trias Westland project team, we drafted a timeline of the most important moments and events during the development process of the project. Three main stages were distinguished:

1. Ideation and preparation stage from 2008 to 2014
2. Project design and business case from 2015 to the middle of 2017
3. Construction, drilling, testing from the middle of 2017 to summer 2018.

The timeline below gives an overview of the most important events during these stages.

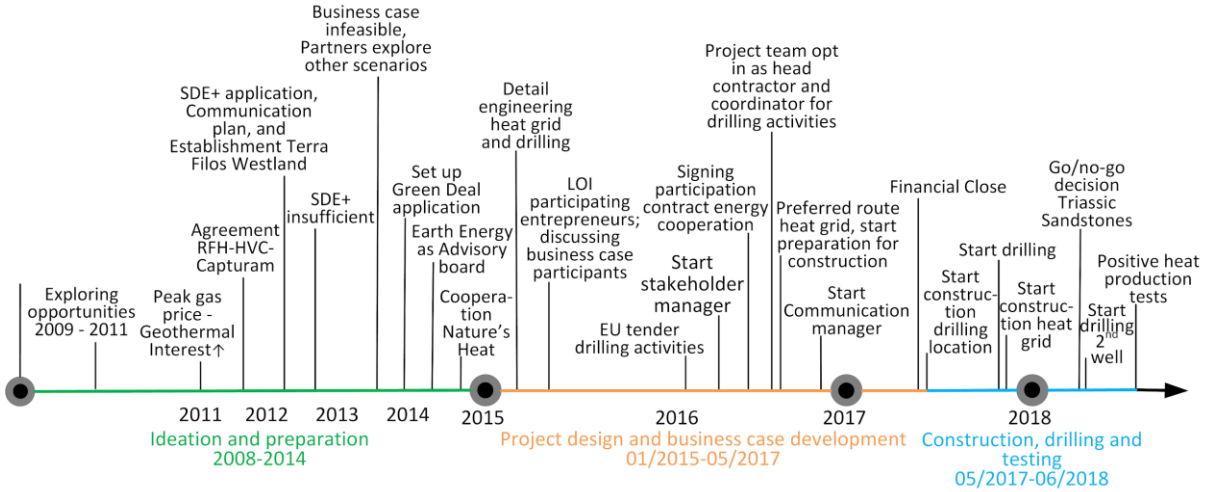


Figure 38. Timeline of the most important events during the three stages of development of the Trias Westland project. (TNO, 2019).

Ideation and preparation stage from 2008 to 2014 (Figure 38)

The ideation and preparation stage was characterized by 1) exploring the options for successfully implementing a geothermal energy project in the Westland region and 2) consortium building. As mentioned in the introductory paragraph, three local companies agreed to jointly explore and coordinate the options for a real geothermal energy project in the Westland region: Royal Flora Holland (RFH), the local waste management company HVC and Capturam, an engineering company for heat infrastructure. They jointly explored options for getting the project subsidized (SDE+). In addition, they started collaborating with local horticultural greenhouse farmers in order to include their interests as far as possible in the design of the project and business case (Terra Filos, Earth Energy and Nature's Heat). In this stage, the risks and uncertainties involved in developing a geothermal energy project in the Triassic sandstones at a depth of 4 kilometers seemed to be too high for the initiators. Due to the positive attitude and the ambassadorial role of the local government, the initiative was kept alive. After several hesitations, the option emerged to develop a combined project with a fallback option in the Lower Cretaceous sandstones. This option also led to collaboration with the national government in a so called Green Deal[13] under which the national government would guarantee the cost of drilling down to the Triassic sandstones located at a depth of 4 kilometers, in case the test phase showed that production of heat at this depth would not be possible (go/no-go). In that case, the initiators of the consortium would only have to pay the cost of drilling to the Lower Cretaceous sandstones, which made the business case acceptable for both the initiators and the participants in the heat cooperative.

[13] The Dutch government supports sustainable economic growth, or 'green growth', by stimulating sustainable innovation. This has a positive economic impact (growth and job creation) and avoids harm to the climate, water, soil, raw materials and biodiversity. Companies, community organizations and other government bodies who want to advance towards sustainability sometimes encounter barriers. Central Government can help them overcome such barriers by closing a Green Deal with other parties. In this way, the Green Deal approach aids the implementation of sustainable initiatives.

Project design and business case from 2015 to half 2017

The second stage was characterized by the detailed engineering of the drilling, wells and heat infrastructure and by drawing up the agreements for participating in the heat cooperation. Finally, during this stage, a stakeholder manager and a communication manager were added to the team. Based on the outcomes of a series of interviews, the Trias Westland team decided that they had three target groups for stakeholder engagement and communication activities:

- 'The participants' - the horticultural greenhouse farmers who were interested in participating in the project, both financially and via future heat consumption
- 'The neighbors' – people who lived at the location of the construction and drilling site.
- 'The general public' – all other stakeholders who were interested in learning more about the project; at national, regional and local level.

The stakeholder engagement and communication strategy consisted of tailor-made activities for all three target groups.

Construction, drilling, testing from the middle of 2017 to summer 2018

Construction of the drilling location lasted from May to November 2017. Drilling down to the Triassic sandstones at a depth of 4 kilometers took from November to December 2017, and included several technical obstacles that had to be overcome. After tests of the permeability and the porosity of the Triassic sandstones, the Trias Westland consortium concluded that the Triassic Sandstones were not suitable for developing a successful geothermal energy project (bad permeability and bad porosity) and that the project would continue with the preparation for a geothermal energy project at 'normal depth' in the Lower Cretaceous sandstones (2 – 2.5 kilometers in depth). On February 16th, 2018, they published a press release concerning the 'no-go'-decision. In parallel, construction of the heat infrastructure began.

During the drilling and testing, communications with the participants and the neighbors became more intense. The participants were interested in the progress of the drilling. The neighbors were faced with nuisance caused by the construction and drilling activities. The stakeholder manager remained in close contact with them to find ways of keeping the nuisance (i.e., lights and noise) to the strict minimum. To insure relations with the neighbors remained cordial, they could contact the project team 24/7 to report problems and/or abnormalities. For the general public, new information materials were produced about the progress of the project.

Collaboration and financial model

The initiators of the Trias Westland project involved the local horticultural greenhouse farmers at a very early stage of the project. During the project development stage, the local farmers were involved via the local interest group 'Earth Energy Westland'. A small group of representatives of this local interest group forms the so-called 'farmers board'. This board became part of the governance of the Trias Westland project and was invited to take part in decision making regarding the project. The members of the board were themselves local entrepreneurs and were considered to be trustworthy by the local community.

During the project design and business case development stage, the participation of these local farmers became more and more formal. At first, they signed a so-called LOI to participate in the future heat cooperation (2015). Later, this LOI was replaced by a 'participation contract' in the future heat cooperation (2016). Signers of the 'participation contract' would be part of the project for 15 years and will then become co-owners of the Trias Westland project. The signers also invested in the development of the project. This 'participation contract' would be substituted by a 'heat supply contract' as soon as the heat supply actually started. During the collaboration period of the Trias Westland project team and the DESTRESS social science research team it was not yet certain which local farmers could be connected

to the future heat network as this would depend on the outcomes of the drilling and testing stage of the project. The farmers who would actually be heat consumers would become a member of the Energy Cooperation Westland. The scheme below shows the participation model for the first 15 years of the Energy Company Westland.

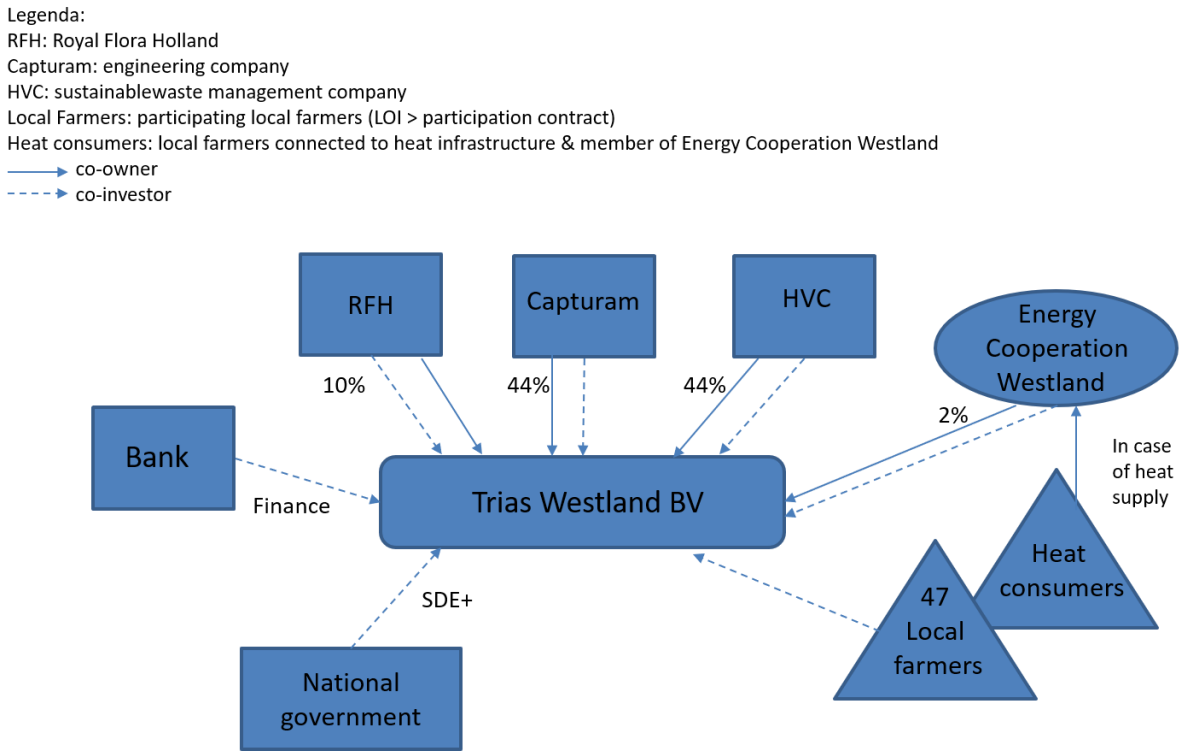


Figure 39. Schematic overview of participation between investors, participating farmers and financers. The 3 initiators of the project are owners of the Trias Westland BV: Royal Flora Holland, Capturam en HVC. These companies are the main investors and main shareholders of the Trias Westland project. The project is financed by two banks (BNG and Rabobank), SDE+ subsidy, investments by the 3 initiators and contributions from the 47 participating local farmers. Only farmers who actually become heat consumers will become members of the Energy Cooperation Westland.

3.2.2 Lessons learned from stakeholder and communication management

Stakeholder and communication strategy

In 2008, Royal Flora Holland, one of the initiators, took care of the communication activities. After the collaboration agreement between the three initiators (2011), Capturam took over this responsibility. At the beginning of the 2nd stage of the 'project design and business case development' (at the end of 2015) the project team was formed for the Trias Westland project. Soon afterwards (at the beginning of 2016), the project director decided to appoint a stakeholder manager and a communication manager (at the beginning of 2017). The stakeholder manager designed a stakeholder strategy based on interviews with key stakeholders in the region. One of the outcomes of this stakeholder analysis was to divide the stakeholders into three target groups for stakeholder engagement and communication:

- 'The participants' - the horticultural greenhouse farmers who were interested in participating in the project, both financially and via future heat consumption
- 'The neighbors' – the people who were living in the direct area of the construction and drilling site location.
- 'The general public' – all other stakeholders who were interested in learning more about the project; at national, regional and local level.

Towards the 'financial closure' of the project (spring 2017) interactions with the participating local farmers were intensified. Communication with 'the neighbors' started in autumn 2016 and intensified towards the construction, drilling and testing stage. The neighbors were carefully informed about new activities at the drilling site before the activities actually happened. It was important for the stakeholder manager to inform the neighbors as openly and as early as possible, as well as obtaining insights into their main concerns and questions to be able to find joint solutions for the problems at hand. Newsletters, a website and several Q&As were designed for the general public. On the day before drilling started, the stakeholder and communication team started a 24/7 WhatsApp group for the immediate neighbors so they could immediately inform the site operator about any irregularities or problems connected with the drilling process.

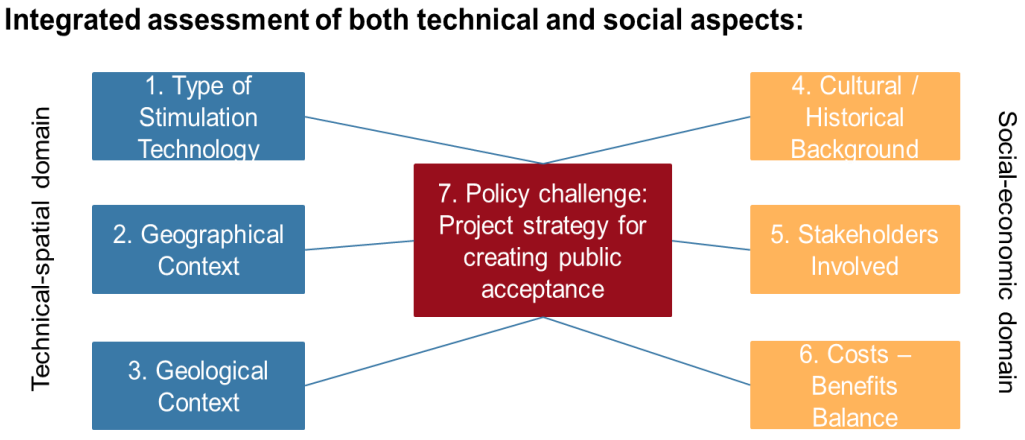
Experiences from real practical experiences

The main insights of the stakeholder and communication team regarding the stakeholder and communication strategy were:

- The uniqueness of the project helped create societal acceptability of the project.
- Local farmers were actively involved in the development process of the project.
- The ambition 'local for local' helped to socially embed the project in its local environment.
- The members of the Trias Westland project team were capable of connecting with different stakeholders at different levels.
- The design of the project represented the local identity of the region. It is the tradition of the horticultural greenhouse sector to collaborate intensively.
- The project team was able to rapidly and creatively respond to reduce nuisance to neighbors.
- Eagerness to learn from a critical society after several bad experiences with geo-energy projects (like CCS in Barendrecht or shalegas in Boxtel).
- Increasing openness and mutual understanding supported the strong collaboration within the Trias Westland team between the stakeholder and communication managers and the technical engineers.
- Trust in the project by all members of the Trias Westland project team as well as the participating stakeholders.
- Local politicians and neighbors became ambassadors of the project and spread the positive story about the value of the project.

3.2.3. Ex-post evaluation of the Trias Westland societal embeddedness strategy

Using the GEISER approach as a framework to evaluate the process and strategy to societally embed the Trias Westland project, we mainly focus on the social-economic aspects on the right hand side of the scheme below.



The ex-post evaluation of the societal embeddedness strategy of the Trias Westland project took place after the construction, drilling and testing phase was finalized. The period used to evaluate the societal embeddedness strategy was the beginning of 2015 (start of the development of project design and business case) until the beginning of 2018 (decision concerning the Lower Cretaceous Sandstone project).

Cultural and Historical background

National. Parallel to the development of the Trias Westland project, the public debate regarding geo-energy projects had become very critical, due to the issues with induced seismicity in the north of the Netherlands as a consequence of natural gas production in the Groningen gas field. Furthermore, the publication of a critical report about the state of the geothermal energy sector increased public awareness of the safety aspects of new geothermal energy projects. Lastly, in order to meet the goals of the Paris Agreement, the Dutch National Government considers geothermal energy will play an important role in the transition to a more sustainable energy system in the Netherlands.

Regional. The drive for the horticultural greenhouse sector in the Westland region to be more independent of the gas market became stronger and stronger. Several individual greenhouse farmers had invested in their own/individual geothermal energy system when the idea emerged to transform heat production in the Westland towards a more sustainable system. Horticultural greenhouse farmers are highly dependent on new and innovative concepts to insure they are sustainable and expand their businesses. The development of an innovative and unique project like the Trias Westland project fits this culture.

Stakeholders involved

The initiators of the project developed a participation and financial model which includes all relevant stakeholders in the region. Furthermore, their partners came from different levels, national, regional and local stakeholders were involved in the development of the project. Lastly, they drafted a suitable stakeholder and communication strategy for different stakeholder target groups.

Cost-benefit balance

The financial participation model as well as the approach for reducing and solving perceived nuisance from the drilling location shows that the Trias Westland team tried to respect the balance between costs and benefits as well as possible:

- Local farmers will become owners of the heat cooperation after 15 years of operation.
- The project team came up with creative and tailored solutions to reduce nuisance caused by the drilling site.
- The neighbors realized that the nuisance they faced as a consequence of the construction and drilling activities would – in the end – result in a more sustainable energy system for the local farmers who are often members of their family or friends.

3.2.4 General conclusions Trias Westland case study

Conclusions of the development of the Trias Westland project

The reconstruction of the development process as well as several interviews and working sessions with the stakeholder and communication manager of the Trias Westland team led to the following key reflections:

- Collaboration with local horticultural greenhouse farmers started at a very early stage of the development process and evolved during the process.
- Despite all obstacles and disappointments regarding (e.g.) financial business case, the stakeholders displayed great perseverance.
- Support from local politicians played an important role in embedding the project in its local environment as well as in overcoming the obstacles encountered during the development process.
- The participating stakeholders became a strong and resilient coalition with great confidence in a successful outcome of the project.
- One of the keys to success was that they jointly defined a set of process principles for the development of the project.
- The project was presumed to be an investment in the sustainability of the local entrepreneurs, who represent the identity of the region.
- The possibility of becoming independent of the gas market and of creating a local and sustainable energy source was an important factor in convincing the participating horticultural greenhouse farmers to remain in the project.
- The director of the Trias Westland project played an important role in connecting different agendas, interests and stakeholders.
- The participating horticultural greenhouse farmers had an important stake in the decision-making process at all stages of the project development.
- 'Local for local' was an important characteristic of the project: local investors, local heat consumers, local engineers, an inclusive business case, a heat cooperation which would be owned by the local end-consumers (horticultural greenhouse farmers) after 15 years.

<u>Conclusions on stakeholder and communication management</u>

- Local support was very strong. The design of the project was very inclusive and represented the interests of the local stakeholders. Further, the neighbors seemed to be very tolerant towards nuisance caused by the drilling site probably because most of them had a stake or relatives with the stake in the horticultural greenhouse business.
- Personal relationships. The Trias Westland project team build personal and transparent relationships with the participating local farmers and neighbors. They communicated openly about all stages of the project as well as about challenges and risks. The identification of key principles for the collaboration process represent the willingness of all participants to design a transparent and cautious development process.
- Local for local. Many aspects of the project design reflect the 'local for local' ambition: the strong collaboration with local farmers; the inclusion of local interests in the project design; a local office for the project team on land belonging to a local farmer; the appointing of as many local engineers and advisors as possible.
- Collaborative attitude. All the members of the project team had a collaborative attitude. This was really helpful in creating societal embeddedness for the project. The ambition of the project director to create strong collaboration with the local greenhouse farmers – the future heat consumers - is a good example – as are the personal relationships with the neighbors, the collaboration and openness between technical and non-technical team members; the personalized solutions to nuisance caused by the drilling site. Finally, the project team was available and approachable for the local community.
- Ambassadors. Many of the participants became ambassadors for the project. Local politicians supported the initiative for the Trias Westland project right from the beginning. Neighbors

became ambassadors and spread the word about the project at parties with friends and family, and the engineering contractors and drilling operators also became real ambassadors of the project, evidence: they all wanted their logos to be displayed on the information board at the construction site.

Conclusions concerning the Societal Embeddedness of Trias Westland

Based on the evaluation of the development process of the Trias Westland project, the understanding of the participation and financial model as well as the evaluation of the stakeholder and communication strategy, the overall conclusion is that the Trias Westland project was perfectly embedded in its local environment.

Although the GEISER-model was not used by the initiators or by the stakeholder or communication manager, all the components of the model were kept in mind and translated into an inclusive and participatory project strategy.

Chapter 6. Unexplored points and recommendations

1. Unexplored points

1.1. The fate of rooted and rootless projects

The work achieved within the framework of the DESTRESS program makes it possible to develop a typology of projects taking into account their integration into the local environment. In a first stage we distinguish between projects rooted in the territory, which are the result of extensive consultations and exchanges with elected officials and residents, and unrooted projects, which did not benefit from such exchanges. However, this distinction is only useful in the analysis of project development and related interactions. It is not very helpful when considering other elements that would facilitate or hinder a public uptake of a project until its production phases. It is therefore necessary to return to the notion of rooting in the light of a more detailed analysis of historical, cultural, sociological and political contexts.

The case of projects in Alsace

Two of the cases studied in Alsace show relatively strong coherence between the history of the area and the introduction of geothermal energy. For example, the links between geothermal energy and oil drilling have often been put forward by political stakeholders in the area around Wissembourg, which can give 'historical' meaning to the deployment of this type of project in northern Alsace. For example, the mayors have created an alliance called "The Land of the Earth's Energies". This "kinship" allows them to root projects in the history of north Alsace, while paving the way for its industrial and political promoters to include deep geothermal energy in a territorial narrative.

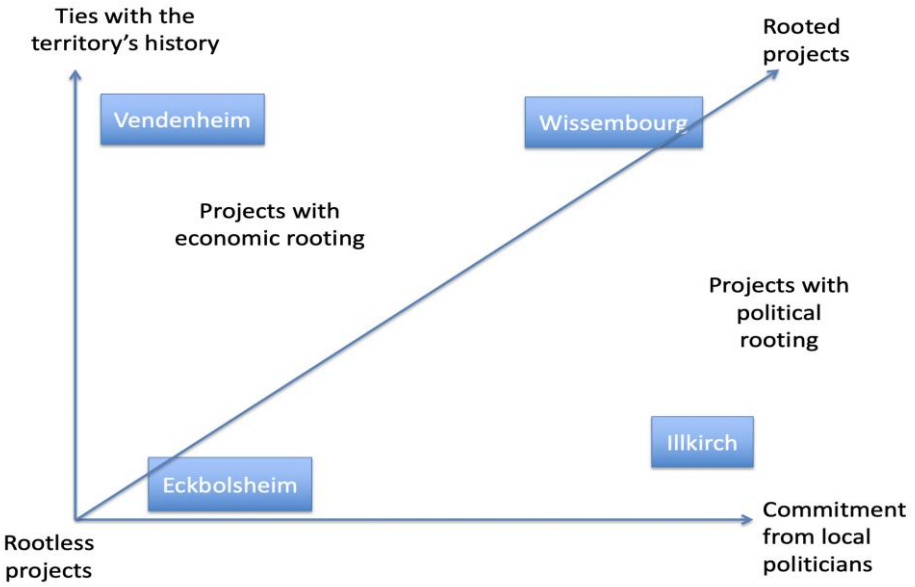


Figure 40. Extent of the economic and political roots of four geothermal projects in Alsace.

In the area around Vendenheim, a municipality that is part of the Eurometropolis of Strasbourg, the link with the history of the territory is less developed by politicians. However, the location chosen for the project (a brownfield land that was previously a refinery site) may help to link the project with the territory's economic and industrial past: energy production—oil or geothermal—is the focus in both cases. In addition, the project is presented as the first step towards the creation of an industrial eco-park presented as real ecological progress compared to the former oil refinery. This historical and

economic continuity, and the move towards the establishment of a green industrial park, may have convinced some local actors who were previously rather reluctant to accept the geothermal project.

A project may also have political roots. In Wissembourg and Illkirch-Graffenstaden, elected officials are particularly involved in environmental issues. Some projects are thus firmly rooted both in the territory's 'history', and in the process of maturation pursued by local politicians. The Illkirch-Graffenstaden project also has strong roots but only in the commitment of local elected officials. Finally, the Eckbolsheim project, which does not tap into any territorial 'history' and which was not sought after or advanced by local politicians, appears 'rootless', with no real local ties.

The results of the quantitative survey conducted in 2017 show a strong correlation between the attitude of the inhabitants towards the project and the stakeholders and the anchoring of the project in the history of the territory and the political commitment of the elected representatives. Support for the project is strongest in the Wissembourg area (75.4% of positive attitude among people who had heard about the project). Likewise, the trust placed in operators and politicians is strongest there, and in Illkirch-Graffenstaden. Admittedly, this trust is not absolute, and respondents remain vigilant, as indicated by the emphasis they place on possible risks.[14]

At the opposite end of the spectrum, we have the Eckbolsheim project which was not supported by local politicians and had no ties with the territory's economic and cultural history. According to the results of the 2017 survey, project acceptance here is the lowest (21.4%) and mistrust of the operators highest in this area.

The Illkirch-Graffenstaden and Vendenheim projects fall somewhere between these two extremes. In Illkrich, support for the project has been fostered through the involvement of local politicians. In Vendenheim, the project's roots in the territory's industrial history had been offset by strong opposition from citizens and elected officials. The Vendenheim project thus appeared somewhat 'rootless' and forced. However, the situation is not static. As a result of a stronger involvement of the Eurometropolis of Strasbourg and the actions taken to transform the former refinery into an industrial ecopark, the project is gradually acquiring more positive connotations.

Rooted and rootless projects in Switzerland

One of the core lessons learned from the Swiss case studies is the importance of close interaction with different stakeholders and the broader public from the very beginning of a project. This means that public participation becomes more and more important.

The example of deep geothermal energy in Switzerland highlights the importance of the social context when planning a project. The varied institutional settings, the multiplicity of actors involved because of the federal structure of the country and its multilingualism highlight how different social characteristics influence the way local populations respond to deep geothermal projects. Therefore, Switzerland offers a good example of how 'context matters' for the siting of contested energy infrastructure (Rosa and Short 2004).

1. 2. What opposing geothermal energy means

We argue that the population's sympathy for a geothermal project largely depends on how the project is introduced, discussed and presented to the local community, i.e., on whether it is a locally rooted or unrooted project. This accounts for the way in which the operators consider their interactions with the communities. In the case of rooted projects, the company appears to adopt an attentive approach towards local communities. This dynamics contrasts with that around unrooted projects. New operators

[14] For more details, see the chapter on 'Public perception of geothermal energy' of the present report.

who entered the geothermal energy sector introduced projects without establishing a local dialogue. Projects that proceed with no upstream consultation or dialogue involving local communities may in the initial phases of project implementation lead to strong opposition from elected officials and inhabitants. And the dynamics of social contest may vary from one context to another because the actors involved in the controversy are linked to different social worlds.

Opposition to geothermal projects in Alsace[15]

As a result of government measures to promote energy transition, in early 2010, the operators *Fonroche* and *Electricité de Strasbourg* designed several projects to be implemented in the Eurometropolis. While these projects appeared to fit the energy climate plan developed by the Eurometropolis of Strasbourg, some can be qualified as unrooted if we consider the limited upstream interactions between the operators and the municipalities or neighborhoods expected to host the projects.

Engagement of elected official: geothermal project as a threat to municipal sovereignty

Thus, these geothermal projects entered the political agenda *via* a different path than rooted projects. In the small towns in the western sector of the Eurometropolis of Strasbourg, elected officials felt it was important to oppose these projects to reaffirm the sovereignty of their communities for the future of their municipalities. In the last few decades, these municipalities have been deeply transformed by the development and increased attractiveness of Strasbourg (their population has doubled in the last twenty years). However, the elected officials of these municipalities are not on the same side as the political majority of the Eurometropolis council and as a result, had little influence on the decisions taken by the council.

Several arguments against geothermal projects were put forward in the deliberations of the municipal councils of these towns, in addition to focusing on induced risks: the absence of an energy master plan in the Eurometropolis of Strasbourg, the negative impact of these projects on the municipal development plans, and errors of judgment on the part of the operators.

However, each municipality had its own way of opposing the projects. One town used multiple means to get local residents to participate in the public inquiries: the issue was placed on the agenda of the district council meetings, and the town hall organized public meetings and drafted notes and articles that appeared in the municipal journal. Another was more amenable to geothermal projects and engaged in negotiations with the company and the Eurometropolis of Strasbourg to make sure that it stood to benefit from the presence of the drilling site. In both cases, elected representatives demonstrated their willingness to take charge of the debate and defend the interests of their town: this was a question of restoring sovereignty to determine their future. In this context, the publicity around the risks related to geothermal projects legitimized the elected officials' approach and helped them to gain support from residents.

Involvement of resident's associations: geothermal project as a threat to the social identity of residents.

Among the controversial geothermal projects in the Eurometropolis of Strasbourg, the La Robertsau project was particularly contested. There, the social perception of risks had more influence than in other cases. The drilling project was to be implemented at a site near the "oil port" (*Port au pétrole*) industrial site and protest against the project was orchestrated by the La Robertsau residents' association (l'*Association de défense des intérêts de la Robertsau* French acronym ADIR), which works to preserve the neighborhood's environment. The association noted the risk of explosion and of seismic activity and

[15] This passage is part of a much broader analysis published in the journal Geothermal Energy (Chavot et al., 2018).

discredited the company responsible for implementing the project by alerting residents to its lack of prior experience.

The La Robertsau controversy grew for two reasons. First, in addition to the fear of new drilling hazards, this project posed a double threat to the social identity of residents, represented by the ADIR. In the past, this group and La Robertsau's inhabitants had been involved in many governance conflicts, such as negotiations concerning the route of the tram line running through the neighborhood, the urban development plan, and the reduction of risks in the industrial zone near the oil port. In addition, the ADIR had been involved in the Technological Risk Protection Plan (PPRT) of the oil port since early 2010. In that context, it was campaigning for a transformation of the industrial park or its relocation and, at the very least, to ensure that no new risk-generating enterprises would be established in the area – the drilling project embodied exactly what the ADIR was fighting against. Furthermore, ADIR has long practiced local democracy at the neighborhood scale. The absence of a local debate on the project conflicted with these democratic principles. Thus, the project and the way in which it was imposed ignored the connection between ADIR members and their territory, their social identity, and their hopes and plans for its future.

Second, by focusing on the idea that one should not add risks to an already sensitive area allowed ADIR members to rely on important allies. La Robertsau is a wealthy residential district home to some of Strasbourg's (political and academic) elite. By March 2017, all the candidates for the departmental elections in the north-eastern sector of Strasbourg had announced their opposition to the project. Shortly before the public inquiries began, the City of Strasbourg announced that it would give a negative opinion on the La Robertsau project.

The diverse range of social meanings given to geothermal project is associated with very different perceptions of the risks involved. Discussions concerning risks are at the heart of the controversies surrounding geothermal project, both in La Robertsau and in the western sector of the EMS. However, emphasizing risks in the debate concerning the geothermal project may follow different logics. In La Robertsau, it enabled banishment of the geothermal project from the industrial zone of the oil port in order "not to add risk to risk". In that case, dealing with risk and the desire to reduce the number of risky installations in the neighborhood is inscribed in the social identity of La Robertsau residents. In the western communities of the Eurometropolis of Strasbourg, publicity about the risks involved plays a more rhetorical role. It provides the necessary foundation for a set of demands by the small municipalities directed toward the operator and Eurometropolis. Because the installation of a geothermal power plant is "costly" in terms of risks, the municipality can ask for compensation, which may be financial (sharing royalties) or political.

1. 3. Part played by state and local authorities

Deep geothermal energy in Switzerland is part of the new federal energy strategy and is strongly supported by national agencies and numerous research projects. However, its development is slow. Two past projects, one in Basel and one in St. Gallen, had to be halted because of seismicity and low water flow, and the project in Haute-Sorne is being blocked by local opposition. Yet prospects are still promising because with the national referendum in 2017 accepting the Energy Strategy 2050 (ES2050), the Swiss Federal Office of Energy can financially support new pilot projects, and research and development is still being encouraged at a large scale. In addition, the shift from only the production of electricity to include the production of heat certainly helps to underline the advantages of DGE for decarbonizing the energy supply.

The case studies in Haute-Sorne and Geneva along with a review of the literature on the Basel and St.Gallen cases, revealed that the interplay between various state levels along with regulatory

mechanisms, play an important part in rooting a geothermal project. Indeed, such institutional roles and mechanisms can legitimize certain decisions in a local context.

From St.Gallen to Haute-Sorne

Before the earthquake in Basel, public discourse on geothermal energy was largely positive, whereas after the episode, reporting began to focus on seismic risk. This became the dominant frame of reporting about geothermal energy. Although the Deep Heat Mining project in Basel involved a local operator and was supported by the city government, it did not succeed in establishing local connections, mainly because of the lack of local public engagement. The project developers emphasized the fact that the project will be the first commercially operating petrothermal power plant in the world, the narrative thus turned to a much stronger focus on taking on a pioneering role rather than embedding the project in the local context. This project can be characterized as a local public-private partnership with little indication of a role for federalism, apart from the fact that it received federal subsidies because of its pioneering character. The failure of the Deep Heat Mining project raised questions about future geothermal developments in Switzerland, especially concerning seismic risk.

It is consequently not surprising that the first major project to emerge after the failure of Basel, the one in St.Gallen, was hydrothermal and that it emphasized its local character. Developers of the St.Gallen project repeatedly stressed that their project relied on a different technology than the one used in Basel. In Particular they emphasized that the seismic risk was smaller in hydrothermal projects as they do not require fracking. As such, the St.Gallen project diverged from the Federal priority, which, at that time, promoted the development of petrothermal projects, as these were the only projects that could be set up anywhere in the country. Project promoters in St.Gallen liked to emphasize the local geological characteristics that would enable them to exploit geothermal energy. They also emphasized the local use of heat. In contrast to the Basel project, the municipal government of St.Gallen engaged with the local public early on and put the project up for public vote.

Although the project in St.Gallen was framed as a local initiative relying on specific geological conditions, it also benefitted from federal incentives. This federal guarantee was an important argument during the public vote in favor of financing the geothermal project. The pioneering aspect of the project helped St.Gallen appear as a path setter which other cantons should follow while the failure of the project called into question the ability of hydrothermal projects to be implemented at the national level. It demonstrated that such projects are too dependent on very local conditions. In a way, the advantage of “localness” the project started out with, turned against it in discussions concerning the possibility to scale up.

The failure of the St.Gallen project was used as an argument by promoters of petrothermal systems to appear again as the only alternative for a large-scale deployment of DGE in Switzerland. Learning, from what happened in Basel, the main developer of petrothermal plants has sought to engage the public early on, like they did for the Haute-Sorne projects. The strong public reactions that followed the earthquake as well as the high costs of reported damage, also led to discussions about the potential benefits of accepting locating petrothermal plants in rural areas (Giardini, 2009).

However, the example of Haute-Sorne is a good illustration of how challenging it is to foster local support for a project when its main goal is to serve as a pilot project to scale-up a technology, with little perceived local benefits. The fact that the project would only produce electricity and did not include a plan for direct local use of heat gave the local population the impression that they would have to bear the risks without receiving any direct benefits. As such, it resembled a project imposed from the outside. This was accentuated by the fact that the operator was identified as coming from Zurich, the economic center of the country. The fact that the discourse on being a pioneer or innovator that was so successful in St.Gallen did not succeed in creating bonding in Haute-Sorne illustrates the importance of context. At the time of writing, it is still not clear whether the federal administrative court decision will provide sufficient legitimacy to the project.

The Geneva programm

The Geneva program focuses on heat, and like St.Gallen, emphasizes the unique and favorable geological conditions that can make it possible to exploit geothermal energy. The program frames itself as a local project executed and planned by the local authorities and utilities. However, it differs from the St.Gallen project in that it prioritizes direct use for local heating, including at low temperatures. Thus, the program did not appear initially to be in line with the federal priority of increasing the share of renewable electricity production. However, the program managers claim to be innovative at the institutional level, arguing that developing a new technology – and hence a new economic sector – requires creating appropriate socio-economic conditions which in turn requires public acceptance, but also local operators and investors who can carry out the projects.

The initial success of the geothermal program in Geneva, with the drilling of two wells at mid-depths, and another one planned, have shown that it is possible to advance geothermal energy in Switzerland for industrial and district heating purposes. Moreover, the managers of the Geneva geothermal program have lobbied Federal experts to change their all-electricity prioritization of the SFOE when it comes to geothermal. Their efforts led to a proposal to extend the Federal guarantee for exploration costs to geothermal heat projects. This extension was introduced in the first version of the Federal act on the reduction of CO_2 emissions, however it is not yet enforced, as the parliament refused the current version of the act in November 2018.

Conclusion

These four case studies illustrate different mechanisms through which a federal state can seek to influence the development of emerging energy technologies by member states. In the case of geothermal technologies in Switzerland, core narratives and the interplay between local and national levels of engagement and action vary as a result of local context and the technologies chosen.

The Federal Energy Strategy 2050 (ES2050) and the associated New Energy Act (EnA) are the main federal instruments that support the development of geothermal energy in Switzerland. The ES2050 sets objectives to be reached for electricity production only, thus formulating a political priority for a specific form of geothermal energy. In the Swiss geological context, this means pushing for the development of petrothermal systems as only these can enable large deployment of geothermal power plants. However, such projects include a stronger need to justify their choice of site and to make potential benefits visible to local communities. Since in the Swiss federal system the cantons are responsible for implementing the EnA and authorizing geothermal projects, this implies that the projects must at least be accepted at the level of individual member states, but even more so, by the local population. The project in Haute-Sorne illustrates the difficulty for petrothermal projects to become embedded in a local context even though there is no technological determinism in this regard. In a non-federal context, like in the region of Alsace in France, petrothermal projects managed to create local legitimacy by framing themselves as a green revival of former mining and oil related activities (Chavot et al., 2019). But the ES2050, as well as the decision of the Federal administrative court, did not manage to do the same in Haute-Sorne.

1. 4. Point on media misunderstandings

In the UK media analysis, we noted multiple examples of misunderstandings between experts and journalists. These misunderstandings concerned (1) the potential capacity of new projects to stimulate the local economy as well as potential heat production rates, and (2) the disassociation between geothermal exploitation techniques and hydrocarbon exploitation techniques. Using two case points below we provide examples of such misunderstandings and warn how these could affect public opinion.

Disassociation between geothermal and hydrocarbon techniques

We noticed in the UK media analysis that the media disassociate geothermal and fracking. This is also the case of UK legislation. Following government acceptance of a proposal by Green et al. (2012), seismic activity caused by 'fracking' for hydrocarbons is very strictly regulated, whereas induced seismicity caused by hydraulic fracturing for other purposes, such as EGS development, is exempt from this regulation. It is covered in the UK only by default regulations affecting all forms of vibration nuisance caused by industrial activity, as discussed by Westaway and Younger (2013). This apparent anomaly has been pointed out in the media, notable in an article by Lyons (2019), in which a representative of the shale gas industry is quoted as saying he was 'disappointed by the blatant double standards being applied to the shale gas industry with no scientific basis or credible research' and an environmental critic noting that 'you would assume, given the similarity of the processes, that there would be similar regulatory oversight for both'. This article also addressed the United Downs project, which involves the development of a deep geothermal reservoir exploiting flow through a natural fracture in granite in Cornwall (GEL, 2019). It quoted a spokesman for this project denying that the development process for this project has any similarity with 'fracking' for shale gas, stating that 'the geothermal concept we are trialling in Cornwall relies on pre-existing natural fractures, not on creating new artificial fractures like the fracking process. The pressures, flow rates and volumes of any well treatments we carry out will be much lower than stimulations carried out in shale exploration. We will be circulating water, not complex chemical mixtures.' However, it is well known that if the natural permeability of the fracture being exploited at United Downs is insufficient, the system might be engineered using 'chemical stimulation'. This is planned for one European Commission funded Horizon 2020 research project (MEET, 2019). It is also well known that this is not without risk. A recent inventory study by Buijze et al. (2019) demonstrated that induced seismicity associated with EGS activity is strongly associated with projects involving injection into granite. An extreme example is the Pohang earthquake (MW 5.5) which occurred in association with an EGS project involving injection into granite, for which the effect of 'hydrochemical corrosion', or dissolution of the granite causing unclamping of the seismogenic fault, is proposed mechanism (Westaway and Burnside, 2019; Westaway et al., 2020). This newly-discovered explanation was reported in a public forum (Westaway, 2018b). In the meantime, a member of the public commented on the online version of the Lyons (2019) article in relation to the United Downs project 'just stop all fracking & anything like it at once. Dumb thing to be embarking on …

Miscommunication of capacity of geothermal projects

A case in point is the HALO project in Kilmarnock, which has been publicized in many favourable articles in the Scottish media. However, analysis by Westaway (2018a) showed that this Deep Geothermal Single Well (DGSW) project could not achieve anything like the heat output that its proponents had claimed. The heat output feasible over any worthwhile lifespan was indeed found to be so low that this project represented an extremely poor investment of public funds. Around the same time as this analysis was published, a review of this project led to the DGSW element being dropped. This is thus an example where the public played no role in the abandonment of what was evidently an unsound project; the decision depended on expert assessments. The idea that some geothermal projects are unsustainable has nonetheless featured in other discussion intended as public engagement (e.g., Fontaine, 2015). However, this point has long been recognized within the geothermal industry (e.g., Rybach, 2003). Accompanying this is the recognition that geothermal developers have a professional obligation to design projects sustainably, and not to claim exaggerated outputs that will deplete any resource and damage its long-term potential (e.g., Ketilsson et al., 2010), as members of the public are not in a position to challenge the developers' calculations (as the HALO case study indeed demonstrated).

2. Recommendations

2. 1. Territorial issues

Recommendation 1. Operators and institutions must consider the territory through the eyes of its inhabitants'

Analyzing project development via the notion of rooted/unrooted projects invites us to consider the different contextual factors that facilitate or hinder, or even prevent, the implementation of a project. As we have seen, these factors may be economic, political or sociological. Thus, in Alsace, the two sites where opposition was strongest during the 2015 public inquiries were the residential district of Robertsau, located near the industrial zone of the Port aux Pétroles, and the small municipalities bordering the western districts of Strasbourg (the towns Mittelhausbergen, Oberhausbergen and Eckbolsheim). In both cases, the projects were perceived by the residents as being imposed by the state and/or the Eurometropolis of Strasbourg. In addition, they are an affront to the social identity (Wynne, 1992) and practices of the inhabitants. In La Robertsau district, the project ran counter to the actions of local residents' associations, which were committed to the establishment of a local democracy and had long been active in risk reduction in the nearby industrial area. In the western sector, opposition to the projects was part of an already tense climate between the Eurometropolis council and elected representatives of the small municipalities in this sector who want to assert their right to freely decide the future of their territory.

The Dutch project Trias Westland in the Westland region can be considered as a project that has been successfully embedded in its local societal environment. The project strategy is characterised by a participatory approach. Local stakeholders could co-invest in the project; they were part of the governance structure and invited to co-decide about important issues regarding the development process; the project was an important development for the future of local businesses, which made them real ambassadors for the project.

Recommendation 2. Expanding the expertise space by taking advantage of the territorial expertise provided by elected representatives, inhabitants, local residents' associations and environmental protection associations.

Upstream of projects, the relationships between operators and local authorities and local residents are generally limited to a small proportion of those involved. The development of projects is generally based on technical and geological expertise as well as the consideration of abstract indicators concerning the local population, urban development and economic aspects. The files prepared by the operators refer to "human environment" or sometimes to "sensitive populations", to "industrial context", without ever trying to understand how these entities may perceive their projects and the way they inhabit the territory in which these projects are to be implemented.

The controversies that arose in certain contexts, particularly in Alsace, highlight the unthought-out aspects of geothermal projects that have not been thought through. The opinions given by local residents' associations, elected representatives and residents during public inquiries sometimes point to proto-expertise, leading to constructive criticism of projects. The insurance coverage of projects, the risks caused by surface installations, the costs associated with connecting power plants to the district heating system, the compatibility of projects with local urban planning, the energy efficiency of cogeneration, etc. are discussed. From this point of view, the public inquiries organized in 2015 can be considered as a place where people express territorial expertise, mobilize a whole range of local knowledge. For example, while it is stressed that none of the sites selected are adjacent to dwellings, residents and elected officials observe that they protrude into living spaces: one of the sites selected is located near a sports facility frequented by associations and schools; another is located near shops, high schools and research centres...

All these factors, which underline the weaknesses of the files submitted by the project managers, are largely taken up by the investigating commissioners when they draft their reports and opinions. And some of the arguments put forward by the proto-experts are taken into account by the prefect during arbitration. In this way, a controversy can become constructive and citizens can contribute to the development of projects. Thus, if this citizens' expertise had been considered upstream, when the projects were not yet almost definitive, it could undoubtedly have led to an enrichment or, at the very least, to a better embedding of the projects in the territory.

In addition to the above examples, the Trias Westland project in the Netherlands cooperated closely with the local community to optimally embed the project in its local environment and to connect it as well as possible with local interests and ambitions. Additionally, local engineers and constructors were employed to build the drilling site.

Recommendation 3. Accounting for the dynamic characteristic of a context

Research in social science and the humanities has shown that a social context is dynamic and continually updated by the actors involved in it as they receive new information (Van Dijk 2008). Stakeholders and members of the broader public *interpret* each of the messages and actions of the developers of geothermal projects. They adapt their position and attitudes toward geothermal energy based on these interpretations, which are strongly dependent on their socio-economic, cultural, linguistic and geographic (rural/urban) backgrounds.

The case studies of Haute-Sorne and Geneva underline the importance of visualizing the context in such a dynamic and reactive way. Although positive or negative pre-conditions that determine the choice of site may exist in certain locations, the way project developers frame a project, the legitimacy of the local actors championing it and the ways in which promoters engage with the local public can considerably influence these conditions. Even when promoters try to communicate and engage with the public, their efforts may be interpreted differently. It is thus crucial to root the communication and engagement processes in a local reality.

In Haute-Sorne, some residents claim that the fact the information meetings were held by the project promoters in the presence of governmental officials during the authorization stage did not ensure their legitimacy. Instead, they would have preferred having the same discussions during a municipal council session where they would have been better able to influence the decision.

A dynamic understanding of the social context implies that it is necessary to also take a dynamic view of communication and public engagement (Krütli et al., 2010): social aspects have to be taken into account throughout the project, and communication and engagement require continuous adaptation. Risk governance frameworks for deep geothermal projects have already integrated an approach that leaves room for deliberative phases throughout the planning process (Trutnevyte and Wiemer, 2017). This deliberative approach during the planning of deep geothermal projects can open up discussions to aspects that might seem beyond the responsibility of project developers. Thus, project developers and policy makers need to integrate geothermal energy as ‘one part of the solution’ in wider discussions about the energy transition. In Switzerland, the GEothermie 2020 programme that was launched in Geneva applies this approach.

2. 2. Political and societal issues

Recommendation 4. Operators and local institutions must be aware that a project may not succeed, whether for geological, political or societal reasons

As evidenced by the French and Swiss case studies, social protest can lead the operator to abandon a project. In France, two projects were abandoned following the organization of legal public consultations. In addition, one of the projects validated by the prefecture has been frozen since 2015 due to an administrative appeal against the prefectural decree. Thus, it appears that some projects may not succeed because of a poor match with the social environment, even if they fulfil all the criteria required by the administration.

Large-scale upstream characterization of the sites, considering it an inhabited/living territory and taking local proto-expertise into account would lead to a better evaluation of the feasibility of the projects. This requires knowing all the dimensions of the territory, whether geological, economic, political, cultural or sociological. It also requires an awareness that a project may fail, not only because the geological conditions are bad or difficult, but also because it is not acceptable to the inhabitants concerned.

Recommendation 5. Local institutions must support projects by providing them with a sufficiently robust political basis.

As shown by our work, unrooted projects have been particularly contested in the public space. On the other hand, projects that included upstream collaboration with local elected officials generated few negative reactions. However, the commitment of elected officials should not be limited to exchanges or transactions with industrialists but should aim to support projects both during the design and development phases and be forward-looking.

This point appeared to be particularly important in the 2015 public inquiries organized in the Eurometropolis of Strasbourg concerning five geothermal projects. The Eurometropolis had engaged in exchanges with operators to define drilling sites. However, at the time of the public inquiries, it was not in a position to present a master plan specifying the role that geothermal energy will play in the city's energy policy. Consequently, no quantified information was provided in the operators' files to measure the cost of such projects to the community. Thus, it is as if the projects were conceived independently of both economic considerations and of the energy policy of the Eurometropolis. While the "Law on the modernization of territorial public action and the affirmation of metropolises" gave the Eurometropolis the status of energy organizing authority, residents and some elected officials criticized its lack of engagement in the issue of geothermal energy.

It was only later, at the end of a study visit to Iceland in 2016, that the Eurometropolis became involved in supporting projects and became a major political actor for the inclusion of geothermal energy in the region.

Recommendation 6. National institutions must provide framework that legitimize geothermal energy, yet allows projects to emerge from - or adapt - to local realities

Current developments and potential changes in federal policies to support geothermal energy in Switzerland show that the federal administration is also learning from what is happening in the cantons and cities. In fact, they probably could do this more systematically, as different contexts call for locally adapted technologies and thus broaden learning at the national scale by multiplying and diversifying such experiments. Although geothermal energy might not contribute to the increase of renewables in the electricity sector to the extent projected by the Energy Strategy 2050 (ES2050), it might become central in reducing CO_2 emissions caused by heating. It is however, still too early to assess the impact of these dynamics.

Our study also underlines the need in federal countries to link federal policies and local realities. Although transitioning the energy system is a political goal that enjoys wide legitimacy through the referendum for ES2050, it does not mean that specific implementation measures and single projects have the same level of acceptance. Federal mechanisms and instruments alone do not appear to be sufficient to render new energy infrastructure acceptable to local populations. Such acceptability is mainly created at the local level by taking contextual factors into account (Ejderyan et al., 2019). Specific federal mechanisms and instruments, such as the federal guarantee that enables the sharing of financial risks among sub-national states, or the ability of states to develop regulations that address local concerns could help make energy projects more acceptable locally.

Finally, in order to systematize learning from bottom-up initiatives and make their experience transferable, the flow of information and coordination between the federal state and the cantons should be improved. This would also enable better tailoring of federal policies to cantonal needs and possibilities. Currently, exchanges take place bilaterally, or informally in events such as the conferences organized by Geothermie-Schweiz. Permanent platforms enabling exchanges between the SFOE, cantonal offices, cities and operators could be set up. These platforms could take the form of commissions or working groups involving representatives of federal and cantonal offices in charge of areas that may be appropriate for the development of geothermal energy as well as representatives of municipalities who have the capacity to develop geothermal projects and operators. Such platforms already exist in other policy sectors, such as the National Platform for Natural Hazards (PLANAT, 2019).

More non-volcanic countries are planning to develop deep geothermal energy in the future, in order to meet Greenhouse gas reduction goals. The Swiss experience will be useful to others. The way the relationships between the national state and subnational levels are organized may vary between countries, but the Swiss experience illustrates the importance of coordinating between the different state levels in order to enable an effective implementation of top-down policies and to scale-up local successes.

2. 3. Communication issues

Recommendation 7. Identifying and informing residents about sensitive points that may involve risks, whether they concern drilling, stimulation or surface installations

Operators should be fully transparent about the pros and cons of projects and the potential impact of projects in all its developmental stages. If they are not, in the event of controversy, criticism may focus on points that were not explained during the first communication campaigns and their credibility may be largely undermined.

Thus, in Alsace, in the Authorization of exploration work files disclosed in 2015, operators present the study of risks and impacts of the projects by focusing on the drilling stages. The finality of the projects and the method of exploiting geothermal heat are only briefly described. For instance, the cost of connecting the geothermal power plant to the urban heating systems is not specified, nor are the risks caused by the heat exchange system to exploit the heat (in particular, the possibility of an accumulation of radioactivity on the surface and the risks related to the use of a highly flammable gas). This lack of information and transparency was often mentioned in residents' opinions during the 2015 legal public inquiries, and this argument was widely echoed by the investigating commissioners.

Recommendation 8. The operators must favor partner-based communication over acceptability communication

As can be seen in the case studies commented here, operators have used different communication approaches, whose effects seem to vary considerably. Thus, it appears that a re-insurance

communication in a controversial situation has only very limited effects. For example, when the public inquiries were launched in Alsace in 2015, the two operators tried to convince the population via an acceptability communication. In practice, these attempts ended in failure or were even counterproductive, especially during public meetings where the reassuring words of industrial stakeholders had only a weak impact or even aroused frank hostility on the part of the inhabitants. Indeed, they considered that thanks to their local knowledge, they were capable of forming their own opinion as enlightened citizens.

Accompanying a project with communication should not aim to gain acceptance, but rather to give people the opportunity to understand to enable them to build their own opinions in an environment that is already full of meaning and knowledge.

The posture of the *Electricité de Strasbourg* operator upstream of the Illkirch project seems more appropriate. Here, the operator played the role of partner. As a local energy supplier, it had a long-standing commitment to partnership relations with municipalities and local institutions. The local roots of the Illkirch project were therefore not only due to the consultations with the city of Illkirch, but also to the fact that it is part of a web of interrelationships between actors involved in a network of public actions. With this acquired legitimacy, *Électricité de Strasbourg* and the city of Illkirch launched a community-based communication process very early in the development of the project. This partly protected the company from the mass of criticism that crystallized in 2015. Indeed, attacks by opponents did not call its legitimacy or operating mode into question but focused on technical aspects.

In 2015, the operator Fonroche, on the other hand, had to respond to numerous criticisms regarding its lack of experience, opportunism and financial fragility. The local discredit that weighed on the company led to the failure of most of its attempts to reassure residents. The public meetings it organized in the municipalities were unproductive. It was only through more concrete actions, in the form of partnerships involving different categories of actors, that the company gradually gained credibility. In 2016 and 2017, it increased its consultations with elected representatives, local companies and the Eurometropolis of Strasbourg, in order to integrate its action in local development policy. Thus, like *Électricité de Strasbourg*, it became a partner in the public action network aimed at the economic renewal of the Vendenheim-Reichstett industrial area.

Recommendation 9. Operators and other stakeholders must take the functioning of the media into account and favour long-term communication as a framework for event-driven communication

Our preliminary observations show that the media treats the field of geothermal energy in a very partial way. Media coverage of projects often ignores information regarding the nature of the projects, economic considerations or the inclusion of the project in the territory. In addition, traditional media often select their sources of information, focusing on institutional, scientific or industrial actors. Thus, they tackle geothermal energy in very general terms, emphasizing the interest of this technology for the community and ignoring the "price to pay" for the implementation of such projects. This is especially visible in the media coverage of projects in France and the UK. In fact, these narratives very rarely meet the expectations and concerns of residents at the site of the project, who, in order to be informed, tend to favor other sources of information.

To better meet the expectations and concerns of residents, operators and other stakeholders should focus on long-term communication by providing the media with more comprehensive information on the technical aspects of projects, their incorporation in a given territory, and the economic, political and territorial objectives to which they respond. The aim should be to provide journalists with the resources they need to grasp the subject from different angles, to build a narrative likely to meet the interests of the public, and to inform them while avoiding confusing, for example, the different types of geothermal energy.

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