

D7.1 Report on Social Acceptance



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LIST OF ABBREVIATIONS

ACRONYM	DESCRIPTION
LDA	Latent Dirichlet Allocation
NLP	Natural Language Processing
ERDF	European Regional Development Fund
LIAG	Leibniz Institute for Applied Geophysics
MRL	Land Use and Building Act (Finland)
MW	Megawatt
CO ₂	Carbon Dioxide
SKEWs	Saisonaler Kristalliner ErdWärmeSondenspeicher
VITO	Flemish Institute for Technological Research

EXECUTIVE SUMMARY

Scope of the deliverable

The objectives of deliverable 7.1 are to examine and enhance community acceptance of geothermal energy by closed loops through an interdisciplinary focus. To this end, analysis of media representation of pilot sites was conducted together with an investigation of the role of key actors in shaping local acceptance. The analysis for the Balmatt site reveals how the traditional media have characterized early deep heat pilot sites and gives an overview of the benefits and technical challenges highlighted in the traditional media. Furthermore, a social media analysis for four European countries (Belgium, France, Germany and Italy) was performed to capture media sentiment trajectories, common themes in the social media discourses.

Furthermore, the HOCLOOP pilot sites were utilized in stakeholder identification and co-creation work. Seven interviews were conducted to understand local context and guide stakeholder identification. Local citizen and community groups in various sites were engaged to understand how they contribute to shape acceptance of HOCLOOP type of innovation at the local level. Within task 7.1, co-creation workshops took place with 60 persons in three countries.

Main conclusions

The analysis of traditional media coverage at the Balmatt site in Belgium revealed a predominantly positive portrayal of geothermal energy, with environmental benefits such as carbon emission reductions and renewable heat supply being frequently highlighted. Economic benefits, including job creation, regional investment, and cost savings, were also commonly mentioned. However, technical challenges such as seismic risks, drilling difficulties, and infrastructure limitations were noted in a significant portion of the articles. Social media analysis across Belgium, Germany, France, and Italy showed similar trends, with positive sentiment dominating but concerns over seismicity and governance issues were also present. Peaks in social media activity were often linked to project milestones or local controversies, indicating the importance of transparent communication and stakeholder engagement.

Stakeholder interviews and citizen workshops provided deeper insights into the perceived benefits and risks of the technology. Participants recognized the potential of deep geothermal energy to contribute to climate goals, improve energy security, and support local economic development. However, they also expressed concerns about high upfront costs, long payback periods, environmental risks during drilling, and the complexity of regulatory frameworks. Social challenges such as unequal benefit distribution, lack of trust, and limited public awareness were also identified as barriers to acceptance.

To address these challenges, the report outlines several strategies for improving social acceptance. These include inclusive governance practices that actively involve local communities in project planning, transparent and tailored communication efforts, and innovative business models that promote community ownership and long-term partnerships. Educational campaigns, media engagement, and certification schemes were also suggested as tools to build trust and raise awareness. The findings emphasize that social acceptance is a dynamic and context-dependent process, and that proactive engagement with stakeholders is essential for the successful deployment of closed-loop deep geothermal energy systems.

1. Introduction

There are approximately 168 geothermal powerplants in operations located across 32 countries worldwide, with the total installed capacity of around 16300 MW (Gutiérrez-Negrín, 2024). The United States is the clear leader in installed geothermal energy capacity, followed by Indonesia, Philippines, and Turkey (Gutiérrez-Negrín, 2024). Italy is the single European Union member country making the top 10 of this list, although there are some relevant geothermal energy plants in operation in France, Belgium, Austria, Croatia, Germany, Hungary, Portugal, and Romania (Gutiérrez-Negrín, 2024). The installed capacity of geothermal energy thus has remained noticeably lower than other forms of renewables, such as solar or wind energy (Li et al., 2015).

In contrast to shallow geothermal energy, which can be accessed at depths of up to approximately 400-500 meters, deep geothermal energy is found at depths greater than this, in some cases reaching as far as 5 kilometers. The deep geothermal reservoirs can naturally provide more geothermal energy due to higher temperatures, but deeper drillings are also more technically demanding and costly (Heidinger, 2010; Soltani et al., 2021). There are two types of deep geothermal energy systems: Hydrothermal systems, which utilize naturally occurring hot water aquifers found at these depths, and Hot Dry Rock (HDR) systems, which require external water injections to exchange the heat. These HDR systems are still much less common but have great potential to enable areas without naturally occurring water reservoirs to tap into deep geothermal energy (Agemar et al., 2014).

One of the central issues that has hindered the scaling up of deep geothermal energy is social acceptance. Although the environmental benefits of the low-carbon energy source are often well-recognized, concerns over seismicity are prevalent, especially around urban settlements (Balzan-Alzate et al., 2021; Knoblauch et al., 2019). The local opposition at the development sites is a recurring issue, significantly contributing to conflicts, project delays, increased costs, and even failures (Kubota et al., 2013; Renoth et al., 2023; Stauffacher et al., 2015; Vargas Payera, 2018).

However, there is a promising new deep geothermal technology that could potentially extend geothermal energy's reach beyond the traditional hotspots, reduce project costs and negative environmental impacts, while enhancing the power production capacity and reliability of geothermal heat: a horizontal closed-loop geothermal system. It is a petrothermal system that uses water or carbon dioxide-based fluids that are injected into deep wells to extract heat from the rock formation (Leontidis et al., 2025). Researchers have found that these closed-loop systems could reduce the risk of induced seismicity (Santos et al., 2022; White et al., 2024), which would indicate that the closed-loop technology could also potentially generate more favorable social acceptance, making it even more promising for scaling up geothermal energy generation.

The purpose of this report is to offer insights on closed-loop deep geothermal energy's social acceptance in the European Union, based on the research work conducted in the HOCLOOP project under the task 7.1. In the project, social acceptance from two viewpoints and temporal perspectives were studied: the development of social acceptance in the past 10+ years in the media, and the anticipated social acceptability of the new closed-loop technology among various stakeholders.

The media focused research investigated the sentiments around geothermal technology currently in use in different traditional- and social media outlets, and how this media has influenced social acceptance. Whereas traditional media often presents institutionalised narratives from established outlets, social

media captures diverse, unfiltered expressions from citizens, stakeholders and opinion leaders. Social media platforms have become an important arena for public discourse, shaping opinions and influencing perceptions about topics of social relevance, which makes it an especially valuable source of data for understanding prevailing public sentiments and social engagement. It can offer an opportunity to gain a deeper understanding of which arguments gain traction, how trust or scepticism shapes over time, as well as whether any of these are linked to outside events.

With stakeholder perception focused research, we strived to better understand the potential new social acceptance matters related to the application of the new closed-loop technology. Foreseeing the potential issues and understanding the strengths from various stakeholders' points of views can enable developers and policymakers to more proactively address these concerns and lay the foundation for creating a positive sentiment around deep geothermal technology. The combination of approaches ensures gaining a comprehensive understanding of the socio-political environment surrounding deep geothermal in general and the new closed-loop system in particular. This can help identify grounds for communication, engagement and policy making that support inclusive and informed decision making.

2. Social acceptance

2.1 What is social acceptance and why is it important

Social acceptance refers to the extent to which new technologies, infrastructure, policies or frameworks are perceived as legitimate, desirable or appropriate by individuals, communities or societies at large. It is critical in determining whether an innovation can successfully progress from research and development to widespread adoption and use. Social acceptance is important in the context of emerging technologies and novel solutions, as it provides insights into the extent to which the community and stakeholders are willing to embrace the solution and determine whether it can sustain in an environment with the incumbent technologies.

In the context of energy technologies, social acceptance becomes even more important since many of these technologies are disruptive in nature. Their adoption often requires changes in existing infrastructures and market arrangements but also changes in consumer behaviour and practices. While many renewable energy technologies promise clear socio-economic benefits, which may be in the form of reduced emissions, optimal use of indigenous resources, reduced long-term costs and new business opportunities, they may also generate concerns or opposition at the local level. In such situations, social acceptance captures people's willingness to support, adopt or at a bare minimum do not actively resist the deployment of a technological solution. A lack of acceptance can halt technological development, decelerate the adoption, or diminish the value these innovations might otherwise deliver to the systems and consumers, despite all the support it would receive from policies and regulatory systems.

A key feature of social acceptance is its dynamic nature. It is not a static, one-off condition, but rather an evolving process that changes over time as people gain knowledge and understanding about the technology, develop trust, and experience the impacts of technology on their daily lives. Acceptance can also shift across different stages of a technology or project's life cycle. From planning and permitting to construction, operation and eventual decommissioning. In practice, this underscores that energy projects should be grounded in principles of fairness and participatory governance. These include open

communication, meaningful community engagement, and opportunities for co-creation to ensure stakeholders remain informed, engaged and committed to collaborative problem solving.

Social acceptance is a fluid concept with multiple definitions and interpretations. A commonly used conceptualisation distinguishes three dimensions: socio-political acceptance, community acceptance, and market acceptance (Wustanhagen et al 2007). Socio-political acceptance refers to the support at the broader societal level, including the alignment of policies, regulations and overall technological pathways to facilitate the development and deployment of technological solutions. Community acceptance relates to the people and public in general. It reflects their willingness to accept or resist projects in their surroundings, often influenced by the perceived benefits or burdens of the projects. Market acceptance focuses on the overall appreciation of consumers, investors and businesses to adopt, finance and support innovations, impacting their competitiveness and scalability.

The level of social acceptance is also shaped by a variety of contextual and perpetual factors. These include the value proposition of the technology (environmental offerings, cost savings, ease of use), trust in institutions and project developers at the local level, the perception of fairness in the decision-making processes and the distribution of benefits and costs and the perceived risk or reward the use of the technology entails. Taken together, these factors highlight that social acceptance is not merely an external consideration but a decisive determinant in successful technology diffusion. Without it, a technically advanced and viable solution may face obstacles and fail to gain the success it deserves.

2.2 The social acceptance of deep geothermal

Social acceptance of disruptive technologies becomes even more challenging and essential if they are to gain a foothold in the markets. Historically, the diffusion of renewable energy technologies has often been slower than expected due to a range of socio-economic, technical and regulatory challenges (Shakeel et. al., 2017). Geothermal energy is one such technology that holds huge potential. It taps into heat stored within Earth and harnesses this for heat and power generation. Deep geothermal, an advanced form of the technology, extends the capabilities of conventional geothermal by accessing the heat reservoirs several kilometres below the Earth's surface. This allows reach out higher temperatures for largescale, continuous energy for electricity generation and heating in areas that offer suitable geological conditions.

Compared with other renewable energy sources, geothermal energy offers several unique advantages. Unlike wind or solar, which depend on weather conditions and often require backup solutions to ensure an uninterrupted supply, geothermal ensures stable and around-the-clock energy regardless of the time or weather. Deep geothermal systems can achieve capacity factors exceeding 90%, making them comparable to conventional baseload power plants. In addition, geothermal often requires minimal land, has relatively low ecological impacts and offers superior thermal efficiencies. Harnessing the Earth's internal heat for both power and heating makes geothermal a reliable, stable and low-emissions energy source that can strengthen energy security, ensure autonomy, diversify the energy mix and accelerate transitions towards a clean energy future.

However, despite numerous benefits, widespread adoption of deep geothermal energy remains relatively limited. A comparative study conducted by Evans et al. (2009) ranked various renewable energy technologies based on several sustainability indicators. The findings highlight that geothermal energy was ranked the least accepted compared to the others, while wind energy ranked the highest. Similarly, Dowd et al. (2011) and Kubota et al. (2013) found that public awareness of geothermal energy among the general public is markedly lower than other power generation technologies, including hydrocarbons, nuclear, hydro,

solar and wind energy. These findings highlight that despite strong technical, economic and environmental potential, its societal perception and visibility lag behind other conventional and renewable technologies, making social acceptance a decisive factor if the technology is to be successful.

Limited knowledge and awareness reduce the support and make it vulnerable to opposition. In addition, deep drilling is often associated with concerns regarding induced seismicity, noise, risk to groundwater, and in some instances small earthquakes. Similarly, the distribution of benefits and costs further complicates social acceptance. The benefits, in terms of uninterrupted supplies, access to clean energy and overall improved environmental conditions, are often enjoyed regionally or nationally. However, the burdens and risks are often borne by those living close to the project sites. The concerns related to cost versus benefits and risks versus rewards induce reluctance and induce instability in widespread adoption. This overall situation complicates the widespread adoption and social acceptance of geothermal.

It, therefore, becomes critical to address these challenges and overcome barriers that cloud geothermal development without broad social acceptance, project risk delays, cancellation, stagnation or rejection from the local community. An open and transparent communication becomes essential, followed by a fair benefit sharing and inclusive community engagement to ensure deep geothermal technology moves beyond a technological solution with the potential to become a widely accepted and used solution that plays a significant role in the future energy transition.

3. Research methods

To study the social acceptance of deep geothermal energy in a comprehensive manner, we applied three different research approaches within Task 7.1 of the HOCLOOP project: 1) traditional media analysis, 2) social media analysis, and 3) stakeholder perception study. Traditional and social media analysis can shed light on how deep geothermal technologies have been portrayed in the media and how their sentiments have evolved over the years. This can offer important insight into how public opinion is formulated. Through a stakeholder perception study based on interviews and co-creation citizen workshops, we can directly get the opinions of actors potentially or directly involved or influenced by deep-geothermal projects.

3.1 Case selection

In the first phase of HOCLOOP T7.1, we explored the potential cases for the social acceptance study. The Balmatt site in Belgium and the Lichtwiese site in Germany formed the starting point for the case study, as these sites were identified already in the project preparation phase. Early in the exploration phase, we saw that we can increase the impact of the work carried out in T7.1 by broadening the focus and by including other sites and locations. For the final case selection, the aspects of stakeholder accessibility as well as the potential for development of future deep-geothermal sites were also considered. In addition, we stressed the responsible research and innovation principle of responsiveness, i.e. the ability to adapt to and make decisions influenced by local societal needs in the existing deep-geothermal sites of Balmatt and Lichtwiese as well as potential future sites in other European locations. Next, we will provide a short overview of all the selected cases. More detailed descriptions of the cases with existing geothermal projects can be found from the HOCLOOP deliverable D4.1.

The Balmatt geothermal plant in Mol, Belgium includes three deep geothermal drillings, one of which is a vertical production well at 3610 m and two deviated wells at 4341 m and 4905 m. Eventually, the second

well at 4341 m was used as the injection well, as the third drilling at 4905 m proved to be insufficient and was thus used only for research and monitoring purposes. The geothermal system is connected to a local district heating network, which provides heat to offices, a nuclear waste processing company, and a nuclear research institute. When the demand for heat is low in the network, the plant is able to switch to electricity generation. The plant was developed by a cleantech and sustainable development focused research organization VITO and it was strongly supported by the local Flemish government that provided it with a 2-million-euro subsidy in 2014. The project has faced several challenges, particularly in the drilling phase, e.g., dry wells, as well as seismic activity that triggered a temporary shutdown of the plant. The first signs of seismic activity were recorded already in 2015 during the first drilling, but a larger earthquake of 2.1 magnitude in 2019 actually led to a full shutdown of the plant in for nearly two years. The plant has since then been restarted after the development of more advanced management and monitoring systems that can respond to the new seismic activity.

Lichtwiese campus in Darmstadt, Germany is a promising potential site for new deep geothermal drillings. There, the Technical University of Darmstadt's is seeking to decarbonize the district heating and cooling system of its Lichtwiese campus. Currently, there are already three borehole heat exchangers operating at the depths of 750 m at the Lichtwiese campus to demonstrate the concept of a medium deep borehole thermal energy storage system. The HOCLOOP project has assessed different options for integrating a deep geothermal closed-loop system into this district heating system.

In Italy, the HOCLOOP project has focused on three potential pilot sites for deep geothermal: **Gargano**, **Gavorrano**, and **Monte Amiata**. Gargano is located in Southern-Eastern part of the Apennines, whereas Gavorrano and Monte Amiata are both in the Northern-Western Apennines. These areas have been identified for further study because they all present diverging geological settings. Monte Amiata is located close to an active geothermal field, which produced approximately 35% of the regions' electricity with its 954 MW installed geothermal capacity. Gargano and Gavorrano do not have existing geothermal fields in close proximity, but Gavorrano is an old abandoned mining area with lots of existing geological data.

The Parisian basin in France has a long history of geothermal energy projects. The exploitation began in 1969 and today the area has the highest density of geothermal doublets (multiple well closed systems) in the world. The project has faced several challenges in trying to target both deeper and hotter, and shallower new reservoirs. There is thus a need to consider new technological solutions, such as closed-loop deep geothermal, in the region.

Finland, unlike the other cases, is not directly linked to specific deep geothermal pilots in our research, but it was chosen for the social perception study to extend the geographical scope of the investigation. Finland's ambitious climate targets and heavy reliance on district heating make deep geothermal energy a potentially valuable addition to the national energy mix. However, as a relatively novel technology in Finland, deep geothermal development is in early phases and faces several uncertainties that influence deployment. Finland presents a particularly relevant context for studying social acceptance as municipalities and local stakeholders are typically involved in energy decisions via institutionalized processes such as compulsory environmental impact assessment. Citizens generally exhibit high trust in institutions, and cultural values linked to nature and land use may shape how projects are viewed. Understanding acceptance across citizen groups in Finland can provide valuable insights for understanding common bottlenecks in large-scale renewable energy deployment and how citizen engagement is linked to just transition outcomes in high-trust, well-governed societies. Table 1 summarizes the overview of the selected cases, data collected, and use.

Table 1: Overview of the selected cases, collected data, and the research they were used in.

Case	Traditional media analysis	Social media analysis	Stakeholder perception study	
			Interviews	Co-creation citizen workshops
Balmatt – pilot site in Belgium	81 news articles	1	4 interviews (1 person in each)	-
Lichtwiese - pilot site in Germany	-	1	1 interview (2 persons)	1 workshop (17 participants)
Gargano, Gavollano & Monte Amiata - pilot sites in Italy	-	1	2 interviews (1 person in each)	1 workshop in Florence in connection with Monte Amiata (12 participants)
Parisian Basin - pilot sites in France	-	1	-	-
Finland – no connection to specific pilot developments	-	-	-	2 workshops (31 participants)

3.2 Identification of stakeholders

The identification of key actors and stakeholders has been fundamental in assessing social acceptance of the geothermal technology. As the widespread adoption and acceptance of a technology is influenced by a number of socio-economic, technical, and regulatory factors, it is essential to gather input from a broad spectrum of actors and stakeholders. This ensures a comprehensive understanding of the situation, incorporates the voices of all relevant players, and helps prevent the exclusion of important perspectives. The inclusive and comprehensive approach also provides the basis for designing appropriate measures that can address concerns, enhance transparency and foster acceptance.

To ensure that the relevant stakeholders were identified and included, we adopted a systematic and iterative approach. The process began with the identification of key actors at each pilot site, facilitated by the HOCLOOP project partners. Since the project partners have an established presence and local knowledge of their respective sites, they were well-positioned to identify influential and relevant stakeholders, including commercial actors, public administration, international collaborators, citizens, and representatives of local communities. This initial mapping provided a robust foundation for further exploration and guided subsequent steps for stakeholder engagement.

Once the engagement with these initially identified actors commenced, we employed a snowballing approach by asking respondents to suggest additional relevant actors who should be considered in the study. This method proved particularly helpful in uncovering less visible or informal stakeholders, thereby ensuring that their perspectives also receive recognition. This iterative process ensured a gradual mapping of the stakeholder landscape.

The process continued until all relevant actors were identified, resulting in a comprehensive set of stakeholders for the subsequent phases of the study, including interviews and co-creation workshops. The process was applied consistently across each site, which not only ensured comparability but also allowed

for the consideration of local specifications. As an example, the stakeholders and their roles in the Balmatt site are listed in Table 2.

Table 2: Overview of the stakeholders identified for the Balmatt site.

Name	Stakeholder Group	Description and relation to the project
Vito	Research	Vito is an independent research organization based in the Flemish region, working on cleantech and sustainable development. Vito is the primary stakeholder actively involved with the development of the first deep geothermal plant in Flanders and researching the potential of deep geothermal energy in the region.
Hita	Developers	Hita is a VITO spin-off that is actively involved with the development of geothermal energy projects in the region.
Flemish Government	Polymakers	The Flemish government provides critical regulatory support, policies, and financial support to the deep geothermal energy projects in the region.
Local Residents of Mol and Dessel	Local Citizens	The biggest stakeholders of the project are the residents as deep geothermal energy extraction will impact their environment and the benefits of geothermal energy will impact their quality of life, so their interest is high, even if their influence is lower.
Janssen Pharmaceutica	Industry	Janssen Pharmaceutica is a local company which has invested in the deep geothermal project. It aims to significantly reduce CO2 emissions by using geothermal energy to heat its premises.
European Union	Polymakers	The EU is providing substantial financial backing by investing and co-funding 5 million euros in the HOCLOOP Deep geothermal energy project. It also provides funding and policy oversight through programs like the European Regional Development Fund (ERDF).
Smet	Industry	Smet is a drilling company. As one of the major concerns with deep geothermal energy is the drilling at such unprecedented depths, drilling companies like Smet play a technical role in the project with drilling expertise but have limited interest beyond their contract fulfilment.
Belgoprocess	Industry	A nuclear waste processing company. Involved due to its role in nuclear waste management and energy nearby the geothermal plant.
Voka Kempen	Industry	Voka is a network of entrepreneurial companies in the region that are supporting the development of deep geothermal energy in the region.
European School (Mol) & Thomas	Research	Local vocational and educational institutions. The deep geothermal energy project brings more jobs and learning opportunities for the students in the region.

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3.3 Data collection and analysis

3.3.1 Traditional media study

The traditional media analysis is based on a dataset of 81 media articles related to the geothermal energy project in Belgian Balmatt, during a monitoring period from 20.10.2011 to 27.7.2021. Roughly half of these articles were published in the regional print media, 41 to be exact. The rest of the articles were from national print media (n.18), digital-only outlets (n.12), television (n.3), radio (n.5), and institutional press releases (n.2). The article database was collected with the support of Auxipress media service platform.

As the articles were mostly written in Dutch, we used an artificial intelligence based DeepL translation service to translate all the content into English. A Dutch native speaker manually checked all the translations before the start of the analysis.

Then, we performed a sentiment analysis and topic-based modelling on these articles with an artificial intelligence-based multimodal large language model GPT-4. Beyond understanding the general sentiments towards deep geothermal, the topics of our interests included the benefits and challenges of deep geothermal, and the key stakeholders related to these developments. For this purpose, we presented GPT-4 a list of analytical questions and commands based on which to perform the analysis. The analytical questions and commands are presented in detail in Table 3. The accuracy of the AI to perform these modelling tasks was tested with supplementary manual reviews.

Table 3 3: List of analytical questions and commands.

1. Analyze the overall sentiment of the article text towards geothermal energy. The categories are Negative, Neutral, Positive.
2. Does the article mention opposition to geothermal energy (e.g., local stakeholders rejecting the technology)? If yes, what reasons are given?
3. Are seismic events (e.g., earthquakes, tremors) discussed in the article? If yes, what is said about them?
4. Does the article mention any failures, setbacks, or cancellations of geothermal initiatives? If yes, summarize the information provided.
5. List the economic benefits of geothermal energy mentioned in the article.
6. List the environmental benefits of geothermal energy mentioned in the article.
7. List the social benefits of geothermal energy mentioned in the article.
8. What technical limitations or challenges (e.g., drilling risks, resource variability) are discussed?
9. Does the article refer to financial instruments or incentives (e.g., government subsidies, public funding)? If yes, what details are provided?
10. What is said about the future potential of technology?
11. Identify the key actors mentioned in the article.
 - o *Sub question categories searched included: Journalists, Researchers, State actors, Judicial actors, Municipal actors, Landowners, NGOs, Entrepreneurs, Indigenous communities, Local Communities, and Individuals

3.3.2 Social media study

The data collection was carried out on the widely used social media platform X (formerly Twitter). X is particularly suitable for this type of analysis for several reasons. In addition to X, we also explored other widely used social media platforms like Facebook and LinkedIn to incorporate discussions related to geothermal energy and sustainable energy sources. However, these platforms yielded significantly lower relevant posts, and the content largely overlapped with what was already found on X. Given these constraints, X provided the most suitable balance of accessibility, relevance, and diversity of perspectives. For these reasons, we choose to limit our primary data collection to X.

The data collection was carried out using keyword-based queries carefully designed to capture discussions relevant to geothermal energy. Given the diversity of regions and languages, we tailored our search query to ensure the inclusion of discussions in the local languages, regions and contexts. To achieve this, a string of keywords included general words to ensure the maximum number of hits relevant to the topic. The string also included the names of regions or terms in local languages, where these geothermal sites were based, to ensure maximum coverage of the relevant discourse. Specifically, individual keywords were developed for each case to incorporate local language, place, names, and project-specific terminology. In principle, we paired the term ‘geothermal’ with the names of the project pilot sites, both in English and in the respective national languages for each case. This bilingual approach broadened the scope of data collection, allowing us to capture a comprehensive spectrum of discourse around the cases. Table 4 presents a full list of keywords used for each selected case.

Table 4: Keywords used for the selected cases.

Case	Keywords Used
<i>Balmatt, Belgium</i>	Vito and geothermal, Vito and geothermisch, Vito and géothermique, Mol and Geothermal, Mol and geothermisch, Mol and géothermique, Balmatt and geothermal, Balmatt and geothermisch, Balmatt and géothermique,
<i>Lichtwiese, Germany</i>	Darmstadt and geothermal, Darmstadt and geothermie, Lichtwiese and geothermal, Lichtwiese and geothermie
<i>Parisian basin, France</i>	Dogger and geothermal, Trias and geothermal, Cretaceous and geothermal, Dogger and géothermique, Trias AND géothermique, Cretaceous and géothermique
<i>Italy</i>	Gargano and geothermal, Gavorrano and geothermal, Monte Amiata and geothermal, Gargano and geotermica, Gavorrano and geotermica, Monte Amiata and geotermica

Once the data was gathered, the next step involved extracting useful insights and preparing the analysis. The first step involved identifying the main themes and topics discussed in the social media posts. This thematic exploration helped us to categorise the discourse and the breadth of public conversation on geothermal projects. This allowed us to distinguish between supporting narratives such as opportunities and benefits (e.g. economic growth, emission reductions, energy security, and positive externalities), and narratives emphasising risks and concerns (e.g. geological risks, environmental challenges and safety issues) associated with the project. The categorisation clarifies the picture of how the current and potential socio-economic, technological and environmental impacts of geographical projects are framed by different actors and stakeholders. This set the foundation for more systemic, in-depth analysis of public sentiments and the overall contexts in which these projects are being discussed.

To delve deeper into the topics and extract insights from social media data, we also conducted sentiment analysis. Sentiment analysis is a method that employs Natural language processing (NLP) to identify and categorise opinions expressed in the text into three main categories: positive, negative or neutral. The approach is also referred to as subjectivity analysis or opinion mining (Drus & Khalid, 2019).

In social media research, sentiment analysis is often applied to tweets, posts, or comments to understand how people feel about the topic under discussion. It offers a practical and cost-effective method for analysing extensive datasets, while applying uniform criteria by providing immediate insights into public attitudes. In practice, it involves polarity classification (categorising contents as positive, negative or neutral), emotion detection (identifying underlying emotions in the form of trust, fear, optimism, anger, or excitement), and context interpretation (considering hashtags, emojis or keywords that influence the tone of the message).

The value of sentiment analysis lies in its ability to help researchers and decision makers to understand public attitude, level of support and areas of concern. For example (Aftab et al, 2023) used sentiment analysis to assess people's perception of political candidates during elections, enabling predictions of potential outcomes.

We identified the common themes and emerging topics in the dataset using topic modelling. Topic modelling is a computational approach for automatically uncovering the hidden themes or topics in a large collection of text. Specifically, we incorporated Latent Dirichlet Allocation (LDA), a widely used statistical technique that assigns probabilities of topics to documents and probabilities of words to topics. As a data-driven approach, LDA is particularly beneficial in fields like communication, as it enables the identification of themes within large collections of text with ease, offering a faster and scalable alternative compared to manual analysis (Maier et al, 2018).

In the context of social media analysis, LDA is well-suited for examining tweets to uncover the dominant themes without requiring a line-by-line reading of every single post. In this method, each topic is characterised by a distribution of words, while each tweet is represented as a distribution of topics. This probabilistic approach enables the identification of explicit issues as well as underlying concerns embedded in the data.

We used AI (ChatGPT-4) for this study to perform the topic modelling process. After the modelling was completed, the next step involved systematic interpretation of the results and the identification of the main themes. The thematic analysis provided deeper understanding of insights into people's perceptions, expectations, and concerns regarding deep geothermal technology.

3.3.3 Stakeholder perception study

The stakeholder perception study was based on a series of interviews and workshops at various locations (see Table 5 for more details). Interviews with key stakeholders were conducted specifically to provide more contextual information about the existing geothermal pilot projects and related key stakeholders and to collect some preliminary insight into the social acceptance matters that should be investigated in more detail. Thus, they provided some background knowledge for designing the citizen co-creation workshops. Overall, we conducted seven interviews at three deep geothermal project locations as a part of the T7.1 work. All interviews were recorded and transcribed.

Table 5: Interview details.

Related project	Number of interviews	Role of interviewees and their organization	Duration	Interview mode
Balmatt, BE	4	Research coordinator, Vito	58 min	In person
		Citizen engagement, Vito	51 min	Online
		Citizen engagement, Vito	47 min	Online
		Project engineer, Hita	44 min	Online
Lichtwiese, DE	1 joint interview	Project researcher, TU Darmstadt	63 min	Online
		Scientist, TU Darmstadt		
Bari, IT	1	Scientist, University of Bari	45 min	Online

We also carried out four citizen co-creation workshops. (90 to 135 mins each). Three of these workshops took place face-to-face in the following cities: Vaasa in Finland (18 participants) in August 2023, Darmstadt in Germany in November 2023 (17 participants), and Florence in Italy (12 participants) in June 2025. In addition, we arranged a virtual workshop targeting a Finnish audience in June 2025. In total, 60 participants attended the workshops. All the workshops were recorded and transcribed, and additional workshop notes by the workshop facilitators were also used for the analysis.

The point of departure in the selection of workshop locations was the HOCLOOP partnership and accessibility to contexts allowing arrangements of citizen co-creation workshops. One of the workshops was arranged as a part of a larger open event in Vaasa, Finland targeting citizens, policy makers, industry and companies as well as governmental actors. The other three workshops were carried out in close collaboration with HOCLOOP partner universities, and the participants were primarily students, PhD students and researchers. The setup in all workshops was guided by the aim of gathering citizens' perspectives on selected topics. The collaboration with local HOCLOOP partners was crucial to engage participants with a strong interest in local geothermal development.

The workshop format included an introduction of about 30 minutes, which explained the aims of the workshop. This introduction also provided an overview of the technology and local energy needs, to contextualize the HOCLOOP technology in the local setting. After the introduction, participants were divided into three groups. The discussions took place in a world café format, with three tables covering different topics: participation and regulations, benefits and drawbacks, and long-term perspectives.

Each round of discussion at a table lasted about 20 minutes, after which the groups rotated and built upon the inputs from the previous group. After three rounds of discussion, the workshop continued with a plenary session in which the contributions from all groups were discussed and complemented. The organizers then summarized the findings and explained the next steps, including further engagements with stakeholder groups in other project pilot sites. The discussions at the world café tables were recorded and later transcribed.

After the data collection, we then applied thematic analysis to investigate reoccurring themes among the samples. This analysis was conducted partially with qualitative data assessment software NVivo15 and partially with manual methods. NVivo15 was used specifically to analyze the risks and challenges of deep geothermal technology, whereas the themes of associated benefits and ways to improve social acceptance

were extended later on through additional manual analysis. In Nvivo15, we predefined a coding framework according to which the data was organized into themes. These codes included: social risks, economic risks, environmental risks, risk perceptions, acceptance and support, and mitigation strategies.

4. Media analysis

4.1 Traditional media study

The traditional media analysis of the social acceptance related to geothermal energy was conducted around a specific geothermal heat drilling site in Belgium. The results of this work were mainly aligned with earlier research based on interviews, whilst also indicating some interesting, underexplored factors behind the construction of social acceptability. The traditional media analysis has been presented more thoroughly in an upcoming research article “Harnessing a Large Language Model to analyze Media Discourse: Insights into Social Acceptance of Deep Geothermal Energy in Mol, Belgium” by Anis & Juntunen (forthcoming).

The general sentiment towards geothermal heat in the explored sample of 81 newspaper articles written about the Balmatt plant from 2011 up to 2022 was positive, with 76% of the articles having a positive tone while only 9% a negative one. In addition, 15% of them presented a neutral stance. These results indicate that there was only minimal opposition or concern regarding the plant in the overall media landscape. The recurrent words in the positive and negatively toned articles are presented in the word clouds in Figure 1.



Figure 1: Word clouds describing the terms associated most often with positive and negative sentiments. The larger the text, the more frequently it was found in our data.

A further sentiment assessment revealed that the media coverage had become more positive over time and was often linked with substantial project milestones. The (positive) media attention spiked in 2014 to 17 articles after the Flemish government awarded the project a 2 million euros subsidy and peaked at 28 articles the following year when the first exploration drilling was completed. These articles focused on covering the encouraging results of the exploratory drilling, which foresaw that the plant could potentially become the largest one in Western Europe, employ up to 2000 people in the region, and substantially reduce carbon emissions. At the same time, however, there were five articles that took a more cautionary stance towards the plant and its potential impacts in the region. The period of the most negative media attention collided with the shutdown of the plant due to the seismic activity, but even then, only three

articles opted for a negative stance towards the development. The positive media attention spiked slightly again in 2022, after the development of the new systems to manage and monitor the seismic activity that led to the re-opening of the plant. The complete timeline of the articles is presented in Figure 2.

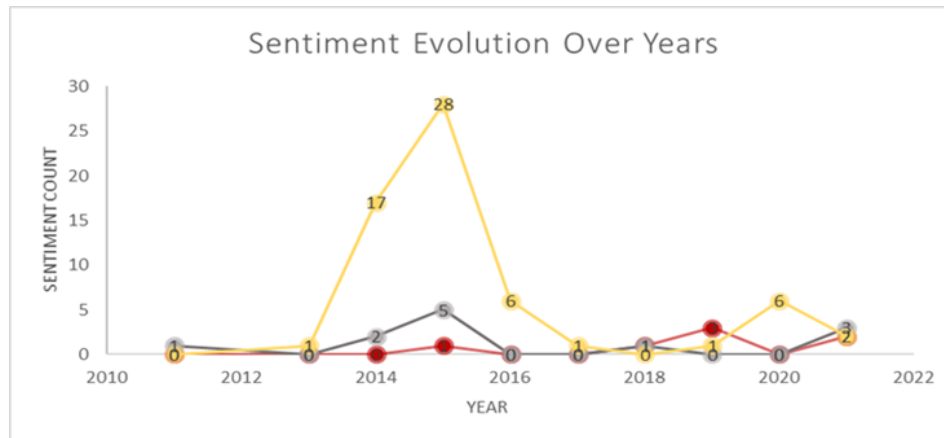


Figure 2: A graph illustrating the evolution of the sentiment in traditional media outlets throughout the years.

A closer exploration of the positive impacts associated with geothermal heat in these articles revealed that environmental matters such as reduction in carbon emissions and renewability were the most commonly mentioned impacts – with 70 out of 81 articles mentioning them. The economic impacts such as job creation, investments in the region, government financing, cost efficiency, and energy savings were mentioned in 64 articles, whereas the social benefits of the geothermal plant – providing low-carbon, local heat and electricity to the local communities, and contribution to research, education, and innovation, were mentioned in 63.

In addition to highlighting the benefits of deep geothermal technology, 23% of the articles also brought up technical challenges related to such deep geothermal drillings, such as drilling to such unprecedented depths requires specialized equipment and there is uncertainty related to whether the water temperature is high enough for electricity conversion. Other technical challenges included the risk of earthquakes and other seismic activity related to the drillings, as well as managing the water flow to such deep reservoirs. A summary of all the positive impacts and technical challenges associated with geothermal heat identified by our study are presented in Tables 5 and 6.

All the results presented thus far are quite well aligned with the findings from earlier research. However, our study also revealed some new perspectives. First, we found that there was a notable difference in how the media discourse evolved after the seismic event in our Belgian case in contrast to a case study conducted in Switzerland (Stauffacher et al., 2015). There, a seismic event resulted in a spike in media coverage and the whole reporting remained fixed on risks from thereon, whereas in our case the media narrative quite quickly balanced out and bounced back towards a more optimistic sentiment after the earthquake. This is not to say that the Belgian media ignored the risks from seismicity but rather focused on reporting the potential solutions that were being developed to mitigate them, obtaining a more optimistic tone. Second, our assessment also identified some technical and logistical challenges that may contribute to negative sentiments, which have not been recognized in earlier studies. These challenges included, for example, setting up a heat network, laying pipes, and ensuring consistent pricing for the residents.

Overall, we contemplate that the continuous media favorability contributed towards rising public support for the geothermal drillings in Belgium, together with several public and private financial schemes that have strengthened the publics' trust in geothermal heats' market potential.

Table 6: Overview of the benefits highlighted in the traditional media.

	Identified benefits	N. of articles	Exemplary Quotes from the articles
ECONOMIC	Investment & Financing	34	"Our country's largest pharmaceutical company, Janssen Pharmaceutica, is investing 40 million euros over the next two years in a 100 per cent green energy source for heating and cooling its site..." <i>De Standaard, 14 July 2017</i>
	Job Creation	11	"The new technology could also boost employment in the economically troubled Kempen region. An Idea Consult estimate suggests 2000 jobs in direct employment, possibly more if new companies cluster around geothermal power plants." <i>De Standaard, 15 September 2015</i>
	Cost Efficiency & Energy Savings	12	"Over a 20-year period, a power plant should be able to make an average profit of about 10%, possibly even more. The end user's energy bill should be able to come in up to 20% cheaper." (Dirk Fransaer of VITO). <i>Duurzaamheidskrant, 1 October 2015</i>
ENVIRONMENTAL	Carbon Emission Reduction	20	"While it is not easy, or cheap, the development of deep geothermal energy is a promising domain in the struggle to develop CO2-neutral energy supplies. "Especially when it comes to heating, which makes up about half of our energy consumption," says Ben Laenen, who leads the deep geothermal energy project at VITO." <i>Flanders Today, 14 September 2019</i>
	Renewable and Sustainable Energy Source	37	"Geothermal energy is cheap, sustainable, and always available," says VITO manager Geert De Meyer. "In contrast to wind or solar, geothermal is not dependent on conditions." <i>Het Belang van Limburg, 15 September 2015</i>
	Efficient Water Usage	7	"VITO's geothermal survey pumps red-hot water from a depth of 3.5 kilometers and injects the cooled water back into the subsurface after use (for heating buildings)." <i>Gazet van Antwerpen, 20 April 2021</i>

SOCIAL	Heating and Powering Local Homes & Businesses	30	<p>“By October 2016, the first heating could be delivered and used. VITO estimates that 15000 families around Mol and Dessel could eventually benefit from this.”</p> <p><i>De Morgen, 15 September 2015</i></p>
	Education & Research Collaboration	11	<p>“The Flemish Institute for Technological Research (VITO) in Mol will restart its geothermal research, which allows buildings to be heated with water from deep underground, on Monday. Researchers now want to spend a year adjusting the pressure under which they inject the water they’ve pumped up back deep underground.”</p> <p><i>Gazet van Antwerpen, 20 April 2021</i></p>
	Sustainable Energy for Social Progress	16	<p>“Green heat remains the poor relative in our renewable energy policy to date. Until today, it remained unclear how the government intends to green our heat demand. Geothermal energy now seems to have the potential to contribute to this.”</p> <p><i>De Standaard, 19 April 2021</i></p>

Table 7: Overview of the technical challenges highlighted in the traditional media.

Technical Challenges Identified	N. of articles	Exemplary Quotes from the Media Articles
Challenges associated with deep drilling and the specialized technology required	19	<p>“Last week, VITO had to stop its first test drilling for scalding hot water at a depth of about four kilometers. The THV Balmatt Drilling specialists’ drill bit got unexpectedly stuck at a depth of 3143 meters. VITO will probably just leave the drill bit in place. It got stuck due to the instability of a geological layer,” according to Dirk Fransaer.</p> <p><i>Gazet van Antwerpen, 30 November 2015</i></p>
Efficient water management	5	<p>“At exactly five past nine this morning, the towers drilled the very first centimeters. In three months, the first 3.5 kilometer deep hole should be ready through which hot water can be pumped. This will immediately be followed by a second drilling, to ensure that the water can be returned underground. They’ve been preparing for this moment for five years, and it should determine whether or not all the theoretical preparatory work has been in vain.”</p> <p><i>rtv.be, 14 September 2015</i></p>
Seismic concerns due to geothermal drilling and	10	<p>“VITO started its own geothermal project at its site in Mol, but the plant was shut down almost a year ago after a slight, albeit</p>

<p>reinjection activities</p>	<p>palpable, earthquake." ... "We've conducted a thorough analysis on this and listed where we need to make adjustments in order not to cause any more palpable earthquakes." (Ben Leanen, VITO Researcher)</p> <p><i>Het Belang van Limburg, 16 April 2020</i></p>
<p>Infrastructure and logistical problems, especially related to setting up heat networks</p>	<p>9</p> <p>"But things went completely wrong during the construction of the above-ground installations, and in particular the connection of the wells to the plant. The pump installation to bring up the almost 130 degree hot water doesn't work. And that's while VITO's installation company Engle Fabrcom for the pumps and the connection to the geothermal power plant has already gone 2.2 million over budget on the original tender of 7 million euros,"</p> <p><i>Franssaeradded. De Standaard, 16 October 2018</i></p>
<p>Water temperature for electricity production</p>	<p>7</p> <p>"The intention is to build one or two geothermal power plants depending on the results of the measurements. If it turns out that the underground structure near Dikberd (business zone in Herentals, ed.) is ideal, we can pump hot water to heat the residential areas on the edge of the city-center. Or if drilling is more appropriate on the Olen side, we can supply heat to businesses and village neighborhoods. 70 degrees is just not hot enough for industrial processes, let alone to produce electricity, but is ideal for district heating."</p> <p><i>Gazet van Antwerpen, 17 December 2020</i></p>

4.2 Social media analysis

4.2.1 Volume of tweets

The analysis of the tweets volume shows the number of tweets collected, over what time frame and highlights whether and when activity peaked, declined or remained relatively stable across project sites. Presenting the scope and scale of the dataset provides a deeper understanding of when public attention was the highest and what external events may have triggered spikes in activity to help contextualise public engagement with geothermal projects.

The results show that the platform X activity varied significantly across years and locations, reflecting similarities and differences in local contexts, project milestones and external drivers. The following picture shows the number of tweets related to the pilot CAA location over time. The following sections provide a more detailed analysis, focusing on individual geographical locations to explore the dynamics behind these trends.

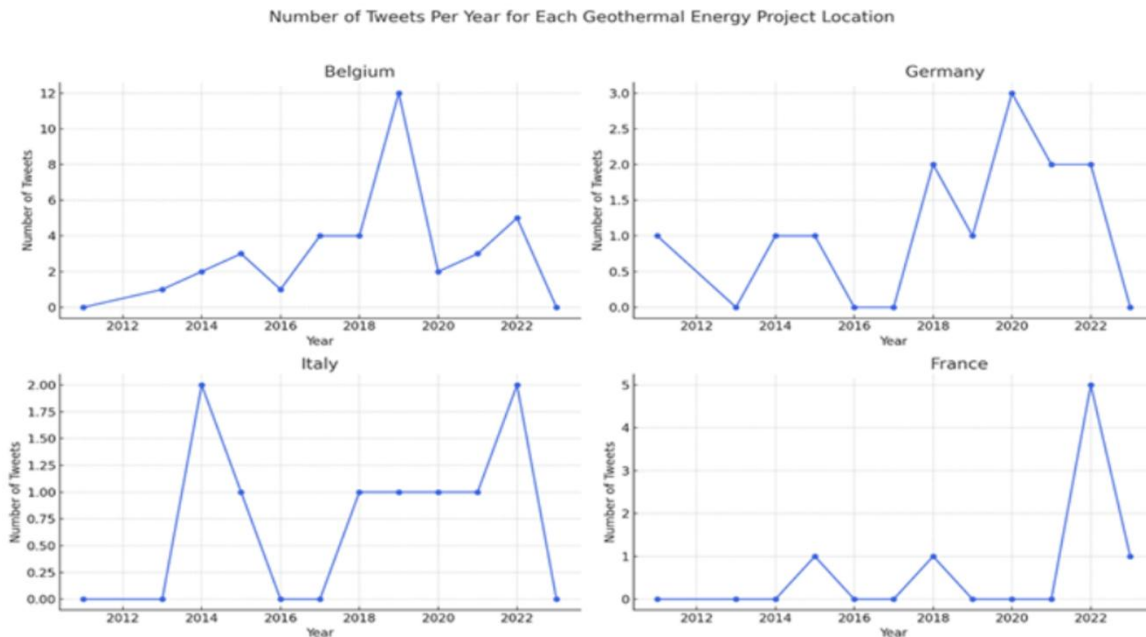


Figure 3: Total Number of tweets about pilot case locations over years.

In Balmatt, Belgium the overall tweet activity remained fluctuating throughout the observed period, with a noticeable peak in 2018. This surge in interest likely resulted from a symposium organised by VITO related to its Balmatt geothermal power plant in Mol. The one-day conference, open to all interested parties, focused on geothermal energy as a key sustainable source, covering exploration, operation, a new geological model of Flanders, advanced exploration techniques, and evolving Flemish and European legislation. It concluded with a visit to the Balmatt plant and resulted in increased discussion about geothermal energy on social media. A second spike in 2019 was linked to a public statement issued by the municipality of Mol, declaring there would be no heating network connections between Mol and Dessel. The connection was considered important by the people because it was originally planned to supply renewable heating to around 2,000 apartments, schools, and other public buildings in Mol and Dessel. This announcement triggered strong criticism from the local residents and stakeholders, as reflected in the increased social media activity including one tweet that mocked it as “a Belgian joke.”

In Lichtwiese, Germany, the number of tweets remained relatively low, but the activity peaked in 2020. This peak appears to be connected to several initiatives highlighting active geothermal research and education in the region, including announcements of a researcher position at TU Darmstadt focused on Enhanced Geothermal Systems and the launch of a European education network in geothermal energy.

In Parisian Basin, France, tweet activity was sporadic, with a clear peak in 2022. However, interestingly, this peak did not appear to correspond to any particular event or incident.

In Gargano, Gavorrano, and Monte Amiata (Italy), the volume of tweets also showed variations across the years, however, the overall interest remained very low. A small spike in tweet activity was observed in 2021 linked to a local incident near Monte Amiata, Tuscany, where environmentalists and community

groups successfully blocked the development of a geothermal power plant.

4.2.2 Sentiment analysis

In the context of geothermal energy projects, sentiment analysis can reveal potential barriers to acceptance, highlight enthusiasm or opposition, and inform communication strategies. For instance, the following tweet by Manuel Sintubin, a professor of geodynamics, about the Balmatt site conveys a positive sentiment by stating "interesting visit to #geothermal project at #Bamatt site. They reached reservoir rock ... temperatures promising ;-)". The message not only reflects optimism but also include technical details such as the achieved drilling depth of 3,148 meters and the promising temperature conditions, thereby portraying trust and confidence in the project potential.



Figure 4: Example of a tweet with positive sentiment towards the geothermal energy project

Figure 5 presents the results of the sentiment analysis for each pilot study. The graph displays positive, negative and neutral sentiments, providing an overview of how geothermal projects are perceived across

different locations over time.

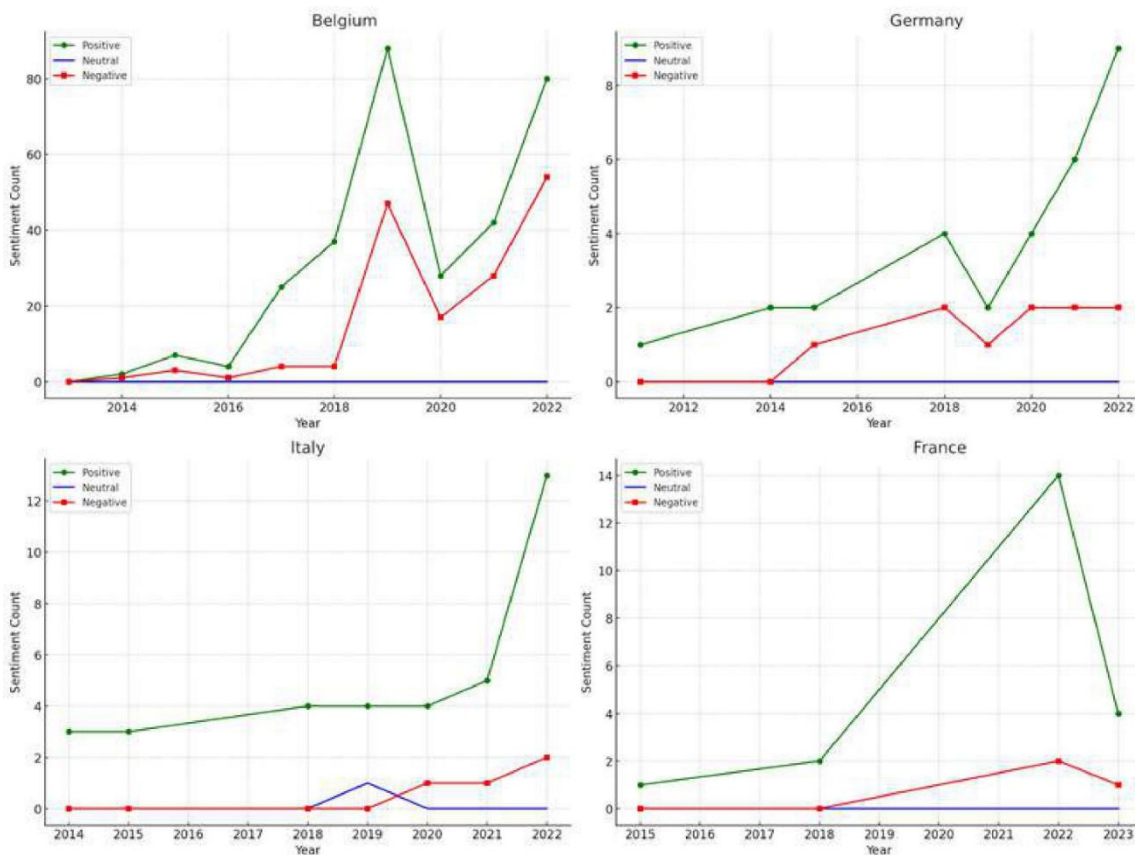


Figure 5: Sentiment Analysis of tweets over the years

At the Balmatt site in Belgium, overall sentiment was mainly positive, peaking in 2017-2018 following the news about the start of the construction of geothermal heating networks in Mol and Dessel in 2018. The negative sentiments reached its highest in 2019, largely in response to the decision by project stakeholders to scale down the heating network in Mol and Dessel due to the low power output generated by the geothermal plant in Donk. Neutral sentiments remained stable throughout the period, indicating a continuous stream of balanced discussion about the project. Interestingly, this temporal development of the different sentiments presented diverges from the findings of the traditional media analysis, where the media coverage and positive sentiment peaked already in 2015. However, also the traditional media had a small peak in negative media coverage in 2019, although this was much less prominent than that in social media.

The public sentiments in Lichtwiese, Germany, varied over time, with neutral and positive sentiments peaking in 2020 and 2022 respectively. While the increase in positive sentiments in 2020 was likely influenced by announcements of geothermal research job opportunities and the launch of a European education network. The spike in 2022 was due to key project milestones in Lichtwiese, including the SKEWs project, a world-first mid-depth geothermal heat probe storage system, and the approval of a near-surface geothermal plant. Negative sentiments were less frequent overall, suggesting general satisfaction with the project. The only noticeable peak in criticism was due to the concerns expressed by local opposition to a

geothermal plant in Massenheim, where residents raised environmental and safety concerns.

In the Parisian Basin, France, the public sentiment was overall positive over the years. However, a sharp rise in both positive and negative sentiments was observed during 2022, suggesting a polarised public reaction. The positive sentiment can be attributed to the technological advancements and educational initiatives led by a research institute named LIAG in collaboration with Technische Universität Darmstadt. The collaborative geothermal heating project planned by three cities near Paris will use the Dogger aquifer to provide renewable heat for around 20,000 homes and public buildings, offering cleaner energy and more affordable heating. Negative sentiments from locals were driven by governance concerns, as they feel Dogger aquifer used for geothermal energy does not follow city boundaries, and control of the heating network by a single city could slow the transition to renewable energy, emphasizing the need for collaborative management.

When it comes to Italy, sentiments were generally positive, with a noticeable peak in 2012 and 2022. The 2012 peak is attributed to the initial excitement on approval of the project, while the 2022 rise was related to the discussions about the potential for geothermal energy in Mount Amiata and surrounding areas could not be related to any specific incident, however one notable tweet reported the approval of a new 10 MW geothermal plant using a binary cycle system, which is expected to provide heat for over 32,000 families and reduce CO₂ emissions. Negative sentiment peaked in 2020, hinting at the opposition faced by the project as environmental groups and local committees successfully halted the development of the geothermal power plant in Tuscany near Monte Amiata.

4.2.3 Common themes in the social media discourse

To understand the public discourse on geothermal energy, we performed a thematic analysis of tweets to ascertain the recurring narratives. This analysis revealed several broad categories that captured the main directions of debate, encompassing both supportive and critical perspectives. These insights provide valuable information on the social acceptance of geothermal technology, the drivers of public support, the sources of resistance, and the aspirations that shape how people perceive its impact on both society and the broader energy landscape.

Environmental benefits and concerns

Environmental benefits and concerns emerged as one of the leading themes in discussion surrounding geothermal energy projects. Conversations spanned a variety of issues, including potential for CO₂ emissions reduction, the incidence of seismic events, and the assessment of geological risks.

The analysis of tweets for the different geothermal sites indicated a moderate level of public awareness regarding the environmental impacts. Concerns about seismic activities were frequently mentioned, especially in the Balmatt and Mol sites, where such risks were seen as an obstacle to broader social acceptance. Conversely, several tweets expressed appreciation for the environmental benefits of geothermal projects, particularly their potential to deliver suitable, emissions-free heating networks and reduce dependence on conventional fossil fuels. This divergence of opinion highlights how geothermal energy is perceived as both beneficial and potentially hazardous to the environment.

Overall, the results suggest that while geothermal energy is widely perceived as a sustainable solution to environmental challenges, greater attention is needed to ensure transparency on environmental risks and measures to mitigate these. Clear and truthful communication can foster public trust and strengthen confidence in geothermal initiatives.

Economic and social benefits

Economic and social benefits associated with the geothermal energy projects also emerged as decisive in influencing public perceptions and social acceptance. The discussions primarily focused on potential household energy savings, employment opportunities for local communities, and the overall broader positive economic impacts. These economic and social aspects particularly highlight the potential benefits geothermal energy can offer beyond its environmental benefits.

The results indicate that several discussions referred to local development and job creation linked to geothermal project activities, emphasising employment opportunities and stimulating economic activities. The generally positive tone of these discussions suggests that geothermal energy is perceived as a driver for economic growth and social well-being.

Furthermore, the perceived value for households in terms of energy saving and cost reductions also sparked interest in the technology: this not only reflects the level of knowledge and awareness about the technology but also highlights the degree of attention and interest geothermal technology received from the wider public. The moderate level indication of such issues reinforces that the socio-economic dimension of the geothermal is recognised and valued.

Future outlook

The dialogue reflected a strong interest in the future potential and continued development of geothermal technologies. Discussions frequently centred on both challenges and opportunities associated with the development of the technology, as well as the importance of ongoing research and development efforts on geothermal reservoirs, seismic monitoring campaigns and establishment of collaborative educational networks. The presence of such discussions emphasises that geothermal energy is perceived as a technology with utility, potential and prospects for further development.

In addition, there were mentions of novel technological solutions and innovations that could facilitate progress in this sector. These include references to nuclear magnetic resonance (NMR) tools, study of rock properties, and new extraction approaches. The discussions illustrate a sense of public interest and optimism, suggesting that geothermal energy is perceived as a growing field with substantial future prospects.

Community engagement and local response

The analysis of social media data also offers valuable insights into community engagement and the local response to geothermal energy projects. The aim has been to gain a deeper understanding of how residents and other stakeholders either opposed or supported projects, and to identify cases where community feedback and participation influenced the course of action or execution of geothermal energy initiatives.

The findings highlight instances of both contestation and support. Though there were posts about controversies, opposition, and concerns related to geothermal power plant, there were expressions of encouragement and recognition of the benefits. The primary concern has been related to small earthquakes and insufficient power supply, particularly in Montrouge and Tuscany (limited output) and Mol and Dessel (earthquakes). Local authority involvement was also highlighted with discussion focusing on environmental compatibility, project limitations and public health implications. In several regions, residents actively resisted and protested against the geothermal projects to halt the operations. In the Monte Amiata

region of Italy, environmental organisation and regional office of the Ministry of Culture (the Superintendence of Archaeology, Fine Arts, and Landscape) expressed concerns about the potential impacts on nearby thermal springs and a UNESCO heritage site. Furthermore, there have been concerns about the construction of geothermal plants at the same location. These findings suggest a mixed local response to geothermal energy.

Table 88: Themes identified for each case study

Case Study	Common Themes
Balmatt, Belgium	<ul style="list-style-type: none"> • Focus on the Balmatt geothermal power plant's energy production and its related seismic activities. • Insights into geothermal energy research and the challenges related to seismic activities, particularly by VITO. • Optimistic outlook on geothermal energy's potential and seismic research findings • Detailed insights into the Balmatt project, including geological studies and project challenges. • Focus on the local geothermal heating networks and community engagement.
Lichtwiese, Germany	<ul style="list-style-type: none"> • Emphasis on communication efforts and outreach through discussions and podcasts. • Highlighting educational and research opportunities in geothermal energy. • Overview of job and research openings in geothermal energy systems and storage. • Focus on geothermal plant developments and the crucial roles of researchers. • Emphasis on the vibrant research environment and opportunities in geothermal energy.
Parisian Basin, France	<ul style="list-style-type: none"> • Exploration of the Dogger aquifer's potential for geothermal energy projects. • Technical focus on aquifer permeability and its implications for energy projects. • Highlighting research and exploitation activities within the Paris Basin. • Concentration on studies and developments in the Dogger Basin's geothermal energy potential. • Emphasis on project development and technical analysis of the Dogger aquifer.
Gargano; Gavorrano; Monte Amiata, Italy	<ul style="list-style-type: none"> • Integration of geothermal projects within Gargano National Park's renewable energy initiatives. • Focus on local opposition and environmental concerns around Monte Amiata's geothermal plants. • Development of new geothermal projects and the dynamic of potential opposition. • Governmental approval of geothermal projects amidst significant local and environmental opposition.

5. Stakeholder perception study

5.1 Benefits, risks and challenges of the technology

From the stakeholders' viewpoint, the development and deployment of deep geothermal energy have several benefits, but they also pose risks and face general challenges. We have categorized our findings further into three categories: economic, social, and environmental.

5.1.1 Economic

The workshop participants were often well aware of the potential of deep geothermal energy projects to contribute positively to regional economic development. In practice, this would mean the creation of new jobs and new skills. A participant of an Italian workshop stated, for example, that: *"Geothermal energy projects lead to more development and creation of new jobs and skilled workforce contributing to the economic development of the area"*.

However, we identified two main types of economic risks that could hinder this positive development: high initial investment costs and financial barriers, and market and economic uncertainty. These factors can substantially discourage investments and make the technology less commercially appealing than other forms of renewable energy, although the research participants participating in our workshops did think that the technology is beneficial from the long-term investment perspective due to its long-life cycle.

The deep geothermal energy projects have very high upfront investment costs, which can easily lead to an exclusion of smaller or poorer communities from these projects. Simultaneously, the return-on-investment timelines are relatively long due to extensive development periods and high drilling costs, which also influence the cost competitiveness of the technology. For example, a participant of the Finnish workshop raised concerns such as *"maintenance costs are yet to be known, fear that altogether different costs can make this system a costlier solution than existing ones...concerns about the return on investment ratio"*. The participants also contemplated that even if there are financial means to carry out drilling pilots, there is always the risk of finding dry wells or insufficient thermal resources, which increases financial risks. A participant of the German workshop, for example, contemplated that deep geothermal is *"higher in risk as not enough drilling information exist before"*.

There are also major concerns related to the future market size and demand for geothermal energy, especially in connection with district heating. Uncertainty regarding the technical performance of technology on a long-term that is required for the payback is also something adding to this uncertainty. The workshop participants had concerns such as: *"does technology work as planned?"* or *"what if there is not the same level of demand for district heating?"*.

Finally, it must be noted that, in many countries, the profitability of deep geothermal projects is also heavily dependent on government subsidies. Unavailability of government funding to support realization of the drillings can substantially reduce private investments in such projects. According to a Finnish workshop participant: *"private investors have great potential to benefit from such solutions, but additional help is needed from policy makers"*. Overly complicated bureaucracy and unclear regulation can also negatively influence project timelines and increase their costs. These aspects are covered more in detail in section 5.1.3.

5.1.2 Environment

From the environmental perspective, the stakeholders were quick to identify both climate-related benefits of sustainability and emission reductions, as well as impacts related to the local environment and comfort.

Overall, the fact that geothermal energy is a renewable energy source that can contribute to substantial carbon reductions was highlighted as a major benefit of the technology in all the workshops and interviews. According to an Italian workshop participant: *"geothermal energy is a renewable source with less emission and provides a green solution to energy problems without risking environment"*. It could also reduce air pollutants locally and thus contribute to better air quality. In comparison to other renewable energy developments, the benefits of deep geothermal also include the absence of noise pollution once operational and the size of the surface area needed for operations. As the closed-loop geothermal system does not inject any fluid directly into the earth, some workshop participants also felt that the technology has a reduced risk of ground water contamination and altering the earth structure.

Despite these identified benefits, participants still felt that the deep geothermal energy developments can negatively influence the surrounding environment – especially during the drilling process. Most notable such influence is the risk of increased seismicity and earthquakes in the area due to the necessity to conduct drilling to significant depths. This concern was brought up constantly during the workshops and interviews. Some informants noted for example that small local earthquakes due to geothermal drillings have known to damage houses near the project sites. This concern was especially prominent for areas with existing geological vulnerabilities and sensitive infrastructure such as in Italy, where one workshop participant stated that: *"there are already higher number of earthquakes in the region, so the safety becomes a concern...some of the areas that are not stable like hilly areas that have received a lot of rain might be a little risky for drilling"*.

The risks of noise pollution and water contamination were also prominent to many participants. The drilling process produces a lot of noise pollution, which can disrupt the daily life of the local people and have negative health effects. Many, including some industry representatives, also shared the sentiment that deeper drilling depths have the potential to increase the risk of water and soil contamination in case of a system failure. A participant of a Finnish workshop noted for example that: *"potentially dangerous liquid might harm the environment in case of a leak or critical failure"*. One interviewee also brought up concern over air quality issues, especially related to nitrogen emissions.

Finally, potential land-use conflicts were brought up. The project sites may disrupt local ecologically, culturally, or even historically sensitive areas such as parks or community spaces. In many cases, trees need to be removed to enable construction of the project sites which can raise concerns over loss of biodiversity. This issue also relates to whether the project sites critically disturb the visual appearance of the surroundings. In the Italian workshops, one participant for example contemplated that *"people see renewable energy initiatives as a burden on the area and consider them environmentally degrading - the visual aspect needs to be considered ensuring the beauty of the place remains intact"*.

5.1.3 Social

Several social benefits of geothermal energy to local communities we brought up during the workshops and interviews. First of all, the technology has the potential to provide affordable low-carbon heat and electricity to the region – both public facilities and households. It can thus enable new community groups to take part in the energy transition that would not necessarily have the means otherwise. Secondly, once deep geothermal technology is operational, it provides continuous uninterrupted power regardless of the

weather, even if there is “no sun, no wind”, thus improving energy reliability and security. This matter of energy security was also brought up in the context of conflicts – the local communities are less dependent on interruptions in global energy supply.

The core social challenges of the technology identified were the lack of equality and inclusivity; and building trust and awareness. It is crucial that the benefits of the technology are distributed evenly in the communities, especially when public funds are used to support the developments, and that different community groups have equal access to take part in these developments. The Finnish workshop participants noted that there is a notable risk that especially rural communities and small households are excluded from these developments due to e.g., lack of funding, which could further foster social division. Some workshop participants also argued that people living closest to the plants should receive additional benefits or compensation to make up for the disturbances. Overall, local stakeholders stressed the importance of ensuring that the benefits are transferred directly to the local communities to improve social acceptance.

Another core challenge has to do with lack of trust to the technology by local community groups. Deep geothermal energy is a relatively new technology, from a general public perspective, and people have limited understanding of the benefits and risks related to it, which can lead to misconceptions, uncertainty and mistrust in the projects. The developers and other responsible stakeholders thus have an important role in actually building trust in the technology and managing the expectations of the public to avoid disappointments that can hinder project success. As one interviewee project developer noted: “*after about two years of pure scientific development, we certainly noticed, okay, without reaching out to our neighbors, to our citizens over here, this project is never going to fly*”.

5.2 Ways to improve social acceptance

The participants presented a lot of great ideas on different strategies through which the social acceptance of deep geothermal projects could be improved. We have divided these into three categories: governance strategies, communication strategies, and innovative business-model development strategies.

5.2.1 Governance strategies

Ensuring that local communities and other stakeholders are treated as active partners in the project developments was continuously highlighted as a critical element for building trust, reducing perceived risks, and increasing the long-term acceptance of deep geothermal energy projects. The interview and workshop participants highlighted numerous ways through which projects could actively foster this type of engagement and community embeddedness.

Stakeholder inclusiveness

Study participants highlighted the importance of identifying and engaging all relevant stakeholder groups that a deep geothermal project might influence. The different stakeholder groups can include not only local citizens, but also industry actors, policymakers, and researchers among others. One central aspect to stakeholder inclusion is to consider wide range of age and class groups. Especially the younger generations were seen as both a critical audience and a potential channel for spreading awareness within their families. A participant of a workshop based in Italy stated for example that “*because these solutions concern future generations, involving schools and universities and young people to participatory processes*”.

The participants across all the workshops also felt that to make local communities feel part of projects, the

opinions of these different types of stakeholders should be truly valued. They called for early and genuine involvement of local actors to hear these opinions and take them into account in shaping the design of the geothermal projects, particularly during site selection and planning phases. As brought up in the German workshop, this could also mean collaboration with trusted, local organisations to improve project visibility and legitimacy.

One of the workshop discussions proposed concrete mechanisms to institutionalize local input, such as establishing a local support association for the project. This approach aims to strengthen legitimacy and acceptance by including the community into the project governance process. However, it's not enough just to involve people in meetings the process should also look for ways to fit the technology into the local area in a way that is good for the environment. This means working together with the community to make sure the project works well with the place where it will be built.

Local benefit investments

Another concrete way to improve social acceptance through governance is to systematically redirect part of the profits towards local benefit investments. The investments should be planned directly with local stakeholders. The workshop participants mentioned examples, such as, heating the local football stadium (Lichwiese workshop) or invest in nearby parks or schools (Italian workshop) as strategies to foster greater social acceptance for the projects among the locals.

5.2.2 Communication strategies

Transparent and proactive communication

The participants felt that trust in deep geothermal initiatives relies heavily on clear, timely, and balanced communication from the start of project development. In general, stakeholders want to understand the opportunities and potential risks related to projects before crucial milestones are reached. However, it is also important to recognize that the different stakeholders also have potentially varying needs and priorities that need to be recognized in the design of communication strategies. For example, a participant of the German workshop stated that: *"General citizens want information, companies have business interests, researchers have an interest in science aspects etc. Different methods need to be applied for different stakeholder groups"*.

Insufficient communication and lack of clear information cause confusion and leave space for mistrust, which can substantially influence project outcomes and acceptability by feeding opposition. In the Italian workshop, this topic of communication sparked lively discussion. Many felt that the companies driving these developments should be more transparent and proactive in their communication with local citizens. It was stated, for example, that *"there is lack of information for, let's say, telling people what technology is beneficial for, what are the issues, what are the risks"*. Moreover, many felt that this communication should not be overly technical but balanced so that it is understandable for all the stakeholder groups. The participants of the German workshop contemplated how for citizens, it is important to articulate clear messages, e.g., the benefits of geothermal energy are. This includes answering basic questions such as how much heat can be extracted/stored, what is the difference compared to traditional fossil fuel sources, or how does it contribute to the energy transition. One interviewee explained that to foster local citizens understanding of the geothermal developments they have *"used visuals to explain complex concepts like seismic activity and subsurface structures"* and that their *"team designed workshops to make the discussions as interactive and informative as possible"*.

One important factor in ensuring successful communication that reaches a wide range of stakeholders is to use a variety of different channels. This means a mixture of social media and traditional in-person information sessions. An online platform for two-way communication, such as a city homepage, could serve as a centralized information hub. The presence of neutral expertise in these communication materials was also valued, with calls to include academic experts alongside industry representatives to increase credibility and balance.

Raising public awareness

The social acceptance of individual deep geothermal projects can also be improved by influencing public awareness at large, beyond engagement with just the imminent stakeholders. This work is more long-term and continuous, but it can substantially shape how a new energy technology is generally perceived across communities. The study participants mentioned several different types of concrete strategies for raising public awareness, which are listed below.

Educational Campaigns: Community-based education initiatives emphasizing the long-term environmental and cost benefits address misconceptions and build confidence. Some of the deep geothermal energy projects are already conducting school visits to the sites and open sessions to educate people.

Surveys and Seminars: As suggested by the participants from the Italy workshops, surveys and educational seminars can help with the stakeholder inclusion as well as generating trust and acceptance towards the technology.

Media Engagement: In the past year's media, especially social media, has become a primary source of information for people shaping their attitudes about important issues including emerging technologies. Positive media coverage can create a supportive narrative, counter negative perceptions and create favorable public opinion.

Dedicated Online Resources: One of the industry representatives mentioned the use of a Website with FAQs in simple language for one of their projects leading to effective information sharing with the public about the project. Similar practices can be used at other deep geothermal sites to ensure that even individuals without prior technical knowledge feel informed, directly enhancing acceptance.

Ongoing Dialogues: Regular open sessions with communities with planned deep geothermal projects allow for addressing fears and emphasizing benefits, improving trust and alignment with stakeholder expectations.

Engaging the Public: Deep geothermal energy is a relatively less-known technology, as compared to other renewable sources, so presenting information at large-scale events could help to reach a broader audience and spread awareness.

5.2.3 Innovative business-model development strategies

Community ownership and long-term partnerships:

In the future, the business models of deep geothermal energy projects could be made more community central by design. This could mean directly sharing the ownership of the energy projects with the local communities to allow the citizens greater benefits from living near the sites, as brought up during the Italian and Finnish workshops. It was even suggested that local communities or governments should be made

shareholders in these projects by default, so that they have a say in the project development. Another way to establish this would be to develop long-term power-purchase contracts that offer geothermal energy at a low fixed price. For example, in an Italian interview, one participant contemplated that this could be a fixed contract of 25 or 30 years with possible extension at the end.

European or national certification schemes

One way to increase local communities' and citizens' trust towards deep geothermal projects could be to develop new environmental certification schemes for geothermal energy projects. This idea was brought up during the Italian workshop, where the participants felt that this could be one efficient way to address safety concerns.

5.3 The role of policy & regulation

Finally, regulation and policy have notable effect on the profitability of deep geothermal projects. We identified five prominent aspects that the stakeholders, mainly in this case the industry representatives and project developers, felt may hinder the scaling up of deep geothermal projects. These include permitting efficiency, subsurface ownership and land access, unclear and overly complex environmental protection demands, and drilling and safety standards.

Many participants agreed that the approval processes for geothermal energy projects were unclear and need to be further developed. This permitting varies based on locations and becomes even more difficult in locations like Italy, where permitting process for even simpler renewable technologies such as solar PV, face licensing delays. One interviewee noted, for example, that there have been *"delays caused due to permits required related to environmental regulations leading to high costs"*. Without firm deadlines in regulation, projects risk stalling indefinitely, hence the call for *"legislations to ensure renewable energy projects are completed in time"*.

In some countries, the geothermal resource beneath the ground belongs to the state, a fact that can add complexity to project initiation. A participant of an Italian workshop for example stated that: *"State is the owner of underground heat resources in Italy. This can become an obstacle in the development of geothermal energy. The use of the resource s should be made easier."* Beyond ownership, the basic right to access land, whether through leasing, permits, or even expropriation was cited in Finland as a fundamental but often complicated step: the land use permits, leasing rights, and expropriation shape who can actually develop projects, how quickly, and at what cost.

In some cases, environmental regulation can impact the development of deep geothermal energy. In Finland, for example, the workshop participants listed several legal acts that directly affect such projects, including: *"Land Use and Building Act (MRL), current construction law, Act on Environmental Impact Assessment Procedure, Government Decree on Environmental Impact Assessment Procedure and Environmental Protection Act / Water Act"*. Beyond binding regulation, there are growing calls for the responsibility to undertake restoration of the damage caused by these projects to the environment. A participant of the Finnish workshop underlined, for example, the need to balance development with ecological and community safeguards. In Germany, concerns extended to personal and property rights, with one participant asking: *"what are the compensation models if the vertical drilling is affecting a larger area with a lot of existing houses and buildings?"*. Collectively, these discussions highlight the complexity of the environmental legal framework that geothermal developers must navigate. Multiple overlapping laws, assessments, and permit requirements create a difficult regulatory landscape, requiring significant time, expertise, and

resources to ensure compliance.

These challenges with permitting and regulatory compliance could be handled by establishing early and ongoing dialogue with the government bureaus. to understand their concerns and expectations for permitting documents. One interviewee contemplated how this could ensure that submissions align with regulatory requirements and reduce the likelihood of delays or rejections. The developers could also use the services of consulting companies who can help them with research and reporting, a practice one of the industrial stakeholders we interviewed had already in place.

6. Conclusion

This deliverable has assessed the social acceptance of deep closed-loop geothermal energy systems across multiple sites across Europe. The work includes an analysis of how the sentiments towards deep geothermal have developed in the traditional and social media, as well as a stakeholder perception study based on a series of workshops and interviews. Together, these different studies provide a nuanced understanding of the social acceptance of deep geothermal energy, capturing both support and areas of concern.

The media analyses showed a generally positive sentiment toward deep geothermal energy projects. Positive spikes in sentiment often coincided with major project milestones, such as announcements of new plant installations. For example, in Belgium, a clear increase in positive sentiment followed the announcement of a new facility. A similar pattern was observed in Germany, where approval of a geothermal power plant generated a surge of positive reactions, and in France, where news of a plant providing affordable heating to households led to heightened optimism. An exception was observed in Italy, where a peak in positive sentiment occurred without any identifiable event. Overall, however, the findings suggest that announcements of new installations and project progress tend to reinforce public confidence in the potential of deep geothermal energy. These results also underline the importance of transparent communication and visibility of project achievements in the media for generating a positive outlook for the technology and hence strengthening social acceptance of deep geothermal energy.

Media coverage with negative sentiment was less common. These sentiments peaked at different project locations due to several factors: the failure to achieve the originally planned targets of the plant in Belgium, environmental and safety concerns raised in Germany, protests from environmental groups and local communities in Italy, and governance-related issues in France. Although reasons for the spike in negative sentiment were diverse, there was one common factor: the lack of public trust. Whether caused by overly ambitious commitments that raised public expectations, insufficient information and communication about the technology, or inadequate stakeholder engagement, such situations often led to protests and opposition, which reduces the public acceptance of deep geothermal energy.

The stakeholder interviews and workshops, which focused on the potential future deep closed-loop geothermal developments, highlighted strong recognition of the technology's benefits but also called attention to several challenges and risks that could hinder the social acceptance of these developments. Through these discussions, we were able to extend our investigation to new stakeholder groups and hear their feedback directly. This also provided excellent channel through which these stakeholders could raise their opinions and suggest improvements to future projects.

The recognition of different benefits of deep geothermal energy appears to drive the generally positive sentiment as observed from the media sentiment analysis. This report identified a range of benefits associated with deep geothermal energy, each highlighting important themes that influence public acceptance of the technology. Environmental benefits were the most frequently mentioned in the media coverage, with key aspects including reduced emissions and the characterization of geothermal energy as a renewable and inexhaustible resource. These views were also reflected by workshop participants, who emphasized the role of deep geothermal energy in lowering CO₂ emissions. While some stakeholders emphasized the potential for job creation, media coverage highlighted additional economic benefits, such as investment opportunities, government support, cost efficiency, and energy savings, which can positively influence public opinion and support broader social acceptance of geothermal energy. Government financing emphasizes the economic feasibility of geothermal projects, increasing their attractiveness to the public. While the social benefits of technology remain underreported, they are very important for understanding broader acceptance. Different stakeholders from the Interviews and workshops as well as media coverage, often recognize the supply of geothermal heating and electricity to local communities, which improves the quality of life and can enable a just energy transition as a prominent social benefit of deep geothermal energy. Additionally, research and educational collaborations, such as efforts to raise technical knowledge and promote a diversified energy mix, help engage society and support technological innovation. Emphasizing these benefits in future communications and outreach efforts could further enhance public awareness and foster higher levels of social acceptance.

On the other hand, perceived risks associated with deep geothermal energy were found to limit its social acceptance, sometimes leading to opposition to the technology. While discussions of benefits largely focused on environmental advantages, the risks of deep geothermal energy were dominated by economic concerns. However, environmental and social risks were also widely discussed across different stakeholder groups.

Economic concerns varied across stakeholder groups, reflecting their different priorities and risk perceptions. Local communities were primarily worried about higher energy costs, while developers and industrial actors emphasized high upfront investment, long “return-of-investment” timelines, and the need for subsidies to offset these risks. Researchers highlighted drilling costs and the need for technological improvements, whereas developers additionally raised permitting delays and policy uncertainty as major challenges. Although financial support mechanisms such as subsidies were seen as essential by developers, industry, and researchers, they did not strongly influence the views of local communities.

Seismicity emerged as one of the most common environmental risks, consistently identified in both the media analysis and stakeholder workshops and interviews. However, perceptions of this risk varied across countries depending on the local context. In areas with sensitive infrastructure near geothermal sites, such as the nuclear storage facilities in Belgium, local communities expressed heightened concern and fear of safety risks, which amplified resistance to the technology and reduced levels of social acceptance. At the same time, the traditional media analysis in Belgium showed that proactive measures taken by developers, especially the establishment of seismic monitoring systems, were reported in a positive light, suggesting that effective risk communication and transparent risk management can help mitigate concerns. The stakeholder interviews also suggested there was a significant shift in local community attitudes from opposition toward support and acceptance when effective and transparent communication strategies were implemented, suggesting this might enable higher acceptance even during the development stages of projects.

Social risks were frequently mentioned by stakeholders, with issues such as lack of trust and insufficiently

transparent communication standing out. A particularly notable but often underexplored risk was public disappointment, which can have a strong influence on long-term acceptance of the technology. The inherent unpredictability of deep drilling means that projects may sometimes fail to deliver the expected heat output, leading to skepticism among local communities about the viability of deep geothermal energy. This loss of confidence reduces public support and acceptance. Developers and industry stakeholders further highlighted limited communication with local communities, contributing to misunderstandings about the actual potential of geothermal projects. These findings underline the importance of managing expectations through clear and proactive communication strategies

It was found that there was no single dominant factor influencing acceptance of deep geothermal energy instead, the perceived severity and importance of risks varied depending on stakeholder priorities, knowledge levels, and involvement in geothermal projects. Deep geothermal energy is generally considered a green technology with strong potential to support the energy transition however, for some stakeholder groups, including Industrial actors, developers, and local community, economic considerations tend to outweigh environmental benefits. Without economic viability, positive environmental or social aspects alone may not be sufficient to gain broader levels of acceptance from communities, industry, and other stakeholders.

Our research highlights the matters that can substantially influence the social acceptance of deep geothermal energy technologies now and in the future. Throughout the interviews and workshops, the participants also brought up various strategies through which social acceptance could be systematically fostered. These strategies include active involvement and benefit-sharing with local communities, alongside transparent and targeted communication. Strategies such as community ownership, long-term partnerships, and decentralized business models can give residents a tangible stake in projects, while environmental certification and visible local benefit investments such as funding schools, parks, or public facilities can further build trust and legitimacy. Proactive engagement through educational campaigns, workshops, media outreach, and dedicated online resources helps raise awareness, address concerns, and manage expectations. Combined with effective regulatory management and early stakeholder inclusiveness, these approaches foster trust, reduce perceived risks, and enhance long-term acceptance, creating a foundation for the successful deployment and scalability of deep geothermal energy projects.

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