Factors and dynamics of the social perception of geothermal energy: Case study of the Tolhuaca exploration project in Chile

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Factors and dynamics of the social perception of geothermal energy: case study of the Tolhuaca exploration project in Chile

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Abstract

This paper analyzes local stakeholders' perceptions of the Tolhuaca geothermal exploration project in Chile from 2009 until its cancellation in 2016 for financial reasons. The research is based on a qualitative case study using focus groups and interviews to reconstruct local stakeholders' perception changes throughout the project. The results indicate that stakeholders' perceptions were not only influenced by the company's engagement activities, but also by the exploration project activities, and contextual elements. We conclude that understanding the interplay between these factors is crucial when planning the stakeholder engagement process of geothermal projects.

1 Introduction

Geothermal energy developers increasingly recognize the importance of non-technical dimensions for the successful implementation of projects. Academic and practice-oriented literature on geothermal energy stress that its large-scale deployment or even small project does not exclusively depend on technological innovation. It is crucial to consider social aspects when planning geothermal infrastructures (Cataldi, 1999; Department of Energy, 2019; Duijn, Puts, & Boxem, 2013; Reith, et al., 2013; Trutnevyte & Ejderyan, 2018; Trutnevyte & Wiemer, 2017).

Geothermal energy remains understudied by the social sciences when compared to other renewable energy sources (Gross, 2012). However, there is a growing body of social science research on this matter (Manzella, et al., 2019). One focus of social research on geothermal energy is the acceptance of the technology whether in general or for specific projects by local residents and authorities (Chavot et al., 2019; Dowd, Boughen, Ashworth, & Carr-Cornish, 2011; Knoblauch, Trutnevyte, & Stauffacher, 2019; Meller et al., 2017; Romanach et al., 2015). Social studies have

highlighted that the acceptance of projects does not simply depend on the balance between benefits for a community and the risk this community might have to bear, rather an acceptance is strongly linked to the perception that local stakeholders will have of the project (Carr-Cornish & Romanach, 2014; Moser & Stauffacher, 2015; Stauffacher, et al., 2015).

Taking into account social dimensions has gained importance in the planning of geothermal energy projects after the recognition that such projects have consequences on local communities: they might provide benefits, but they also bring some risks (Canan, 1986). Such research is crucial for the development of geothermal energy as it tackles an important dimension of why these projects are accepted or refused by certain social groups. Social science research on geothermal energy has had a strong focus on social acceptance studies as some consider that companies can inform or even improve communication strategies and public engagement with local stakeholders (Meller et al., 2017).

However, one of the main risks when it comes to acceptance studies is that they take a normative stance and consider the acceptance of a technology exclusively from the perspective of project developers. In such a view, local stakeholders are explicitly or implicitly considered as a barrier that must be overcome (Contini et al.,2019; Kubota, et al., 2013; Pasqualetti, 2011). This approach is problematic because stakeholders are considered as actors that must be persuaded, educated or compensated in order to accept a project. Social sciences studies on innovation and science communication have shown that views of the public or local stakeholders as "lacking" capacities or willingness to understand the "necessity" to develop a technology (Wynne, 2006) or as inherently hostile to innovation, hinder trust in communication and public engagement processes (Marris, 2015) as they get engaged in a confrontational way.

Analyzing the social acceptance of geothermal energy in Chile, Vargas Payera (2018) has underlined the importance of bonds of trust between geothermal project developers and the local community. Considering the local community as an obstacle to overcome might not constitute an adequate basis to build trust. Geothermal project developers must construct an understanding of their interaction with stakeholders that is not exclusively one-directional, that is an interaction only meant to justify developers' intentions and provide their public (the stakeholders) with the "right" kind of information. As put by Williams et al. (2017, p. 101) in their study on public controversies about hydraulic fracturing in the UK, "public engagement (invited or uninvited) is as much about policymakers learning about public issue definitions, competing visions of the future, and priorities, as it is about publics learning the facts".

Indeed, for local stakeholders, the acceptance of a geothermal energy project is not simply the acceptance of a technology that might bring benefits or risks. The acceptance of geothermal energy might also imply changes in their daily routines at a personal or professional level. In their study about the acceptance of geothermal energy by Japanese hot springs owners, Kubota et al. (2013) found that owners feared both potential negative impact on hot-spring operations but were also concerned about keeping the "traditional" character of their hot-spring resort. The importance of such cultural, aesthetic, and spiritual considerations has also been highlighted by other authors (Canan, 1986; Vargas Payera, 2018).

Because of the many different reasons that lead local populations or stakeholders to accept or reject geothermal energy projects, Chavot et al. (2018) have argued for a more differentiated understanding of social acceptance. In their study about the development of geothermal energy in Alsace, they show that social acceptance also depends on the ability of projects to get anchored in

local reality, that is to connect with existing practices, the history of a region, and political concerns. What geothermal energy is in general, as well as what a specific geothermal energy project means is socially shaped by the anchoring or not of a project in a local reality (Chavot et al., 2018). Such studies show that geothermal energy projects interact with the social context in which they are located.

Studies on the contextual conditions in which geothermal energy projects (and energy infrastructures more generally) are sited have highlighted that the perception of projects is neither a function of social or psychological characteristics of a population, nor it is given by technical characteristics of a project alone, but by how these relate to each other (Chavot et al., 2018; Ejderyan, et al., 2019). Individual interests or preferences of local residents and other stakeholders play a role. However, the way a geothermal project will be perceived and how actors will react to it is also largely dependent on things as different as local collective norms, ongoing social conflicts locally, the political agenda, past experiences with other infrastructure projects, existing economic activities or media reporting (Cuppen et al., 2020). We speak of the social perception[1] of geothermal energy because it is always mediated by such collective processes. Looking at Carbon Capture and Storage (CCS), Oltra et al. (2012) found that interrelated factors such as the characteristics of the community, the characteristics of the project, risk perception, actions, the context, and finally the engagement process influence perception.

Through this paper, we want to understand how the perception of geothermal energy is formed. Our key question is: what factors influence the perception of geothermal energy? This requires 1) identifying which factors related to geothermal energy projects affect the perception of these project by local stakeholders and 2) understanding how these factors interact when a geothermal project is concretely planned in a location.

2 Research context

In this section, we present the context for this research. We provide an overview of geothermal energy development in Chile to understand the regulatory framework as well as the technical rationales that underlay the Tolhuaca exploration project. We then introduce some elements of the socio-political context of the La Araucanía region in which the project is located, before presenting the case history of the Tolhuaca geothermal exploration project.

2.1 Geothermal energy in Chile

As Chile is located in the Andean volcanic area and an active subduction zone, it has a large geothermal potential. Recent estimations based on information provided by the geothermal energy industry in Chile and academia point out that the average range of geothermal potential developed in Chile for the period 2017-2050 would estimate at around 2100 MW (Geothermal Table, 2019). However, Chile offers a good illustration that plentiful geothermal resources do not necessarily

[1] Public perception is another term widely used to describe the collective perception of an event. Some studies use both expressions without explicitly differentiating them (Oltra et al., 2012). Others use public perception in a way close to social perception as defined in this paper (Devine-Wright, 2005). The notion of public perception is widely used in research on risk perception based on aggregated individual responses.

mean a large-scale deployment of geothermal energy. Geothermal development has been slow in Chile. In 2019, geothermal energy represents only 0.2% of the energy matrix. As in other South American countries, geothermal resources in Chile have been traditionally used for recreational and touristic purposes with thermal waters collected from natural hot springs and piped to buildings and pools.

A turning point in Chilean geothermal history was the enactment of the Geothermal Law (19.657) in 2000, providing a framework for the exploration and exploitation of geothermal energy for electrical power production. The 19.657 law points out that a geothermal concession could be located in private and public land, but the state has the absolute and exclusive ownership of all subsurface resources. A peak of 76 geothermal concessions was reached in 2014 (Lahsen et al., 2015). However, the number dropped dramatically due to economic and non-technical barriers such as the absence of medium-to-long term energy policies and a lack of government incentives for companies to overcome financial risk (Sanchez et al., 2015). Despite this adverse scenario, in 2017, the Italian company Enel Green Power (EGP) and the Chilean state-owned Empresa Nacional del Petróleo (ENAP) started operating the 48 MW Cerro Pabellón geothermal binary power plant, after having a power purchase agreement (PPA) between EGP and Endesa. Cerro Pabellón was South America's first geothermal power plant and the world's first large-scale plant to be built at 4500 meters above sea level. In 2019, the plant started an expansion project, planning to reach 81 MW.

Geothermal energy is one of the least known sources of energy among the Chilean population, a situation comparable to other countries (Gross, 2013; Kubota et al., 2013; Pellizzone, et al., 2015). In the 2016 National Energy Survey (2016), only 33% of respondents declared to know that geothermal energy could be used for power generation, a figure similar to tidal energy. Geothermal has not played a prominent role in public debates on renewable energies. This was clear in Chile in 2009, when geothermal energy was put in the spotlight due to an incident that took place at the El Tatio geothermal field, where a 60-meter-high steam discharge took place in the context of private company explorations (Otero, 2015).

The most recent study on social acceptance was performed in 2018 in Southern Chile, in La Araucanía, one of the high-enthalpy regions of Chile (Vargas Payera, 2018), also the home of the Tolhuaca geothermal project. The results showed that the local community had a rather negative opinion, whereas officials and consultants were more receptive to geothermal projects. Such negative opinion was influenced by past (non-geothermal) energy projects and late top-down communication from those energy companies. The study highlights the importance of establishing a bottom-up, transparent, and trust-based communication between geothermal developers and stakeholders, including local communities (Vargas Payera, 2018).

2.2 Project location and socio-political context

The Tolhuaca exploration project was located in Southern Chile, on the border between the Bio Bio and La Araucanía regions (see figure 1). The closest urban area is the Curacautín municipality in La Araucanía, with a population of 17,221 inhabitants. The main economic activities in the area belong to the service sector. Business activities related to ecotourism play an important role for the local economy, as the area attracts visitors due to its natural landscape. Curacautín is home of

Figure 1: Location of the Tolhuaca project. Own representation.

two national parks: Tolhuaca and Conguillio. It is also surrounded by three volcanoes: Lonquimay, Llaima and Tolhuaca.

This region has a poverty level of 20%, twice as high as the national median (CASEN, 2017). This community is characterized as being well organized, having around 41 social organizations for every 1000 citizens, which is more than double the national average (RIMISP, 2018). There are many small and large energy infrastructure projects around Curacautín. The hydropower project "Doña Alicia", one of the most controversial ones (2013-2017), was canceled after strong social opposition.

From the cultural side, the history of La Araucanía is marked by territorial dispossession of indigenous communities, being an area characterized by a complex relationship between the Chilean State and the Mapuche nation (Ugarte, et al., 2019, CEPAL- ATM, 2012). Furthermore, large-scale infrastructure projects are carried out on indigenous people's lands or lands connected to their cultural and spiritual traditions. The siting of energy infrastructure in the area is, therefore, a sensitive issue.

2.3 Case history: Tolhuaca geothermal exploration project

Tolhuaca geothermal exploration project lasted from 2009 to 2016 (see figure 2). It was one of the most advanced exploration projects in Chile by 2010 and was expected to lay the ground for Chile's first geothermal power plant by then. The project was operated by Geo Global Energy Chile (GGE Chile, referred to hereafter as GGE) and Mighty River Power (MRP, now Mercury Energy), an electricity operator from New Zealand. The construction of the power plant was authorized after an Environmental Impact Assessment (EIA) in 2013, three year later, the project was cancelled for financial reasons (Almarza Farías 2014; Whineray 2015). In 2019, the exploitation license, Peumayén, was transferred to Transmark Chile SpA.

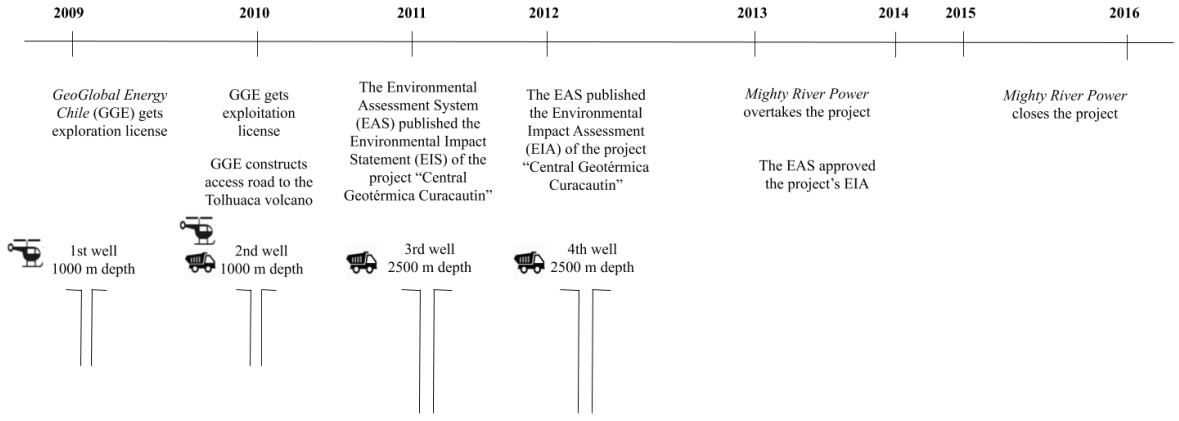

Figure 2. Tolhuaca project's timeline (own illustration based on Lohmar et al., 2012; SEA, 2019; Whineray, 2015)

The Tolhuaca geothermal project was located in a private land on the Tolhuaca volcano at an altitude of about 1600-2000 m. In 2009, GGE obtained a 1-year-valid exploration license and drilled a first slim hole (1000 m depth). In 2010, GGE got a non-expiring exploitation license, built a road to connect the geothermal field to the closest highway, and drilled the second slim hole. By 2013 GGE drilled two deep wells down to 2500 m, obtained the environmental approval from the Environmental Assessment Service (SEIA for the acronym in Spanish) and MRP took over the project from GGE (SEA, 2019; Lohmar et al., 2012). Although the company estimated a potential around 70 MW, the project was officially cancelled in 2016. Following reasons were given: restructuring of MRP, high operation costs at 2000 m (especially in Winter, with heavy snow and temperatures reaching -18°C), uncompetitive electricity price, and lack of subsidies from the Chilean government (Ormad 2013). In the next few years, activities ceased on the geothermal field.

During the exploration, GGE and MRP made contact with communities and stakeholders in the Curacautín area. Between 2009 and 2016 there was no organized regional opposition movement against it.

3 Methods

To understand the social perception of geothermal energy, this research is based on a qualitative approach and uses a single case study design. The main objective of this research is to identify important factors that shape the social perception of geothermal energy and understand the interplay between these factors and local conditions. As Stake (2005) points out, a single case study is suitable to see from a broader point of view and problematize the issue from different perspectives. Because of the specificity and the complexity of social settings - especially the ability of social actors to change behavior based on statements made about them - the goal of case studies in social research is not to provide generalization, in the sense that the explanation elaborated for one case is valid for any other case. Rather generalization is enabled through knowledge transfer (Stake, 2005) which enables to learn from a case study and adapt the findings to a different situation. This requires providing rich descriptions of the interrelationships between the actors and the context of the case under scrutiny. Studying the perception of actors enables analyzing how this perception is constructed in a given context and looks at the interplay between the various elements that are taken into account in the case study. At the same time, this method is adequate to integrate qualitative information from different sources (interviews, documents, observations) and triangulating data (Stake, 1995).

The Tolhuaca exploration project is interesting for a qualitative social science case study on the social perception of geothermal energy for several reasons. It was located in Chile, a country with a high but underdeveloped geothermal potential. The analyzed project was a milestone for Chilean geothermal energy; it was the most productive geothermal well drilled in South America by 2010 (GRC, 2013). As such, there might be lessons to learn from Chile for other Andean and high enthalpy regions that would like to develop geothermal energy. Furthermore, because Chile is a seismically active region, issues of induced seismic risk were not likely to play a central role. This aspect of the perception of geothermal energy is more salient in regions with lower levels of seismic activity and has been well studied (Knoblauch, et al., 2018; Trutnevyte & Azevedo, 2017;

Trutnevyte & Ejderyan, 2018; Trutnevyte & Wiemer, 2017). Studies in a European context have noted that deep geothermal project developers tend to focus on induced seismicity and overlook other perceived risks (Chavot et al., 2018; Ruef, 2018). Because seismic risk was unlikely to be an issue, the Tolhuaca case study enables us to explore a broader range of factors influencing social perceptions. Furthermore, the various groups and interests involved in the process and a specific dimension related to the presence of Mapuche communities as well as ongoing controversies about energy infrastructures are likely to highlight the multiple dimensions of the social perception of geothermal energy.

The data for this study were collected during fieldwork in Curacautín with local stakeholders involved in the Tolhuaca exploration project in 2018. We conducted five focus groups (FG) and four semi-structured interviews (SI) with key local stakeholders, giving a total of 24 participants. Participants were chosen through stakeholder mapping and snowball sampling. These local stakeholders were representatives of local social groups concerned for the Tolhuaca project, according toother members of the local community and other research participants. While local stakeholders' views might not reflect those of the whole community nor that of the social group they represent, they appear as legitimate spokespersons and have an ability to influence their community or social group. Therefore, their views on the project are important with regard to the general acceptance.

To structure the discussions in the focus groups a focusing exercise was introduced (Bloor et. al 2001). We used the Story Wall (SW) tool from the Swiss Academy of Sciences TdNet Toolbox. This method includes participants drawing a timeline of memories. This method is useful for analyzing retrospective of a past event. All participants signed written informed consent agreements to assure confidentiality and anonymity before being interviewed. In 2019 all participants were contacted receiving the results of this research. During the focus groups and interviews, the following topics were discussed: a) relationship with the Tolhuaca project, b) memories about the Tolhuaca project throughout time with the aid of the Story Wall tool , c) communication processes, d) relationship with other local stakeholders, e) information received by participants about the Tolhuaca project; and f) opinion about geothermal energy.

Participants were organized according to identified interest groups. Interest was defined primarily by the organizational affiliation of the stakeholders in relationship to the development of geothermal energy in Curacautín. The dynamic for these participants was focus groups. A semi-structured interview was held when only one representative of an interest group was able to participate.

The following Table 1 describes the participants on this research:

Table 1. Participants' list

Stakeholder	**Description**	**Method used**	**Number of participants**
Nearby residents' association	Residents of settlements near the Tolhuaca volcano. They collectively address issues within their community	FG +SW	3

Agriculture Department of the Municipality	Department in charge of agricultural activities such as forest activities in areas nearby Tolhuaca volcano	FG+SW	4
Administration Municipality representative	Officer in charge of administration and planning of Curacautín Municipality. They are capable to oppose to the project through the Supreme Court	SI	1
Ecological NGO	NGO from Curacautín that addresses ecological issues	FG+SW	4
Network of NGOs	Network of organizations from Curacautín that promotes sustainability in the municipality	SI + SW	1
Tourism companies	Companies located in Curacautín	FG+SW	5
Residents association of Curacautín	Residents of the city of Curacautín located at a distance from the Tolhuaca volcano	FG+SW	3
Landowner	Owner of the land where the geothermal concession is located. The access to the volcano is located in this area.	SI	1
Indigenous representatives	Chief of a Mapuche community	SI	2

To reconstruct the case, relevant actors of the Tolhuaca project who provided background information were interviewed. A geologist from GGE, a professional from the regional environmental regulator and a professional from the public relations officer from GGE-MRP were included in this process. At the same time, we reviewed documents from the companies developing the project, Chilean environmental regulations and press articles issued from 2008 to 2014 by two local newspapers (El Diario Austral de Temuco, and Las Noticias de Victoria) as well as online articles as background information and to build the project's timeline.

All the gathered information was coded with NVivo Plus 12 through a qualitative thematic analysis. To illustrate the perception changes, statements that showed an opinion about the Tolhuaca project were coded as positive, negative, or neutral. The statements considered were those that explicitly expressed an opinion. For example: "I was here when they concluded the first drilling and they did not take into account environmentalist or local perspective" (indigenous leader). This statement was coded as a negative perception and enabled to identify the construction work for the exploration as well as environmental impact as elements affecting the perception. Other statements such as: "The project and things done were properly made. All good things must

come to an end. However, the company had good ideas to help attend the community needs" (nearby residents' association) were coded as expressing a positive perception of the work conducted as well as a positive perception of potential benefits of the projects for the community. Going through such statements for all the phases of the project enabled us to analyze changes in perception for each stakeholder group.

4 Results

In this section, we introduce the findings of the interviews and focus groups that were conducted in the Curacautín region. At a very general level, these findings highlight that the perception of the project changed over the different time-phases of interaction between the project developers and local stakeholders. In the first part of this section, we show how the stakeholders perceived the geothermal energy project and how their perception changed over time. In a second step, we categorize the different elements that we identified as influencing stakeholders' perceptions.

4.1 The dynamics of perception

A significant finding of our study is that the perception of most of the stakeholders in the project changed over time. These changes often corresponded to interactions that the stakeholders had with the company or information they received. Based on the document analysis we conducted and the interviews with the stakeholders, we could identify five phases of interaction between the company and the stakeholders. These five phases do not correspond to a public engagement strategy, nor standard project planning phases. They are characterized by planned or accidental contacts between GGE-MRP and the stakeholders that we identified as changing the perception of some of the stakeholders (see Table 2).

Phase 1. Project presentation to the authorities (01/2009-06/2010): during the first year of the project, the company held first meetings and interviews with authorities before the exploitation license was granted, to inform them about potential future activities in the region.

Phase 2. Project presentation to community stakeholders (06/2010-03/2012): after receiving the exploitation license in 2010, the company organized presentations and workshops for the general public about the Tolhuaca project and its potential impacts. Presentations and workshops were open to everyone and took place in different settings, such as a school and a community meeting room. They were attended mainly by representatives of associations and other groups from Curacautín.

Phase 3. Visits to the geothermal field (03/2012-04/2012): during this phase, GGE-MRP organized guided tours for local stakeholders to the Tolhuaca geothermal field. They could visit the drilling site and other infrastructure for the planned plant. The company explained the project they were doing on the volcano.

Phase 4. Assessment and agreements for the exploitation project (02/2012-04/2013): the last meetings between the company and stakeholders were workshops organized by the Environmental Regulator (SEA). The goal of these meetings with different groups and associations was to inform the community about their right to participation during the Environmental Impact Assessment process. The project was assessed positively by the SEA and the participants of the last meetings

with representatives, who would agree with the company upon the possible benefits that the company would offer to the community.

Phase 5. Project cancellation (04/2013-2016): the last stage went from the EIA approval to the cancellation of the project. During this stage, there were no public events organized.

Table 2. Perception changes of local stakeholders throughout the five engagement phases of the Tolhuaca geothermal project

Stage / Stakeholder	*Phase 1 Project presentation to the authorities*	*Phase 2 Project presentation to the community*	*Phase 3 Site visit*	*Phase 4 EIA*	*Phase 5 Project closing*
Residents' association of Curacautín	Negative	Very negative	Neutral	Neutral	Negative
Network of NGOs	Neutral	Very negative	Very negative	Negative	Negative
Municipality Administration representative	Neutral	Neutral	Negative	Positive	Neutral
Tourist companies	Very negative	Negative	Negative	Negative	Very negative
Nearby residents' association	No data	Very positive	No data	Positive	Very positive
Ecological NGO	Very negative	Very negative	Very negative	Very negative	Negative
Landowner	Positive	Positive	Positive	Positive	Positive
Agriculture Department of the Municipality	Neutral	Neutral	Neutral	Neutral	Neutral
Indigenous leaders	Very negative	Very negative	Very negative	Very negative	Very negative

Very negative	Negative	Neutral	Positive	Very positive	No data

Table 2 shows that the perception of the project changed throughout the phases for six of the nine categories of stakeholders that participated in the project. For the landowner, the local authority 2, and the indigenous leaders, there was no change in perception. These were also the stakeholders that had the least contact with information from GGE-MRP. This is the only clear pattern visible in the table. The landowner saw the project favorably as it would bring financial benefits. The nearby residents' association showed only a positive perception that is linked to employment and funding for the local community. However, information for this group is lacking for phases 1 and 3. The local authority 2 had a rather neutral position and did not change, while the Mapuche

community leader had a very negative view throughout the process as he argued lack of participation in the process and that the project was disturbing sacred sites. However, this did not lead to any opposition movement.

The involved stakeholders had different expectations and interests concerning the project. Therefore, there is no common pattern to all of them. Only the environmental NGO 2 had a better perception at the end of the process compared to the beginning, and it remained a rather negative perception. The project perception of the network of NGOs was worse at the end of the project than at the beginning. All other research participants had a similar perception at the beginning and at the end of the process. However, it is noticeable that for a majority of stakeholders there was some improvement in the perception of the project during one of the phases 2 to 4. These were the phases in which the company had most contact with the local communities and organizations.

4.2 Factors influencing the social perception of the Tolhuaca project

When talking about how positively or negatively they perceived the exploration project, stakeholders did not only make evaluative judgements (talking about "good" or "bad"). They also mentioned specific elements related to project work, the engagement process, energy infrastructures in general or the social and political situation in Chile, which they used as arguments to explain their judgement. These elements enabled us to identify factors influencing the stakeholders' social perception. The arguments that influenced stakeholders' perception were grouped into three categories according to factors' linkages mentioned by participants: project activities, the engagement process and context.

4.2.1 Project activities

This category groups all mentions of aspects to harness geothermal resources and build the geothermal plant. In this group, we included actions made by the project, such as the drilling stage and potential project activities that were not carried out such as transmission lines. GGE-MRP did not have any direct intention on shaping stakeholders' perceptions when undertaking some of these activities.

One of the aspects mentioned the most was the construction of the drilling platforms at the top of the volcano. Because the drilling area was on a volcano, the first stage of the exploration was made by helicopters. This situation triggers social nuisances because it contributed to make project visible for the surrounding communities. The developer did not necessarily manage this information about the project execution in advance. Thus, for some Curacautín residents, the first approach to the project was by seeing helicopters, which was considered disruptive.

The alteration of the landscape was another aspect mentioned. In this sense, the building of the access road and site construction on the volcano was criticized because it could lead to cutting protected Araucaria trees and flattening a cone of the Tolhuaca volcano. These elements were raised by the ecological NGO, the Tourism companies, and the network of NGOs.

Similarly, potential project activities not implemented yet also played a role on stakeholders' perception. The future installation of transmission lines was highly criticized because of the

required high investments and high environmental impact since protected forests are located nearby the geothermal field. This was the case even for stakeholders who perceived geothermal energy positively.

> *"Geothermal energy is the friendliest one (energy source); however, energy transmission is the problem. We have natural reserves, geoparks, tourism, and endemic species" (NGO 2, 2018).*

At the same time, the environmental policies adopted by GGE-MRP were seen by some stakeholders as an adequate effort to protect the surrounding environment and mentioned as affecting their view of the project positively, but they argued that this process could start at the beginning.

4.2.2 The engagement process

This category encompasses all references to activities performed (or planned) by the company that were intended to have an effect on the community. This includes communication strategies as well as benefits that the communities would potentially get from the project.

A key element in the engagement process was the timing of the first contact with stakeholders. This refers to the moment when the company informed local stakeholders about the project for the first time. When participants were approached before drilling activities, the perception was influenced positively, whereas it was negatively influenced when the approach happened afterward. GGE-MRP was not legally required to inform or consult with communities in the exploration phase except during the Environmental Impact Assessment, which took place in the exploitation phase. Before starting construction activities, they informed local authorities and some local businesses. The representatives of the residents and NGO´s argued that they were informed once they had already observed construction activities. These stakeholders were also more critical:

> *"The project was presented when everything was already built up, the road and part of the platforms. Therefore, it was something invasive and really badly executed" (NGO 2, 2018)*

The lack of information regarding the closure of the project, and how the interviewed participants learned about this, was another aspect of engagement process that drew criticism In general, this negatively influenced stakeholders' perception started as participants felt that the company did not inform them about the reasons for abandoning the project. This aspect is connected to local expectations. Mainly, Curacautín residents expressed they had high expectations regarding benefits such as job positions or scholarships for the community. How the company managed the closing of the project affected this relationship because, after two years of project activity, local residents had increased their expectations, which was highly affected when the project ended.

4.2.3 Contextual elements

The category refers to all those factors mentioned by participants that are not directly linked to project activities or engagement activities undertaken by GGE-MRP, but that were mentioned by stakeholders when discussing their perception of the Tolhuaca project. Context involves other energy developments during the Tolhuaca project timeframe (2009-2016), such as a controversial hydroelectric project that raised social opposition in the La Araucanía region.

"In energy projects, especially when they include rivers, people are strongly influenced by economic benefits that they might receive. One example is Doña Alicia hydropower project, which was a strong fight that, at least, it was won [...] perceive distrust on any energy projects" (participant from Agriculture Department of the Municipality, 2018).

The perception of energy regulations also permeated the perception of the Tolhuaca project. In Chile, citizen participation is required only for the exploitation stage, which also implies a lack of environmental assessment for the exploration stage. This factor was critical for some participants, who pointed out that the participation process was after years of explorations.

For others, such as the indigenous community, volcanoes are associated with spirits that shall be respected. An example of such value of the nature is following provided.

"One does not go to the Court to argue that a river has an owner, a spiritual being, because that does not exist for them, or in the case of a volcano" (Indigenous leader, 2018).

The connection to the grid that the project expected for the exploitation stage also influenced how the project was perceived. Some participants considered that the possible electricity supply would not benefit the municipality because the electricity would be transmitted to a substation without passing through the local distribution grid.

"*That electricity was not meant to supply Curacautin, but it would be sent outside" (participant from Tourism Companies, 2018)*

5 Discussion

In this section, we discuss the implications of our findings on the dynamics of social perception and the categories for the development of geothermal energy projects. In particular, we discuss how the identified factors impacting perception dynamics and how they are related to one another.

5.1 The dynamics of perception are influenced by the identified categories

The factors identified in section 4.2. played a key role in influencing the dynamics of perception. By looking at the evolution of the perception through this qualitative social science approach, in this case, the perception during the early phases of the project depended on whether stakeholders were involved or not in this stage: those that were involved showed either neutral or positive perception, whereas those that were not showed a negative perception.

The perception from phase 1 to phase 2 improved for the stakeholders that perceived potential benefits of the project, such as job opportunities, and worsened for the ones that had false expectations about the benefits the project would bring, such as an electricity price reduction and long-term employment for locals. This finding shows the two-sided effects of the project's benefits: they do not help build a positive perception if they are over-expected or misunderstood.

Interestingly, most perceptions either remained the same or improved during the visits to the Tolhuaca geothermal field, with the exception of those who were sensitive to the environmental impact of the project. Being able to actually see the exploration installations on the site contributed to clarify some questions that the stakeholders had about the project.

The perception during the meetings related to the IEA procedure did not change for some stakeholders when compared to the previous stage since both stages happened in a very close timeframe. Perceptions of stakeholders who participated in the working group which would decide how to share the benefits of the project with the community were improved. This highlights the importance of inclusion in decision-making typically mentioned in acceptance studies (Vargas Payera, 2018). It further illustrates how communication about potential benefits should be as concrete and realistic as possible but also cautious in order not to create false expectations or being met with skepticism or distrust.

For the last stage, the stakeholders indicated that they did not receive any official communication about the project closure, and perception overall worsened. As this study is retrospective, it is also likely that the negative perception of this last phase negatively influenced the whole narrative about the project. Stakeholders anticipated some problems such as the transmission lines that would be installed if the project proceeded as well as environmental impact. Furthermore, they mentioned the lack of communication as a reason for such a negative perception. These results show the importance of not only communicating about project activities but also about a project's cancelation, as this may influence the future development of geothermal projects in that location. It also highlights that geothermal developers need to have enough information to discuss infrastructures that are beyond the scope of the geothermal plant, such as the impacts of the transmission lines.

5.2 Interrelation of categories

What our research illustrates is that the different factors influencing the social perception of geothermal energy are interconnected: the interaction, or combination, between factors of different categories is what shaped stakeholders' perception of the project (Figure 3). Such interactions happen because of the diversity of actors usually involved in such projects, the discussions that they have among each other, their weighing of different factors (for instance, negative environmental impact vs. financial benefits), as well as the development of the project in time, which might introduce new elements that will affect the perception of the project.

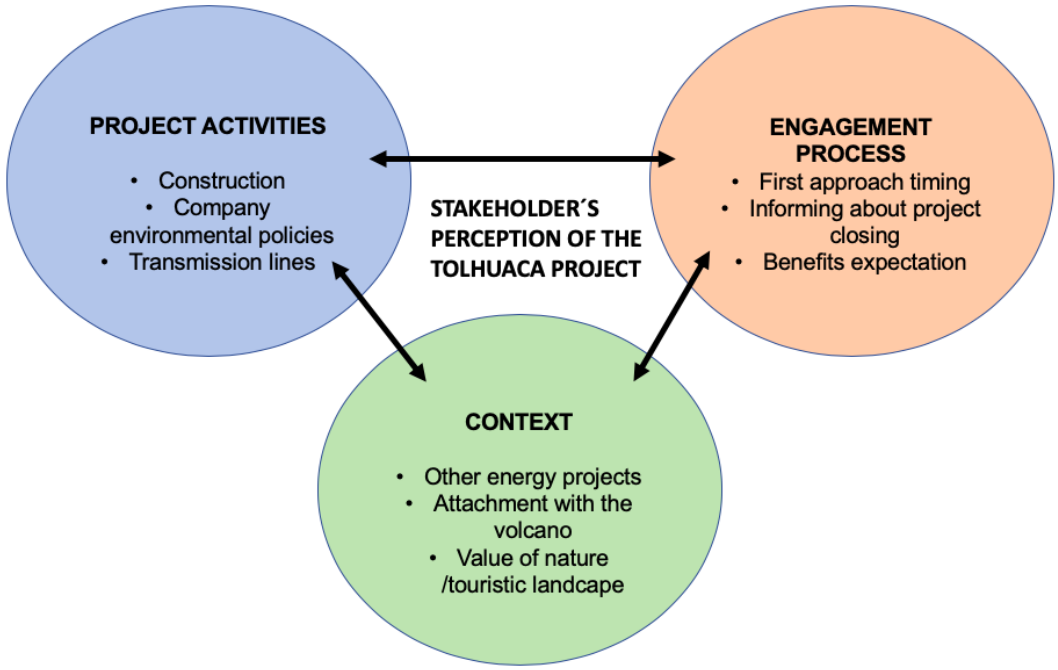

Figure 3. Influence diagram of the perception factors. The factors of each of the three categories and the combination of them influenced stakeholders' perception.

These interrelations become visible in stakeholders' discourse when they relate different factors in order to justify their position, as illustrated by the following quote:

"We saw mistakes that we could verify over a longer term […] Who will carry on the second project about the energy transmission lines? Meanwhile they showed us the enormous investments that they were doing and we saw the mistakes they were making. From April onwards the weather in the mountain is very snowy […]. They made the mistake by flattening a volcano to make the road, and they did not consult anybody […] They expected to get the drilling machine by December, but it only arrived in April. They installed it and it snowed heavily. The machine was not used until November 2011. And when the snow was over, they reinstalled the machine and broke a piece of it. The company was getting worse" (NGO 1, 2018).

The above example shows that some negative opinion of the project was influenced by the combination of factors: an undefined project to install the transmission lines needed to connect the expected production of 70 MW with the environmental impact during the construction phase, and the weather conditions in Winter that delayed project activities. It is through such discursive interrelations that the context of a project becomes shaped (Cuppen et al., 2020; Ejderyan et al., 2019).

However, as illustrated by our analysis of the Tolhuaca project, the engagement activities of the geothermal developer play a role in shaping the perception of the project and are also related to the other factors (see Figure 3).

For example, the only local stakeholders whose perception was improved at the end of the project were the neighboring residents' association, who showed a high level of expectations for the

project, especially in the benefits that this project would bring to their community. This positive perception may have been influenced by the fact that the company was in close communication with these participants and that they knew about the project since the very first geothermal explorations because of their proximity to the geothermal field.

But this also shows how a standard approach to public engagement might be detrimental. In this case, despite their distance to the site, the residents of Curacautín were aware of the ongoing activities on the volcano and also experienced some of the impacts related to the access road because of the low density of the population in the region. But because they were located more than 40km away from the site they had not been consulted. This shows that the definition of close populations is arbitrary, and project developers should identify the connections that the groups of people have with a geothermal site before defining their communication and engagement strategies. This especially applies in the La Araucanía region because of the strong presence of Mapuche communities, who interact with volcanoes that are not necessarily *close* to their settlements, and such relationships shall be respected according to the ILO-convention 169 (ILO, 1989).

6 Conclusion

In the context of including renewable resources in the global energy matrix, geothermal energy could play a pivotal role. In the last decade, there is a consensus about the importance of the non-technical dimensions for the successful implementation of energy projects, however, it is still not clear how to address social aspects such as stakeholders' interactions and social acceptance of the projects, being more complex than a binary spectrum. In this scenario, this paper analyzes how social perception changed during one of the most advanced and ambitious geothermal exploration projects in Chile. Although the project was canceled after years of exploration and after acquiring an exploitation license, this case is an interesting one to see how social perception changed among a diverse group of local stakeholders, and how factors that influence social perception are connected, more than being isolated.

The case study of the Tolhuaca project shows that even in early phases there is a wide range of factors that influence the perception of geothermal energy projects. These factors can be classified in three interrelated categories that encompass the activities that are necessary to physically carry out the project, the engagement activities that relate to all interactions between project developers and local stakeholders, and the contextual factors that relate to dimensions that are not part of the project but will nevertheless influence its development. Those results are fairly consistent with recent studies such as Chavot et al., 2018, and Cuppen et al., 2020 that highlight that local actors' reactions largely depend on local collective norms or contextual factors.

Project developers retain a high level of control over the project activities and are also often initiators of engagement activities. However, they have less influence on what will be considered as relevant contextual elements by stakeholders. These are highly dependent on existing local socio-political issues as well as what is valued by local stakeholders. These contextual elements play an important role in how stakeholders perceive a project. They work as an interpretative grid, through which stakeholders will "read" the developers' intentions.

Contextual elements may be activated by some of the project's activities. For example, the Tolhuaca case highlighted that cutting of Araucaria tree made the environment an even more salient contextual element. This scenario is more complex in contexts where there is a historical territorial dispossession and the energy development has been characterized by a complex relationship among companies, the State and local communities, such as Chile.

What we can learn from our qualitative case study is that engagement activities are critical and should not be thought of as stakeholder-developer interactions isolated from the evolving exploration/exploitation activities, but rather as a whole project that understands and responds to the dynamics within a given territory. There is no standard procedure applicable to any type of project everywhere in the world (Trutnevyte & Ejderyan, 2018). Actors will always relate the project to their specific individual and collective experiences and knowledge because these are the interpretative resources, they have to make sense of a new project (Cuppen et al., 2020). It is necessary to consider such experiences and knowledge when designing and developing a geothermal project that follows the right path.

This case illustrates the importance of doing a systematic assessment of who is in charge of the engagement process in an early stage of the project. Because the first approach between geothermal companies and local communities takes place in the exploration phase, there are some consideration to encounter: a) Develop a broad communication strategy during the early phase of the exploration to avoid lack of information and misunderstanding. In this sense, performing an early social analysis of the project location is critical to take into account local particularities of the territory. The Tolhuaca case points out how project decisions, such as using helicopters to explore the potential project site can raise suspicion and affect social perception, if the reason of their presence has not been communicated broadly. It is therefore crucial to establish communication channels with local stakeholders from the early beginning of the project, b) Because the first interaction is critical, the first workers' group in charge of the exploration phase play a key role. They are the first of getting in contact to the territory and consequently with local people. Even if the geothermal field is not located immediately near a town or a settlement, it is likely that the exploration team will pass and stop in settled area. In this sense, social skills of this group are needed and they should be able to provide some basic information, as for some actors they will be the first source of information about the project, and c) It is crucial to provide information to a broad range of local stakeholder in the exploration phase, including a proper communication of risks and timing of the project.

These research insights offer possible lines of inquiry for future studies, especially in Andean and Latin-American countries. Future empirical research could pay attention to follow up projects currently being developed to avoid some limitations of reconstructive case studies. Currently, in Latin America, there are advanced exploration and exploitation projects such as the expansion of Cerro Pabellón in Chile or Nevado del Ruiz in Colombia that could contribute to a deeper understanding of local stakeholders' perceptions, and the dynamics among contextual factors and engagement strategies.

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References

Almarza Farías, D. (2014). Geothermal development in Chile. Short Course VI on Utilization of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilization. Geothermal Training Programme. UNU-GTP and LaGeo.

Aravena, Diego & Lahsen, Alfredo. (2012). Assessment of exploitable geothermal resources using magmatic heat transfer method; Maule Region, Southern Volcanic Zone, Chile. *Transactions - Geothermal Resources Council*. 36.

Bloor, M., Frankland, J., Thomas, M., & Robson, K. (2001). *Focus Groups in Social Research*. London: SAGE Publications. Canan, P. (1986). Rethinking geothermal energy's contribution to community development. *Geothermics*, *15*(4), 431–434. https://doi.org/10.1016/0375-6505(86)90013-1

Carr-Cornish, S., & Romanach, L. (2014). Differences in public perceptions of geothermal energy technology in Australia. *Energies*, *7*(3), 1555–1575. https://doi.org/10.3390/en7031555

CASEN (2017) Encuesta de Caracterización Socioeconómica Nacional. Retrieved from http://observatorio.ministeriodesarrollosocial.gob.cl/casen-multidimensional/casen/casen_2017.php

Cataldi, R. (1999). Social acceptance: a sine qua non for geothermal development in the 21st century. *Bulletin d'Hydrogéologie*, (17), 467–476. Retrieved from https://pangea.stanford.edu/ERE/pdf/IGAstandard/EGC/1999/Cataldi.pdf

Chavot, P., Heimlich, C., Masseran, A., Serrano, Y., Zoungrana, J., & Bodin, C. (2018). Social shaping of deep geothermal projects in Alsace: politics, stakeholder attitudes and local democracy. *Geothermal Energy*, *6*(1), 26. https://doi.org/10.1186/s40517-018-0111-6

Chavot, P., Masseran, A., Bodin, C., Serrano, Y., & Zoungrana, J. (2019). Geothermal Energy in France. A Resource Fairly Accepted for Heating but Controversial for High-Energy Power Plants. In A. Manzella, A. Allansdottir, & A. Pellizzone (Eds.), *Geothermal Energy and Society* (Vol. 67). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-78286-7

Comisión Económica para América Latina y el Caribe (CEPAL) & Alianza Territorial Mapuche (ATM). (2012). Desigualdades territoriales y exclusión social del pueblo mapuche en Chile: Situación en la comuna de Ercilla desde un enfoque de derechos. Santiago: CEPAL-Naciones Unidas.

Contini, M., Annunziata, E., Rizzi, F., & Frey, M. (2019). Business Strategies in Geothermal

Energy Market: A Citizens-Based Perspective. In A. Manzella, A. Allansdottir, & A. Pellizzone (Eds.), *Geothermal Energy and Society* (pp. 39–53). Cham: Springer. https://doi.org/10.1007/978-3-319-78286-7_3

Cuppen, E., Ejderyan, O., Pesch, U., Spruit, S., Van de Grift, E., Correlje, A., & Taebi, B. (2020). When controversies cascade : Analysing the dynamics of public engagement and conflict in the Netherlands and Switzerland through "controversy spillover." *Energy Research & Social Science*.

Department of Energy. (2019). GeoVision: Harnessing the Heat Beneath Our Feet Executive Summary. Retrieved from http://www.osti.gov/scitech

Devine-Wright, P. (2005). Beyond NIMBYism: Towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy*, *8*(2), 125–139. https://doi.org/10.1002/we.124

Dowd, A. M., Boughen, N., Ashworth, P., & Carr-Cornish, S. (2011). Geothermal technology in Australia: Investigating social acceptance. *Energy Policy*, *39*(10), 6301–6307. https://doi.org/10.1016/j.enpol.2011.07.029

Duijn, M., Puts, H., & Boxem, T. (2013). *Laying the Groundwork for Public Acceptance of Enhanced Geothermal Systems. Deliverable No. 6.4. of the EC FP7 project GEISER. EC contract No. 241321*. Delft.

Ejderyan, O., Ruef, F., & Stauffacher, M. (2019). Geothermal Energy in Switzerland: Highlighting the Role of Context. In A. Manzella, A. Allansdottir, & A. Pellizzone (Eds.), *Geothermal Energy and Society* (Vol. 67, pp. 239–257). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-78286-7

Geothermal Table (2019), Mesa de Geotermia. Rol de la geotermia en el desarrollo de la matriz eléctrica chilena. Retrieved from https://geothermal.org/pdfs/Informe_Final_Mesa_Geotermia.pdf

GRC, Geothermal Resources Council Bulletin (2013) Vol.42, No1.

Gross, M. (2013). Old science fiction, new inspiration: Communicating unknowns in the utilization of geothermal energy. *Science Communication*, *35*(6), 810–818. https://doi.org/10.1177/1075547012469184

International Labour Organization (ILO). (1989). Convention No. 169 concerning Indigenous and tribal peoples in independent countries. Retrieved from http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_INSTRUMENT_ID:312314

Knoblauch, T. A. K., Stauffacher, M., & Trutnevyte, E. (2018). Communicating Low-Probability High-Consequence Risk, Uncertainty and Expert Confidence: Induced Seismicity of Deep Geothermal Energy and Shale Gas. *Risk Analysis*, *38*(4), 694–709. https://doi.org/10.1111/risa.12872

Knoblauch, T. A. K., Trutnevyte, E., & Stauffacher, M. (2019). Siting deep geothermal energy: Acceptance of various risk and benefit scenarios in a Swiss-German cross-national study. *Energy Policy*, *128*(December 2018), 807–816. https://doi.org/10.1016/j.enpol.2019.01.019

Kubota, H., Hondo, H., Hienuki, S., & Kaieda, H. (2013). Determining barriers to developing geothermal power generation in Japan: Societal acceptance by stakeholders involved in hot springs. *Energy Policy*, *61*, 1079–1087. https://doi.org/10.1016/j.enpol.2013.05.084

Manzella, A., Allansdottir, A., & Pellizzone, A. (2019). *Geothermal Energy and Society*. (A. Manzella, A. Allansdottir, & A. Pellizzone, Eds.) (Vol. 67). Cham: Springer. https://doi.org/10.1007/978-3-319-78286-7

Marris, C. (2015). The Construction of Imaginaries of the Public as a Threat to Synthetic Biology. *Science as Culture*, *24*(1), 83–98. https://doi.org/10.1080/09505431.2014.986320
Meller, C., Schill, E., Bremer, J., Kolditz, O., Bleicher, A., Benighaus, C., … Kohl, T. (2017). Acceptability of geothermal installations: A geoethical concept for GeoLaB. *Geothermics*, *73*(April 2017), 133–145. https://doi.org/10.1016/j.geothermics.2017.07.008
Moser, C., & Stauffacher, M. (2015). Literature review: Public perception of geothermal energy. In S. Hirschberg, S. Wiemer, & P. Burgherr (Eds.), *Energy from the Earth. Deep Geothermal as a Resource for the Future?* (pp. 297–306). Zürich: TA-Swiss/Vdf Verlag.
National Energy Survey (2016). Encuesta Nacional de Energia Retrieved from https://www.energia.gob.cl/sites/default/files/informe_encuesta_nacional_energia_2016.pdf
Lahsen, A., Muñoz, N. and Parada, M.A., 2010. Geothermal Development in Chile. Proceedings World Geothermal Congress, Bali, Indonesia. https://www.geothermal-energy.org/pdf/IGAstandard/WGC/2010/0118.pdf
Lohmar, S., Stimac, J., Colvin, A., González, A., Iriarte, S., Melosh, G., Wilmarth, M., & Sussman, D. (2012). Tolhuaca volcano (southern Chile, 38.3° latitude S): New learnings from surface mapping and geothermal exploration wells. Proceedings Congreso Geológico Chileno, 443–445.
Oltra, C., Upham, P., Riesch, H., Boso, À., Brunsting, S., Dütschke, E., & Lis, A. (2012). Public Responses to CO2 Storage Sites: Lessons from Five European Cases. *Energy & Environment*, *23*(2–3), 227–248. Retrieved from http://multi-science.atypon.com/doi/abs/10.1260/0958-305X.23.2-3.227
Ormad, A. (2013). Rüdiger Trenkle repasa las posibilidades y retos que afronta la geotermia en Chile | Piensa en Geotermia—Geothermal Energy News [Interview]. http://www.piensageotermia.com/rudiger-trenkle-repasa-las-posibilidades-y-retos-que-afronta-la-geotermia-en-chile/
Otero, Sofía (2015). Fighting the Information Gap and the Steam Monster, Proceedings World Geothermal Congress. Melbourne, Australia.
Pasqualetti, M. J. (2011). Social barriers to renewable energy landscapes. *Geographical Review*, *101*(2), 201–223. https://doi.org/10.1111/j.1931-0846.2011.00087.x
Pellizzone, A., Allansdottir, A., Franco, R. De, Muttoni, G., & Manzella, A. (2015). Exploring public engagement with geothermal energy in southern Italy: A case study. *Energy Policy*, *85*, 1–11. https://doi.org/10.1016/j.enpol.2015.05.002
RIMISP (2018) Informe territorio funcional Curacautín Región de la araucanía. Retrieved from http://rimisp.org/prototipodeinnovacionsocial/wp-content/uploads/2018/02/2.INFORME-TERRITORIO-FUNCIONAL-CURACAUTÍN CURACAUTÍN -REGION-DE-LA-ARAUCANIA.pdf.
Reith, S., Kölbel, T., Schlagermann, P., Pellizzone, A., & Allansdottir, A. (2013). *Public acceptance of geothermal electricity production*. Retrieved from http://www.geoelec.eu/wp-content/uploads/2013/07/Deliverable_4-4_final-public-acceptance-mmi1.pdf
Romanach, L., Carr-Cornish, S., & Muriuki, G. (2015). Societal acceptance of an emerging energy technology: How is geothermal energy portrayed in Australian media? *Renewable and Sustainable Energy Reviews*, *42*, 1143–1150. https://doi.org/10.1016/j.rser.2014.10.088
Ruef, F. (2018). La géothermie et l'opinion publique: l'importance du contexte. *Tracés*, (21), 18–19.
Sánchez, Pablo & Sielfeld, Gerd & Van Campen, Bart & Dobson, Patrick & Fuentes, V'ictor & Reed, Andy & Palma-Behnke, Rodrigo & Morata, Diego. (2015). Geothermal barriers,

policies and economics in Chile – Lessons for the Andes. *Renewable and Sustainable Energy Reviews*. 51. 1390-1401. 10.1016/j.rser.2015.07.001.
SEA. (2019). Sistema de Evaluación de Impacto Ambiental. Búsqueda de Proyectos: Curacautin. http://seia.sea.gob.cl/busqueda/buscarProyectoAction.php?nombre=curacautin
Stauffacher, M., Muggli, N., Scolobig, A., & Moser, C. (2015). Framing deep geothermal energy in mass media: the case of Switzerland. *Technological Forecasting and Social Change*, *98*, 60–70. https://doi.org/10.1016/j.techfore.2015.05.018
Stake, R.E. 2005. Qualitative case studies. In The SAGE handbook of qualitative research, 3rd ed, ed. N.K. Denzin, and Y.S. Lincoln, 443–466. London, Thousand Oaks: Sage Publications.
Stake, R.E. 1995. The art and science of case study research. Thousand Oaks, CA: Sage.
Trutnevyte, E., & Azevedo, I. (2017). Induced seismicity hazard and risk by enhanced geothermal systems: an expert elicitation approach. *Environmental Research Letters*. https://doi.org/10.1088/1748-9326/aa9eb2
Trutnevyte, E., & Ejderyan, O. (2018). Managing geoenergy-induced seismicity with society. *Journal of Risk Research*, *21*(10), 1287–1294. https://doi.org/10.1080/13669877.2017.1304979
Trutnevyte, E., & Wiemer, S. (2017). Tailor-made risk governance for induced seismicity of geothermal energy projects: An application to Switzerland. *Geothermics*, *65*, 295–312. https://doi.org/10.1016/j.geothermics.2016.10.006
Ugarte, M., Fontana, M., & Caulkins, M. (2019). Urbanisation and Indigenous dispossession: rethinking the spatio-legal imaginary in Chile vis-à-vis the Mapuche nation. *Settler Colonial Studies*, *9*(2), 187–206. https://doi.org/10.1080/2201473X.2017.1409397
Vargas Payera, S. (2018). Understanding social acceptance of geothermal energy: Case study for Araucanía region, Chile. *Geothermics*, *72*, 138–144. https://doi.org/10.1016/j.geothermics.2017.10.014
Whineray, F. (2015). Mighty River Power Financial Results FY2015 Presentation. Issuu. https://issuu.com/mercurynz/docs/mighty-river-power-financial-result_21ae46d8872d8a
Williams, L., Macnaghten, P., Davies, R., & Curtis, S. (2017). Framing 'fracking': Exploring public perceptions of hydraulic fracturing in the United Kingdom. *Public Understanding of Science*, *26*(1), 89–104. https://doi.org/10.1177/0963662515595159
Wynne, B. (2006). Public engagement as a means of restoring public trust in science - Hitting the notes, but missing the music? *Community Genetics*, *9*(3), 211–220. https://doi.org/10.1159/000092659