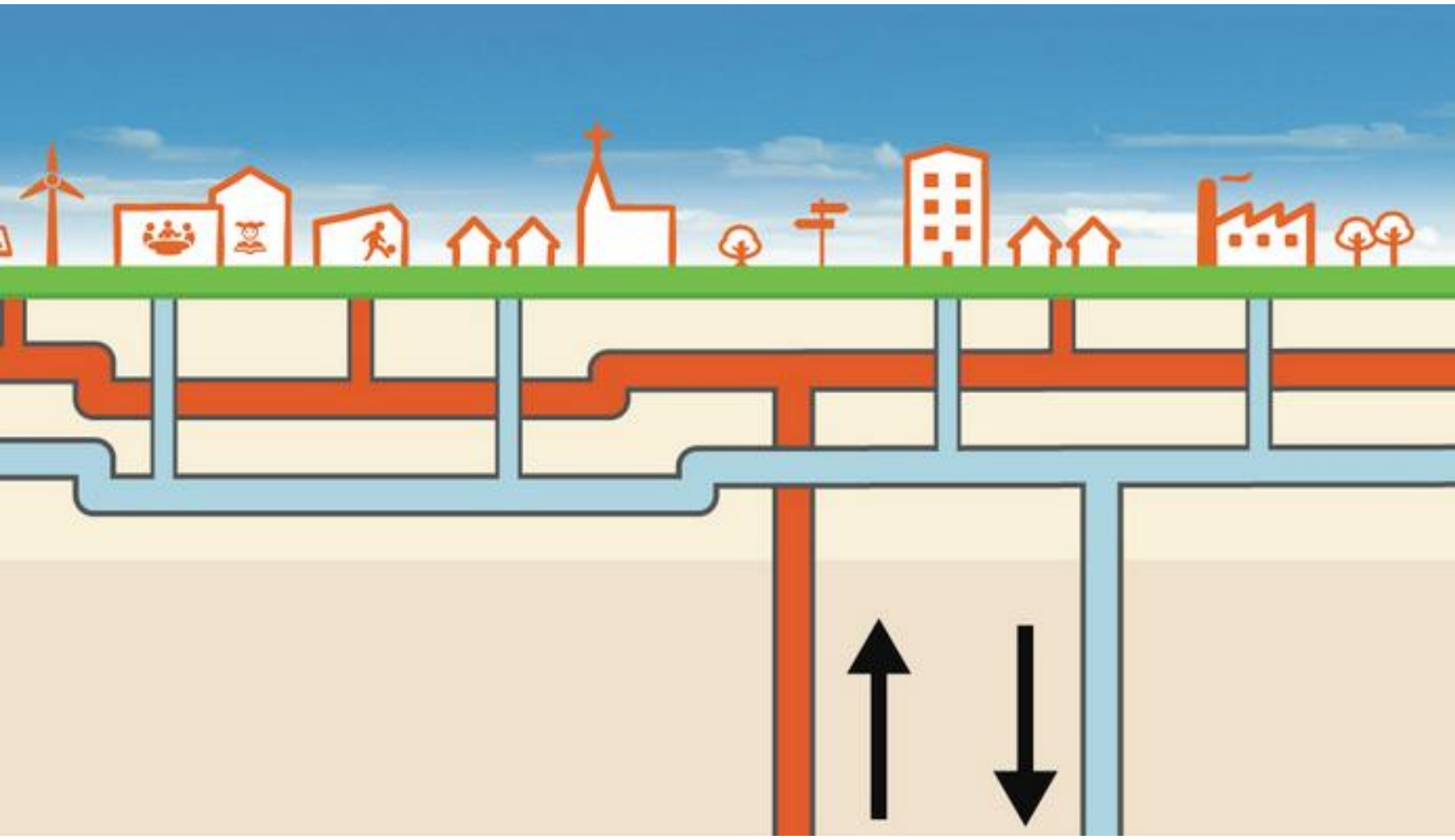
Andreas Vincent van Giezen

# Effects of cumulative social impacts on emotions regarding ultra-deep geothermal energy projects



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Royal HaskoningDHV Enhancing Society Together

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# Effects of cumulative social impacts on emotions regarding ultra-deep geothermal energy projects

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# Preface

I would like to thank Nicole Huijts for helping me find this thesis topic. I appreciated it very much that even though Nicole was switching between universities she still took her time and effort to help me set up a thesis committee and develop a proper research plan. Also thank you for your ideas and suggestions concerning findings throughout my thesis research. Secondly, I would like to thank Royal HaskoningDHV and especially my supervisor Philippe Hanna for providing me the with opportunity to conduct my thesis research within RHDHV. Hearing Philippe and colleagues talk about the importance of stakeholder engagement and impacts that technologies can have on people and the environment has been very interesting and gave me the idea I want to start my career in the field of social impact assessments.

Of course I would also want to thank my thesis committee for guiding me in this research. I would especially like to thank Eric Molin for his continuous feedback and suggestions concerning the statistical analysis chapters. I appreciated it very much that you responded very quickly and elaborately. I would also like to thank my second supervisor Sabine Roeser and my chairman Bert van Wee for their enthusiasm concerning the research topic and findings, as this helped me very much in gaining confidence and motivation to strive for more.

Lastly, I would like to thank my friends and especially my family for their support throughout my studies. It has been an incredible, but sometimes difficult, experience. Most of all I would like to thank my fiancée Wendy Gong for her never ending love and support; I wouldn’t have been able to do this without her.

Andreas Vincent van Giezen

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# Abstract

Royal HaskoningDHV is currently exploring ultra-deep geothermal heating systems in the Netherlands. Within this research it was analyzed whether people show different levels of emotions when being confronted with ultra-deep geothermal energy projects, and whether there are differences in antecedents of emotions between people living in an area with or without cumulative social impacts and between people living closer or further away from a potential project location.

It was found that people do not show different levels of positive and negative emotions when they were asked to imagine an ultra-deep geothermal energy project to be taken place at a distance of 600 meters or 5 kilometers from their living area. However, people living in areas with cumulative social impacts did show significantly higher levels of negative emotions.

This means that when looking at the possibility of starting ultra-deep geothermal energy projects in areas with cumulative social impacts, the project developers have to take into account that people will be more negative towards the technology, in comparison to other regions. As it is argued by some academics that emotions should play a vital role in debates and project developments, this should specifically apply to areas with cumulative social impacts as this will lead to more responsible project outcomes and thus will most likely increase public acceptance.

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# Executive summary

Royal HaskoningDHV is currently exploring ultra-deep geothermal heating systems in the Netherlands. Geothermal energy is generally seen as a safe and green technology. However as ultra-deep geothermal wells are situated at a depth of 4000 meters and deeper, more controversial drilling methods might be necessary. It is expected that this triggers negative emotions and potential objections against the technology. As studies have shown that public acceptance of new technologies is crucial for their successful introduction in society (Wustenhagen, et al., 2007), this is an issue that needs to be addressed. It is argued by some academics that including emotions in decision making processes and assessing risks could lead to more responsible innovations and by that to more public acceptance (Roeser, 2006; Roeser, 2012)

Furthermore, it is expected that resistance or negative feelings towards ultra-deep geothermal projects is more severe in areas with cumulative social impacts, which is defined as "*the successive, incremental and combined impacts of one or more activities on society, the economy or the environment*" (Franks, et al., 2011).

In this study, the impact of cumulative social impacts on people's emotions and antecedents of their emotions is compared to emotions and their antecedents of people living in other regions, that have not undergone cumulative social impacts of technologies. Also, a distance dimension is added where people's emotions and antecedents of their emotions will be compared, differentiating between people who were asked to imagine that an ultra-deep geothermal project takes place at either 600 meters or 5 kilometres from their houses. Based on the findings obtained from this thesis research, several management implications for the ultra-deep geothermal industry are identified. The objectives of this study have been translated into the following research question:

"What is the effect of cumulative social impacts on people's emotions and their antecedents, when being confronted with ultra-deep geothermal projects, and what are the management implications of this for the industry?"

To answer this main research question, several sub-questions have been defined, which read:

1. Which antecedents can be identified that could affect people's emotions when being confronted with an ultra-deep geothermal energy project?
2. What is the relationship between emotions and support or protests against ultra-deep geothermal projects?

3. To what extent do emotions differ when living in areas with cumulative social impacts and people living in areas without cumulative social impacts?
4. To what extent do people's emotions differ when living at different distances from a potential ultra-deep geothermal project location?
5. How do different distances and cumulative social impacts of areas affect the relationship between the antecedents and people's emotions?

A two-phased exploratory design study has been used in this research, consisting of a first explorative phase and a second larger quantitative phase.

## Explorative phase

The first phase consisted of a literature study and interviews. In the literature study it was found how ultra-deep geothermal technology exactly works and what its advantages and disadvantages are. The advantages of ultra-deep geothermal projects are; low $CO_2$ emotions, continuous energy production, low visual pollution, no extraction from the ground, and its long lifetime in comparison to some other renewable energy technologies. Its disadvantages are; more technical challenges, stimulation of deep underground most likely required, risks for explosions and earthquakes and that is creates nuisance for direct surroundings during its construction period.

Furthermore, the literature study focused on the relationship between emotions and technologies and showed the importance of cumulative impact assessments. It was found that emotions arise in response to antecedents that are perceived to be of importance to people. Several potential antecedents of emotions were identified. These antecedents are; perceived risks, perceived benefits, place-attachment, prior awareness, trust in industry, distributive fairness, and procedural fairness. These concepts are also the answer of the first sub-research question. Based on the literature study and unpublished documents provided by Nadja Contzen and colleagues from the University of Groningen, the following eight emotions have been selected for this research; Anger, Fear, Surprised, Irritated, Happy, Proud, Hopeful and Powerless.

Interviews have been conducted with actors who are actively involved within the geothermal industry and with laypeople. These interviews were used to gain an overview of the scope and implications of geothermal energy projects. In these interviews it came forward that people have a low trust in impact assessments and that they question the integrity of the local government. Furthermore, it was found that there is a participation paradox where people are only interested in raising their voice and concerns when a project becomes more tangible and investment have already been made.

Findings obtained from the literature study and from the interviews were used as input for the development of a survey study, that included an information sheet and a scenario description.

### Quantitative phase

In the second phase of this research a survey study was conducted to statistically analyze the differences in emotions and antecedents of emotions between people living in areas with or without cumulative social impacts and between the two measured scenario distances (600 meters and 5 kilometers). A factor analysis was conducted and revealed the following six factors that could be obtained from the survey: procedural fairness, distributive fairness, perceived risks and nuisances, trust in industry, prior awareness and distributive fairness. These factors, henceforth referred to as antecedents, were used in further analysis. Two extra items were added as they were deemed as important and relevant for this study, namely; expected change in quality of people's living area and people's importance of being involved. Furthermore, a factor analyses showed that the eight measured emotions could be reduced to two factors being 'negative' and 'positive' emotions.

Several multiple regression analyses were conducted. It was found that having positive emotions strongly predicts support for ultra-deep geothermal projects, whereas having negative emotions strongly predicts objection against those projects, thereby answering the second sub-research question. Likewise, having positive emotions is a significant negative predictor of objection to ultra-deep geothermal projects and negative emotions a significant negative predictor of support for these projects.

It was found that people's emotions do not differ depending on the distance between people's houses and the project location. Peoples negative emotions however do differ between those living in areas with or without cumulative social impacts, as those who lived in areas with cumulative social impacts showed significantly stronger negative emotions. The emotion fear was experienced most often, whereas the emotion anger was experienced the least. The emotion powerless was experienced the strongest, which confirmed findings from the literature study.

People experience significantly more positive emotions when they expect to get more procedural and distributive fairness and when they expect positive changes in the quality of their living area because of geothermal projects. Furthermore, the results showed that people tend to show more positive emotions when they are older and when they have more awareness about ultra-deep geothermal technology.

When looking at the relationship between the antecedents and the factor 'negative emotions' it was concluded that there are no significant differences in antecedents between areas with and without a cumulative social impact. Negative emotions are experienced stronger when people see more perceived risks and nuisances for themselves and others, but they are experienced less strong when people perceive more trust in the industry. Furthermore, people whose households were already connected to a city heating network tend to experience stronger negative emotions, and these negative emotions are even stronger for people living in an area with cumulative social impacts.

## Management implications

Based on the findings obtained from this research I suggest that the geothermal industry, both private and public, should actively try to include local residents in decision-making processes from the start, and they should find a creative solution to overcome the participation paradox that was identified in the qualitative phase of this study. I suggested developing an interactive digital app or platform that goes beyond the scope of a standard informative website or brochure. Such an app most likely lowers the threshold to go to early information meetings and could create more awareness amongst the residents who are being confronted with ultra-deep geothermal projects.

Another argument of creating more awareness is made as the Dutch government is rapidly decreasing its natural gas production in the province of Groningen. As installing individual heat pumps and making other adjustments to houses, so they become 'all electric', asks for huge investment costs by residents, this creates a potential for the geothermal industry to show its advantages to the general public.

Lastly, it was found that trust in the industry is a significant and strong negative predictor of having negative emotions. In the qualitative phase it was found that people do not always trust the industry and their messages. This is thus an important aspect to focus on, especially in regions with cumulative social impacts. One way of creating trust is by engaging non-biased third parties to presents facts about the geothermal industry and by taking care that the same actor or actors are involved in geothermal projects from the beginning until the end.

# 1. Introduction

This chapter discusses the relevance of this thesis study, its research objectives and research design. Lastly an outline is given on which information can be found in which chapter.

## 1.1 Background

Environmental and societal problems due to mankind's energy usage have pushed developments of more sustainable energy technologies. Some of these sustainable energy technologies are implemented and accepted by society rather smoothly, whilst others have encountered different degrees of resistance from the public (Huijts, et al., 2012) and strong emotional responses. Studies have shown that public acceptance of new technologies is crucial for their successful introduction in society (Wustenhagen, et al., 2007). Acceptance of a technology is the first, and most crucial, level in creating a social license to operate (SLO), which can be defined as approval and ongoing acceptance of a technology development by local communities and stakeholders (Wood & Thislethwaite, 2018).

Gaining knowledge on how people form an opinion on sustainable energy technologies and how they perceive associated risks and fairness creates insights in how a technology should be implemented and communicated, so that the ethical acceptability and societal acceptance increases and the implementation is more responsible and successful. Furthermore, Roeser has argued that people's emotions can provide insights in people's values and in ethical considerations that should be addressed in responsible innovations and that can, as a result, also lead to more public acceptance (Roeser, 2018).

Royal HaskoningDHV is currently exploring ultra-deep geothermal heating and energy systems in the Netherlands. Geothermal energy and heating is generally seen as a safe and green technology that is accepted by the public (Fridleifsson, 2001). However, ultra-deep geothermal wells are situated at a depth of 4000 meters and deeper, and might require more controversial drilling methods such as fracking the earth's crust (Majer, et al., 2007). For this reason, it is expected that ultra-deep geothermal projects will trigger more negative emotions, possibly resulting in resistance against the technology. Given the recent history of earthquakes and associated social problems in the province of Groningen in the Netherlands, due to years of natural gas production (van der Voort & Vanclay, 2015), it is expected that this resistance will be even more severe in such a location.

This master thesis research is linked to and builds forwards on an ongoing project on 'Developing socially responsible innovations: The role of values and moral emotions' by Linda Steg (University of Groningen), Sabine Roeser (Delft University of Technology) and others, funded by the Netherlands Organization for Scientific Research (NWO; Nederlandse Organisatie voor Wetenschappelijk

Onderzoek). The project closely involves several private companies, including Royal HaskoningDHV. In this project it has been proposed that values determine the emotions that people experience when being confronted with innovations, and that the effect of these values on emotions changes under different perceived implications of a technology. Within academic literature, and especially within the above-mentioned project, it has not been researched how the cumulative social impacts of an area changes the way people respond differently to a proposed technology. Franks (2011) defined cumulative impacts as "*the successive, incremental and combined impacts of one or more activities on society, the economy or the environment*" (Franks, et al., 2011). In this research, the term 'cumulative social impacts', or 'CSI', will be used to refer to the cumulated social effects of decades of natural gas production in Groningen on the local society. As it has already been proposed that people's values determine the emotions they experience, this thesis research will not specifically focus on values but on antecedents of emotions in general. The impact of cumulative social impacts on people's emotions and antecedents of their emotions will be compared to emotions and their antecedents of people living in other regions, that have not undergone cumulative social impacts of technologies.

## 1.2 Research objective and questions

In this research, two different dimensions are measured. Namely the distance of a project location to people's living area and areas with or without cumulative social impacts. The research objective of this study is threefold. Firstly, the objective is to identify different antecedents of emotions and to analyze to what extent the above-mentioned dimensions affect the relationship between these antecedents and emotions that people experience when being confronted with ultra-deep geothermal projects. Secondly, the objective is to research whether people show different emotions and different level of emotions when differentiating on these dimensions.

Lastly, the third objective of this study is to distinguish several management implications that the results of this thesis research will have for the ultra-deep geothermal industry. The objectives of this study have been translated into the following research question:

"What is the effect of cumulative social impacts on people's emotions and their antecedents, when being confronted with ultra-deep geothermal projects, and what are the management implications of this for the industry?"

To answer the main research question and to structure the research, several sub-questions have been defined.

1. Which antecedents can be identified that could affect people's emotions when being confronted with an ultra-deep geothermal energy project?
2. What is the relationship between emotions and support or protests against ultra-deep geothermal projects?
3. To what extent do emotions differ when living in areas with cumulative social impacts and people living in areas without cumulative social impacts?
4. To what extent do people's emotions differ when living at different distances from a potential ultra-deep geothermal project location?
5. How do different distances and cumulative social impacts of areas affect the relationship between the antecedents and people's emotions?

A two-phased exploratory design study has been used in this research, consisting of a first small explorative phase and a second larger quantitative phase. The results from the first explorative part have been used as input for the second quantitative phase. The first sub-question has been answered in the first part of this thesis research, which consisted of a literature study and interviews. The other sub-questions have been answered in the second quantitative phase of this research.

## 1.3 Research design

As stated above, this research consists of two phases, and can therefore be referred to as a mixed methods study (Creswell & Clark, 2007) where a survey instrument is developed based on the results of the first phase.

### 1.3.1 Phase 1: Literature study and interviews

The first phase consists of a literature study (see chapter 2 and 3) and interviews (see chapter 4). Findings from the literature study have been used to guide the interviews. Later, the results from the interviews, and detailed literature study, have been used as input for the quantitative part of this research.

Interviews have been conducted with actors who are actively involved within the geothermal industry. These interviews were used to gain an overview of the scope and implications of geothermal energy projects. Besides interviews with external private and non-profit parties, the researcher has used his position within Royal HaskoningDHV to talk to several other people working in the geothermal industry for Royal HaskoningDHV itself.

Based on the literature study and theoretical framework as described in chapter 2 and 3 , and the findings from the interviews with actors in the geothermal industry (chapter 4), an information sheet and scenario study was designed to inform laypeople about the ultra-deep geothermal technology and its risks and benefits, see appendix 1 and 2 (only in Dutch). After this, interviews have been taken with citizens concerning their opinions on the ultra-deep geothermal energy technology, and their considerations and feelings concerning such projects. People living in different types of houses were approached to participate. The results from these interviews and the literature study in chapter 2 and 3 have been used as input for the survey in the second, quantitative, phase of this research.

### 1.3.2 Phase 2: Quantitative study

As stated in paragraph 1.2, the research objective of this study is to identify different antecedents that trigger people to have certain emotions about ultra-deep geothermal projects. Another objective has been to identify whether the cumulative social impact of an area or different distances affects the relationship between these antecedents and emotions that people have regarding ultra-deep geothermal projects. This is done by means of a survey and statistical analysis of data obtained from a survey (see chapter 5 and 6). Background information on ultra-deep geothermal technology is provided in this survey, as well as a scenario study. These are all drafted using the information obtained from the literature study as well as information obtained from the qualitative part of this study. The questions that were asked in the survey and how the answers were coded can be found in appendix 3.

To analyse how people look differently at ultra-deep geothermal energy projects when living in areas with cumulative social impacts, in comparison to those not living in such an area, two different locations in the Netherlands were chosen as areas of interest for this study. The first area of interest is the municipality of Groningen, the second area of interest is in a radius of 5 kilometres around the municipalities of Ede and Wageningen. The population can be defined as anyone living in these areas. Only one location per case was chosen, due to budget and time restrictions. Selecting two locations per case (CSI or no CSI) would also mean the chosen sample size per respective group would become too small to perform reliable statistical analysis.

**Location with cumulative social impacts: Groningen**

The province of Groningen suffers from the (social) consequences (earthquakes, social unrest, and loss of real estate value) of decades of natural gas production in the area (van der Voort & Vanclay, 2015). Figure 1 (left) shows all the earthquakes in the province of Groningen since January 2008 with a minimum magnitude of 1.0 on the Richter scale. Furthermore, a proposed geothermal energy project by the public utility company Warmtestad was cancelled after criticism from the Dutch State

Supervision of Mines (SSM). The SSM stated that it is currently unknown if the likelihood of earthquakes would increase when geothermal projects are to be realised in earthquake prone areas (Volkskrant, 2017). Given the recent history of earthquakes and associated social problems in the province of Groningen in the Netherlands, due to years of natural gas production, it is expected that respondents from this area respond differently to the ultra-deep geothermal technology.


Figure 1: Seismic activities in Groningen and Ede/Wageningen. Data obtained from http://rdsa.knmi.nl/dataportal/

**Location without cumulative social impacts: Ede/Wageningen**

The location Ede/Wageningen was analysed as a nearby paper mill company is currently exploring the possibility of realizing an ultra-deep geothermal energy project as a source of sustainable heating for their production process and the location thus has a realistic potential for an ultra-deep geothermal (UDG) project. This company started collaborating with several parties to analyse the possibilities for an ultra-deep geothermal energy project in the area, so that it can increase its sustainability and so that sustainable heating can be delivered to city heating networks in the municipalities of Wageningen, Ede and surroundings (Aardwarmte in de Vallei, n.d.). This location is suitable to define as a location without cumulative social impacts, as no earthquakes are present in the surrounding, with an exception of one earthquake near the city of Tiel on December 2014, see Figure 1(right). No reports of damages or other social impacts due to this earthquake were found. Furthermore, there are no other processes known within this area that would result to in cumulative social impact as defined by Franks et al. (2011).

### 1.3.3 Data collection and analysis

An electronic survey study was conducted among residents living in the municipality of Groningen and the direct surroundings of the municipality of Ede and Wageningen, both located in the Netherlands. Two surveys were created, where a distinction was made in the scenario description. In the first scenario (henceforth referred to as 'survey 600m'), respondents were given a scenario description where they were asked to imagine an ultra-deep geothermal energy project to be realized within a distance of 600 meters from their living area. This distance of 600 meters correlates with the identified area of influence as described in chapter 2.4. In the second scenario (henceforth referred to as 'survey 5km'), respondents were given a scenario description where they were asked to imagine an ultra-deep geothermal energy project to be realized somewhere else in their municipality, at a distance of 5 kilometres from their living area. This distance corresponds with the identified distance for renewable energy technology acceptance as identified in chapter 3.3. The two surveys were distributed evenly by PanelClix, which is an international online market research panel. Both survey 600m and survey 5km were distributed in the location with and without cumulative social impacts.

Data has been analyzed using the Statistical Package for Social Sciences (SPSS) software. Data was assessed on reliability and validity. Factor analysis was conducted to check whether items and emotions could be combined into groups of antecedents and emotions. After this multiple regression analysis has been conducted and interaction effects were added. For this reason, the questions in the survey were asked on a 5-point ratio scale, where possible.

## 1.4 Contribution

The knowledge obtained from this study can be used by Royal HaskoningDHV during impact assessment processes and stakeholder engagement regarding ultra-deep geothermal projects. It could also be used to improve communication with the general public, so that the perceived antecedents leading to potentially negative emotions could be responsibly addressed. One way of addressing this could be by timely informing the general public and letting them participate in decision making processes. This would entail that Royal HaskoningDHV uses the findings obtained from these discussions in their future projects.

Furthermore, the scientific contribution of this research is to expand existing literature on antecedents of emotions regarding energy technologies in contexts with cumulative social impact. This research will show that emotions and their antecedents can differ per case and location. The results can be used to further improve the understanding of the importance of social impact assessment.

## 1.5 Thesis outline

Chapter 2 discusses why ultra-deep geothermal energy is becoming more relevant and it discusses the potentials of the technology. Furthermore, the chapter discusses the technologies advantages and disadvantages. Literature with respect to emotions and technology acceptance is discussed in chapter 3. This chapter also discusses the importance of cumulative impact assessments. In the end, a conceptual model is created that will be used throughout this thesis. Results from the qualitative part of this thesis research will be discussed in chapter 4. These results have been used to as input for the survey study as to make sure the information and scenario description provided in the survey is as reliable and realistic as possible. A discussion on how the survey was constructed and the validity of data obtained from the survey study is discussed in chapter 5. The results of the analyzed data are discussed in chapter 6, which also answers most of the (sub) research questions of this study. A conclusion of the results, together with a discussion on the limitations of this research and some recommendations for further research is provided in chapter 7.

# 2. Ultra-deep geothermal energy

This chapter provides information on the relevance, advantages and disadvantages of ultra-deep geothermal energy technology. The findings in this literature study will be used to guide the interviews taken in this study (chapter 4) and while developing the survey study (chapter 5).

Royal HaskoningDHV provided internal documents concerning UDG, which have been used as a basis for the first part of the literature study. Several databases have been used to find scientific information regarding geothermal energy, such as Google Scholar and Web of Science. Furthermore, newspaper websites and the TU Delft's library catalogue have been used. Additionally, snowballing (using citations or papers reference lists to find additional relevant papers) has been used throughout the literature study. Since the (ultra) deep geothermal industry is growing and changing rapidly, in the sense that it is becoming more mature, more recent work was preferred if it resembled the same quality as the older work.

## 2.1 Why UDG?

Geothermal energy is energy contained as heat in the Earth's surface. The Netherlands has been using the heat from the earth's surface for the last 35 years using surface heat pumps, which are typically situated between 30 and 150 meters deep. The usage of deep geothermal energy projects (anywhere between 500 and roughly 4000 meters deep) started taking off in 2007. About 15 deep geothermal energy projects have been developed since then and are currently running, where most of these wells are situated at a depth of 2-3 kilometres (Smink, et al., 2017).

A clear consensus on when one talks about deep geothermal and ultra-deep geothermal energy does not exists, however a quick study on different sources shows a general consensus (Gemeente Nijmegen, 2018; Renkum Nieuws, 2016; EBN, 2018; TNO, 2017; Hoogervorst, 2017). Within this consensus geothermal energy projects are referred to as ultra-deep when the reservoirs are situated at a depth of minimal 4000 meters and when a temperature of at least 120°C is reached. These are also minimum values used by the Netherlands Organisation for Applied Scientific Research (in Dutch: Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, TNO) (TNO, 2016).

In 2015, minister Kamp of the Dutch ministry of Economic Affairs and Climate Policy wrote a letter to the House of Representatives that geothermal energy can be seen as a promising technology to supply the Netherlands with a renewable form of heating and that it can be seen as a promising option to decrease the Netherlands' dependency on Natural gas (Ministry of Economic Affairs and Climate Policy, 2015).

Increasing interests in the possibilities of ultra-deep geothermal energy projects from both private and public parties resulted in the signing of a so called 'Green Deal Ultra-Deep Geothermal Energy' on June 19th 2017, by the Dutch government, research institutes and seven business consortiums (Rijksoverheid, 2017). In this Green Deal all parties agreed to share their strengths and knowledge in the research to speed up the development of the technology.

The reasons the Dutch government and private parties are so interested in the ultra-deep geothermal energy technology has to do with its potential. Almost 38% of the Dutch primary energy consumption consists of a demand for heating (Nationaal Expertisecentrum Warmte, 2013). The Netherlands Enterprise Agency (in Dutch: Rijksdienst voor ondernemend Nederland, RVO) stated that using geothermal energy is the only realistic option to provide the Dutch industry with widespread sustainable heating (Rijksdienst voor Ondernemend Nederland, 2015).

To this day there are no ultra-deep geothermal energy projects realized or being realized in the Netherlands. A study by the Joint Research Centre (JRC) of the European Commission showed 32 UDG projects worldwide, of which half of these were located in the EU. Out of all these projects there are 14 being currently developed, 10 have already been realised and the others have either been cancelled or put on hold (Sigfusson & Uihlein, 2015).

This paragraph defined how ultra-deep geothermal technology should be explained to the public and showed its relevance for the Dutch industry and government. This will be included in the information sheet that will be provided to people during interviews and the survey study.

## 2.2 How does UDG energy work?

Geothermal energy is energy contained as heat in the Earth's surface. This heat is present in huge quantities, however unevenly distributed and not concentrated. In literature, four types of geothermal systems are identified; hydrothermal, hot dry rock, geopressured and magmatic. Currently, only hydrothermal systems are exploited due to the technological advancement needed for the three other systems (Barbier, 2002). Therefore, only the hydrothermal systems are meant in this thesis while talking about (ultra-deep) geothermal projects and the others will not be further discussed.

At deep and ultra-deep geothermal energy projects, a well is drilled into a hydrothermal reservoir. This reservoir then provides a steady stream of hot salt groundwater or water vapour, depending on the depth and conditions of the reservoir. The hot salt groundwater is pumped to the surface, where a heat exchanger extracts the heat from the salt groundwater (Platform Geothermie, 2012a). A heat exchanger is an installation that transfers the heat from the salt groundwater towards fresh water.

This heated fresh water is then transferred to industries and/or city heating networks. Once cooled down, the fresh water will once again pass the heat exchanger and thus circles around. A disposal system injects the cooled down salt groundwater back into the deep underground. The salt groundwater will thus always stay within a closed piping system and will not be released into the surface water. The cooled groundwater will be released back into the ground at the same depth as where the water was initially extracted, but at a certain distance from the extraction point (Platform Geothermie, 2012a). This distance enables the cooled down groundwater to regain its original temperature, so that it does not affect the temperature of the groundwater near the extraction point. This is also illustrated in Figure 2 (Agemar et al., 2014, p. 4399).

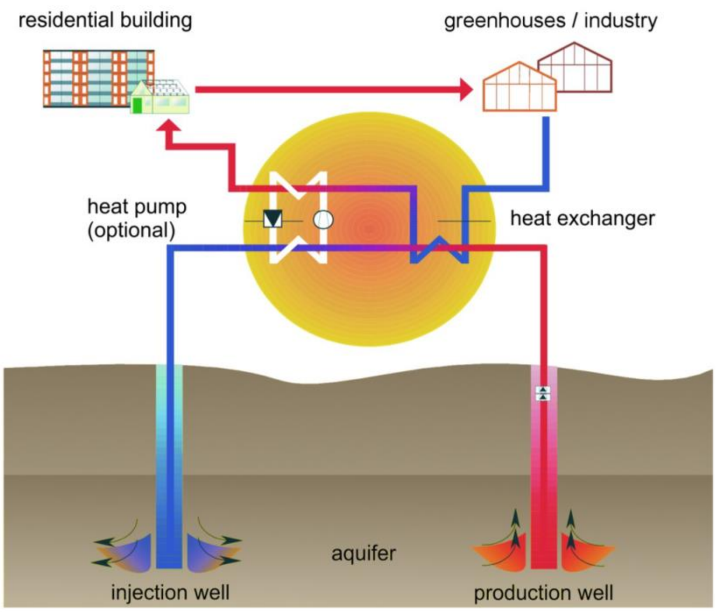


**Figure 2: Diagram of a doublet for hydrothermal exploitation. Reprinted from "Deep Geothermal Energy Production in Germany," by Agemar et al., 2014, Energies, 7, p. 4399, copyright (2014) by authors; licensee MDPI, Basel, Switzerland.**

This paragraph explained what types of geothermal systems exist and how (ultra-deep) geothermal systems work. It is important to ensure the working of the geothermal system is adequately explained, especially concerning the closed piping system, to prevent unnecessary concerns or doubts. To ensure this, the information text, that will be provided during interviews and during the survey, has been distributed amongst colleagues at Royal HaskoningDHV and has been corrected where possible. The next two paragraphs will discuss the advantages and disadvantages of UDG.

## 2.3 Advantages of UDG

This paragraph mentions the most mentioned and relevant advantages of (ultra-deep) geothermal energy. These advantages are based on internal documents provided by Royal HaskoningDHV and have subsequently been checked in academic literature for validity.

**Lifetime**

Geothermal energy is seen as a form of renewable energy. However, it must be noticed that on the long term, the reservoirs will cool down. Once this has happened, it will take a long time for it to restore to the original temperature. After 130 years the reservoir temperature will be at about 80% of its original temperature (IF WEP, Ecofys & TNO, 2011). On average, a geothermal reservoir can be used for about 30 years, which is significantly longer than most other renewable energy technologies.

**Low $CO_2$ emissions**

Heating houses, office buildings and industry with heat from geothermal reservoirs significantly reduces the $CO_2$ emissions in comparison with heating these buildings by means of traditional fossil fuels. An average of 88 percent decrease in $CO_2$ emissions, compared to natural gas, is obtained with current deep geothermal projects (Platform Geothermie, 2018). Most $CO_2$ emissions that are related to geothermal energy are a result of electricity used by the pumps. However, when renewable energy is used these emissions are close to zero.

Other $CO_2$ emissions that are released with geothermal energy production depend on the carbonate content of the water, but are in many cases so low that they are almost negligible, as can be seen in the following example: the Reykjavik District Heating system in Iceland produces a $CO_2$ emission of 0.05 mg $CO_2$/kWh, and the average of some geothermal district heating systems in China produce less than 1 g $CO_2$/kWh (Fridleifsson, et al., 2008).

**Continuous energy production**

Unlike energy produced from other renewable energy sources, such as wind energy and solar energy, geothermal energy can be produced independently from local weather circumstances and can thus provide energy (heating) every day throughout the entire year (Fridleifsson, et al., 2008). Since the production of heat at a geothermal well is very constant the energy prices are also expected to be more constant and predictable. Besides this, using energy from geothermal wells could also decrease the Netherlands' reliance on the energy supply of other countries.

**Low visual pollution**

In contradiction with most renewable energy systems, geothermal energy projects create limited visual pollution during its production lifetime (Office of Energy Efficiency & Renewable Energy, n.d.). Whereas, for example, windmills can be seen from far away and create shadow flicker, a geothermal installation is often only one or two floors high and can only be spotted in the direct surroundings. It must be noticed that this also creates a disadvantage, as will be explained in section 2.4.

**No extraction**

A benefit of this technology is that there is no extraction from the ground; the net pressure stays the same. With gas and oil production the pressure in the reservoir changes significantly, and this results in soil subsidence (TNO, 2009).

## 2.4 Disadvantages of UDG

This paragraph presents the most mentioned and relevant disadvantages of (ultra-deep) geothermal energy. These disadvantages are based on internal documents provided by Royal HaskoningDHV and have subsequently been checked in academic literature for validity.

**Nuisance direct surroundings**

Closeness to the end-users (whether that is a city heating network or the industry) is important to achieve efficiency. Households living in the direct surroundings of an ultra-deep geothermal energy project can expect to find nuisance from building site lighting, heavy traffic and drilling sounds during the construction period of the project (Platform Geothermie, 2018). These are usually present 24/7 for a period of 3-6 months with average geothermal projects.

The distinction between what is the direct surrounding and what is not the direct surrounding of an UDG project can be assessed by determining the projects area of influence (AoI) as set by the International Finance Corporation (IFC). The IFC defines the AoI as "*the area likely to be affected by the project, including all its ancillary aspect....*" (IFC, 1998). An AoI of 500 meter is determined for the Las Pailas Geothermal Project (drilling up to 2200 meters) in Costa Rica (Costa Rican Electricity Institute, 2014), and an AoI of 600 meters at the Tule Moye geothermal project in Ethiopia (drilling up to 3500 meters) (RG, 2017).

**Technical challenges**

As stated before in section in section 2.2, ultra-deep geothermal projects are carried out at a depth of four kilometres and deeper. There is an extensive and detailed knowledge database of the Netherlands' underground between the surface and 3.5 to 4 kilometres deep, due to more than 4000 oil- and gas drillings being carried out since the 1960's. Only 41 out of these 4000 drillings have been deeper than 4 kilometres, and only 6 have been deeper than 5 kilometres (Smink, et al., 2017). This means that, while looking at UDG projects, the 4-kilometre threshold means exploring new soil compositions, more risks in terms of unexpected insufficient results, and more uncertainties for the project executors. Furthermore, the technical challenges in terms of corrosion, blockage of the pipes, ghost-rock karstification, and leakage near the well and pipelines are expected to be bigger due to the different composition of groundwater being pumped to the surface at those depths (IF Technology, 2016).

**Enhanced geothermal stimulation**

At depths deeper than 4 kilometres the permeability of the deep underground might not be sufficient. This means that, at these depths, the high pressure on the rocks prevents water being able to run through the rocks sufficiently in order to create a reservoir. In these cases, it is possible to increase the permeability of the deep underground by means of hydraulic, chemical or thermal stimulation (Smink, et al., 2017). Hydraulic and/or chemical stimulation are the main options for the Netherlands. Geothermal projects are than generally referred to as an Enhanced Geothermal Systems (EGS) and it enables applying geothermal energy projects at places where it normally wouldn't be possible (Smink, et al., 2017). Stimulation for geothermal purposes is different than fracking for oil or gas, as smaller and fewer 'fracks' are required (10-300 meters versus >500 meters, 1 or 2 fracks versus 10-20 fracks) and also less fracking-liquid is required (500 cubic metres versus >2500 cubic metres) (Platform Geothermie, 2012b).

**Explosions and earthquakes**

As with any type of drilling, there is a risk for explosions during the drilling phase and production of sustainable heat from the geothermal well. However, the Dutch State Supervision of Mines (SSM, in Dutch: Staatstoezicht op de Mijnen, SodM) stated that the probabilities for explosions are small. An indication of how likely or unlikely this is in terms of percentages is not provided.

Furthermore, the risks for induced earthquakes due to geothermal energy projects is very small, since these projects do not change the pressure in the deep underground or the composition of the deep underground. However, when stimulation of the underground is required, the probabilities for induced earthquakes do increase. The SSM states that stimulation of the underground in or nearby natural faults or nearby areas with seismic activities due to natural gas production (for example; Groningen, the Netherlands) will almost always result in vibration of the underground (SodM, 2017).

The advantages and disadvantages that were identified are summarized in Figure 3 and will be described in the information text that will be provided to participants of the survey and interviews. Based on this, people will be asked how they perceive the benefits and risks that are linked to the technology in the survey. Since the AoI depends on the project conditions, no precise number can be given for the scenario description in the survey. Therefore the AoI of 600 meters from the Tule Moye project will be used as one of the two distances in the scenario description.

| Advantages | Disadvantages |
|---|---|
| Long lifetime | Nuisance direct surroundings during construction |
| Low $CO_2$ emissions | Technical challenges |
| Continuous energy production | Stimulation most likely required |
| Low visual pollution | Risks for explosions and earthquakes |
| No extraction from the ground | |

**Figure 3: Overview of advantages and disadvantages of ultra-deep geothermal energy**

# 3. Theoretical framework

This chapter discusses theories of emotions relevant for this study and identifies potential antecedents of emotions, specifically in the form of values. Furthermore, it describes the relationship between areas with cumulative social impacts and trust. A conceptual model is created that describes the relationship between the potential antecedents, distances, locations and emotions. Several databases have been used to find academic information regarding emotions and potential antecedents of emotions specific for technologies, such as Google Scholar and Web of Science. Search terms used were amongst others: *'emotions', 'primary and secondary emotions', 'emotions Groningen', 'emotions technology acceptance', 'public acceptance energy technologies', 'concepts of technology acceptance', 'impact assessments'* and *'renewable energy projects and emotions'*. Furthermore, newspaper websites and the TU Delft's library catalogue have been used. Additionally, snowballing technique (using citations or papers reference lists to find additional relevant papers) has been used.

### 3.1.1 Emotions

A definition of what emotions exactly are is difficult to give, as a consensus in academic literature has yet to be reached. Merriam-Webster defines emotions as "*a conscious mental reaction (such as anger or fear) subjectively experienced as strong feeling usually directed toward a specific object and typically accompanied by physiological and behavioural changes in the body"* (Merriam-Webster, 2018). Whereas Scherer defined emotion as "*an episode in the life on an individual"* (Scherer, 2001). In the next few paragraphs, the term 'feelings' is occasionally used. Scherer defined feelings as subjective experiences of emotional episodes and argues that it is a subsystem of emotions (Scherer, 2005).

In the study of emotions, a differentiation can be made between primary and secondary emotions. Primary emotions are direct reactions to external events, whilst secondary emotions are emotional reactions to having certain feelings concerning the external events (Christensen, 2010). For example, people may feel happy when they will benefit from a certain project, but they may also feel guilty about being happy that they benefit, knowing that others will not. In general, secondary emotions are often stronger and more complex. Primary emotions are, amongst others; fear, anger, surprise, happiness, rage, pain and pleasure, whereas secondary emotions can be amongst others; hate, guilt, pride, hope and irritation (Rodriguez-Torres, et al., 2005; Demoulin, et al., 2004; Leyens, et al., 2000). An emotion that is more rarely mentioned in academic literature is the emotion 'powerless'. I will come back to this emotion in paragraph 3.2; as we will see that this emotion plays an important role for this study.

Emotions play a strong and central role in people's lives as they influence our beliefs and attitudes and guide one's decision making process (Beaudry & Pinsonneault, 2010). Individuals form judgements on and have feelings about technologies (Perlusz, 2004), and these feelings are triggered when these technologies interrupt one's routines (Beaudry & Pinsonneault, 2010). Emotions thus arise in response to the antecedents that are perceived to be of importance to people. Both positive and negatives emotions are important in determining one's behaviour. Where negative emotions can point out problems with new technologies, positive emotions can point out positive aspects.

It is important to notice that positive and negative emotions are not necessarily situated on the opposite side of a scale and that they may very well coexist, thus one could naturally experience conflicting emotions simultaneously. This can happen on a frequent base (Perlusz, 2004).

Based on academic literature (Perlaviciute, et al., 2017; Huijts, 2018) and unpublished documents provided by Nadja Contzen and colleagues from the University of Groningen the following eight emotions have been selected for this research; Anger, Fear, Surprised, Irritated, Happy, Proud, Hopeful and Powerless.

### 3.1.2 Emotions & Technology

Emotions often play a major role in decision-making processes and/or the assessment of moral acceptability of risks, but this is usually seen as problematic as decision-makers believe decisions should be based on rational considerations (Roeser, 2006; Roeser, 2012). Emotions regarding energy projects are thus often disregarded, as they are said to result from the ignorance of the public. Roeser however argues that emotions should play a vital role in debates, as they bring up moral values that need to be taken into account. According to Roeser, people's emotions can provide insights in people's values and in ethical considerations that should be addressed in responsible innovation of technologies. She argues that as a result, this can lead to more public acceptance of a technology (Roeser, 2018). Responsible innovation can be defined as interactive and transparent process where different actors actively work together to increase the ethical acceptability, sustainability and societal desirability of the innovation (Owen & von Schomberg, 2011).

Whether or not people are willing to accept new energy technologies is a crucial factor in their success, as studies have shown that public acceptance of new technologies is crucial for their successful introduction in society (Wustenhagen, et al., 2007). Since addressing people's emotions can result in more responsible innovations, which could lead to more acceptance, technology acceptance models could be improved by incorporating people's emotions. However, many models that try to describe technology acceptance do not, or only limitedly, include people's emotions (Perlusz, 2004).

Slovic et. al. states that risk perceptions of laypeople differs significantly from those of experts, as they include concerns that experts do not define in their risk calculations (Slovic, et al., 2004). According to Roeser (2018), this can thus be used as an extra argument to include laypeople's emotions during decision making processes of technological projects, as a project could then become more responsible and most likely more accepted.

### 3.1.3 Potential antecedents of emotions

From the previous paragraph, it can be concluded that including people's emotions in decision making processes, technology developments and projects can lead to more responsible outcomes and more acceptance. As emotions arise in response to antecedents, this paragraph discusses concepts that are related to technology acceptance, and that can be potential antecedents of emotions. These concepts have been outlined as they all appeared in recent papers on public acceptance of geothermal projects and are also mentioned in broader literature.

**Place attachment**

When talking about acceptance of renewable energy technologies, one of the first and most famous concepts that comes to mind is the NIMBY (Not In My Backyard) problem (Devine-Wright, 2007). The NIMBY concept states that people are more negative towards projects in their local residential area than they would elsewhere, even though that project can be beneficial for the local area. It has been widely mentioned in, and is most famous due to, papers concerning public acceptability of wind turbines in and near residential areas. A study on the public acceptability of the geothermal technology in Australia has identified the NIMBY syndrome as a critical source of social resistance against geothermal projects (Carr-Cornish & Romanach, 2014).

The NIMBY concept has however also been criticised for being oversimplified, since negative attitudes towards energy technologies also depends on other social, personal (e.g. concerns regarding real-estate values), political factors and ethical considerations (West, et al., 2010; Devine-Wright, 2005; Basta, 2012). A response to the simplified NIMBY approach is by adding the psychological concept of 'place-attachment'. Place-attachment refers to someone's emotional bond with the local residential area (Perlaviciute & Steg, 2014). Disruptions to these place-based attachments are thus a core for emotional responses (Cass & Walker, 2009).

**Prior awareness**

A second crucial factor of social resistance against geothermal projects in Australia was defined as ´missing involvement issues´. Missing involvement issues, with lack of awareness as a major component, contributes to uncertainties about projects, negative perceptions and even opposition (Carr-Cornish & Romanach, 2014). To prevent these negative associations with a project or a technology, it is thus important that people have a certain knowledge or awareness of it. Leucht et al. argue that when people have no knowledge of a technology or a project this should be compensated by high degrees of trust in the industry or institutions for the project or technology to be accepted, as these concepts are related. This thus created a new factor labeled ‘trust’, which is related to one’s knowledge or awareness of a project or technology (Leucht, et al., 2010).

**Trust in institutions**

As mentioned above, not being involved in projects or a lack of knowledge about a technology could lead to negative perceptions of these projects and even opposition. However, for individuals to be participating in processes, they need to have a certain trust in the public institutions or industry. This has come forward as a crucial factor in a study on public engagement with geothermal energy in Italy (Pellizzone, et al., 2015). Trust can be defined as a psychological state where one intents to accepts being vulnerable if he/she has positive expectation of someone else’s behavior or intention (Rousseau, et al., 1998).

**Perceived benefits**

Environmental issues and energy security (in terms of being independent from other countries) are both identified as factors influencing someone’s acceptance or rejection of geothermal technologies (Carr-Cornish & Romanach, 2014; Pellizzone, et al., 2015). As a lack of awareness of a technology creates a lack of awareness of its benefits these two concepts are linked. So far, the role of deep geothermal energy is perceived as being small in comparison to solar and wind energy.

**Fairness**

Feeling unfairly or unjustly treated can create strong emotional responses to the public. This can be both in terms of procedurals and distributional fairness (Cass & Walker, 2009). The perceived fairness of decision making processes as well as perceived fairness of distribution of risks and benefits are thus important factors in measuring people emotional responses towards energy technologies.

The degrees to which people can participate in decision making processes mainly determine the procedural fairness (Visschers & Siegrist, 2012). High perceived procedural fairness thus contributes to a more positive attitude towards a technology, while feelings of being excluded from decision making processes will lead to negative attitudes and protests (Hanna, et al., 2016). Trust and procedural fairness are concepts that influence each other (Huijts, et al., 2012). Distributive fairness is related to the degree the risks and benefits are fairly distributed over an area and amongst users and non-users of a technology.

## 3.2 Cumulative impacts & Trust

Before new projects are started, project developers are obligated by governments to perform impact assessments. Impact assessments can be either environmental impact assessments (EIA) or social impact assessments (SIA). Environmental impact assessments inform stakeholders of the potential environmental impacts of proposed projects and the alternatives (Ortolano & Shepherd, 1995), whereas social impact assessments inform stakeholders about the potential social consequences that are likely to follow from a project development, including social and cultural consequences that affect the way people live, work, play, and be members of a society (Burdge & Vanclay, 1996).

Impact assessments (IA) focus on assessing the impacts of a single new policy or project development, while cumulative impact assessments (CIA) focus on assessing the combined impacts of activities on society, economy and the environment (Canter & Kamath, 1995). As stated in chapter 1, Franks et. al. (2011) defined cumulative impacts as "*the successive, incremental and combined impacts of one or more activities on society, the economy or the environment"* (Franks, et al., 2011).

Cumulative impacts assessments are rarely conducted and when they are done they tend to focus less on social impacts, giving priority to biophysical impacts. Franks et al. argues that, as the presence of one impact may change how another may be experienced is it especially important to include the social impacts in cumulative impact analysis and that CIA's are especially important in regions where environmental and/or social systems have reached a tipping point (Franks, et al., 2010).

Relating back to the current study, it is proposed that the extent to which people see an energy projects as threatening the locality depends on the trust deposited in the involved in actors (Perlaviciute & Steg, 2014). One of the reasons for this is because the general public needs to rely on the proponents and governments when evaluating costs and benefits of energy alternatives, due to the complex matters of development, production, safety, etc. These parties oversee the impact assessments as discussed earlier. The extent to which people trust these parties is thus an important factor of acceptability (Perlaviciute & Steg, 2014).

Lastly, a study on emotions concerning gas quakes in Groningen in the Netherlands showed that this negative emotion was experienced strongly in one of the areas of interest for this study (Perlaviciute, et al., 2017). As this area is an area with cumulative social impacts, this emotion is added to the previously selected emotions in paragraph 3.1.1.

## 3.3 Distance and technology acceptance

As has been mentioned before, the NIMBY concept states that people are more negative towards projects in their local residential area than they would elsewhere, even though that project can be beneficial for the local area (Devine-Wright, 2007). This thus suggests there is a distance dimension in people's perception on certain technologies. This suggestion is confirmed by Bertsch et al. (2016), who reached public acceptance of various renewable energy technologies and grid expansion, under different distances, in Germany. In this study it was found that distance does affect energy technology acceptance, and that at 5 kilometers or more at least 80 percent of the participants would accept the studied renewable energy systems (Bertsch, et al., 2016). Contradicting the study by Bertsch et al., a survey study by the National Wadden Vereniging showed that there was no relationship between distance and support or rejection of wind turbines in the Wadden region (Wolsink, 2007). As these two studies contradict each other, the dimension 'distance' has been added in this research. The first distance of 600 meters of a projects Area of Influence has already been identified in chapter 2.4, the second distance that will be measured will be the 5 kilometers as identified above.

## 3.4 Conclusion

Several important findings have been made in this chapter that helped improve the design of the questionnaire and thus the validity of this research. It was found that the concepts '*perceived risks', 'place-attachment', 'prior awareness', 'trust', 'perceived benefits',* and '*distributive and procedural fairness'* are all important factors when talking about public acceptance and emotions regarding a technology. This thus answers the first sub-research questions, which relates to which antecedents can be identified that affect people's emotions once being confronted with an ultra-deep geothermal project. Furthermore it was found that there are a wide variety of emotions that can be measured. The following eight emotions have been selected for this research; Anger, Fear, Powerless, Surprised, Irritated, Happy, Proud and Hopeful. As the potential antecedents and emotions have been identified, a conceptual model is developed that will be used throughout this research. Lastly it was seen that an area's cumulative social impacts and different distances (between one's living area and a project location) can affect technology acceptance, and by that potentially people's emotions regarding a technology.

A conceptual model is created based on the concepts discussed in this chapter, which can be seen in Figure 4. Figure 4 shows the potential antecedents that influence people's emotions, and how the influence of the antecedents on the emotions might be moderated by different distances or by locations with or without cumulative social impacts.

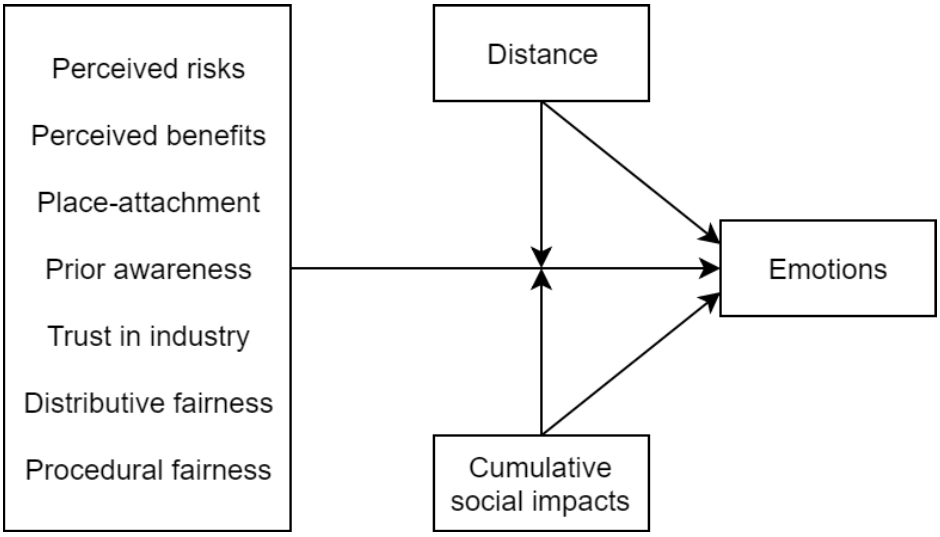


Figure 4: Conceptual model

# 4. Qualitative results

This chapter describes the findings of the interviews with actors involved in the geothermal industry and of laypeople. The results of these findings will be used as input for the questionnaire, information text about UDG and scenario description. The author has tried to translate the quotes to English to the best of his abilities, as all interviews were taken in Dutch. However, minor information loss is possible.

## 4.1 Interviews with actors in industry

Semi-structured interviews with three actors who are actively involved within the geothermal industry have been conducted. Two of these actors are project managers, whilst the third is a consultant working for a non-profit organization. These actors were selected based on their current position within the industry and based on discussion within Royal HaskoningDHV.

These interviews were used to gain an overview of the scope and implications of geothermal energy projects. Interviews were transcribed using NCH Express Scribe Transcription Software and completely anonymized. During the interviews, questions were asked such as '*What is your definition of ultra-deep geothermal, and how does it differ from deep geothermal?', 'What do you think of UDG in terms of its current status, safety, risks, etc.?', 'What is the social impact of UDG on the surroundings?*', and *'How should parties communicate with the public?'*. Responses from these interviews can be divided into four sections; 1) difference between deep and ultra-deep geothermal projects, 2) communication with residents, 3) advantages and disadvantages of geothermal energy and 4) attitude of the public and their concerns.

### 4.1.1 Difference between deep and ultra-deep geothermal projects

As already came forward in the literature study, there is no consensus about when one talks about deep and ultra-deep geothermal projects. One actor mentioned that a depth of 4000 meters or deeper is informally used when talking about ultra-deep geothermal projects.

Furthermore, actors within the industry have different ideas about the differences of deep and ultra-deep geothermal energy in terms of project efforts and safety. It has been mentioned that, besides an increase in scale, there are no big differences in terms of construction work, whilst it has also been mentioned that a significant increase in risks and investment costs is related to UDG. All actors stated that the average construction time increases by a few months when talking about UDG.

Lastly, all actors stated that drilling for geothermal is the same as drilling for oil and gas, and that stimulation might be necessary for ultra-deep geothermal projects and that this can create a bottleneck for a project's success. They also agreed that drilling for geothermal preferably takes place closer to the end-users, which is in contradiction to the oil and gas industry, who prefers drilling further away from residential areas. This confirmed the findings of the literature study.

As with the literature study, no consensus was found concerning the definition of ultra-deep geothermal energy. For this reason, the definition that was previously chosen in the literature study will be used. It was mentioned that the construction time increases by a few months when talking about UDG, and thus the 3-6 months that was mentioned in the literature study might be very optimistic. For this reason, a construction time of 6-8 months was mentioned in the provided information text.

### 4.1.2 Communication with residents

All actors seem to agree that open and regular communication with residents is of vital importance for geothermal projects to succeed. It can be concluded that the geothermal sector wants to be, in contradiction to the more reserved oil and gas sector, open about the risks and benefits of the technology. An example of how this is done in practice is given in the following quotes:

*"People will be invited on the project location for presentations, demonstration. This helps us show to residents that everything will go as planned and that we have the proper experience and knowledge to keep it safe."*

*"Being present with information stands on local events helped us."*

Actors also recognized that communication with residents can be difficult, as they sometimes believe information to be influenced or they show only interest in raising their voice in an advanced stage of the project. This raises the question how project executors should successfully include the public in the early 'vague' stages.

*"There is a participation paradox. Most freedom of a project is in the initial exploration phase. This is the phase where residents are least interested in. During this phase, residents do not attend information meetings. When investments have been made and the project becomes more concrete, residents start seeing the projects implications and raise their voice. At this stage, it is more expensive and difficult to make changes."*

In the literature study, it has come forward that trust is an important factor in acceptability of technologies. It was mentioned by one party during the interviews that people think a message is skewed when it comes from the project executor, whereas a different party said they had no experience with distrust in impact assessment. As this conflict each other, care has been taken to specifically include several questions related to trust in the survey.

### 4.1.3 Advantages and disadvantages of geothermal energy

Several advantages and disadvantages were mentioned by actors, which were also identified in the literature study. Advantages of geothermal energy include having a continuous energy output, predictable energy prices and low visual pollution. The disadvantages mentioned are more focused on the project executor side, such as having a difficult financing and implementation process and the need for continuous energy demand.

No information concerning the financing processes of (ultra) deep geothermal projects was found in the literature review, as this is often private information. Since this is a factor that concerns the industry and not the public, it does not contribute to answering the research questions for this research and will thus not be further discussed.

### 4.1.4 Attitude of the public and their concerns

Actors agreed that, at the time of interviews, the public and residents were moderately positive about geothermal projects and the technology. However, they mentioned there have also been negative reactions on having a semi-industrial installation placed above the ground, possibly in residential areas and that people associate seeing a drilling derrick with the oil and gas industry. It is important to notice that there are currently no ultra-deep geothermal projects realized or being realized in the Netherland. Findings and experiences of actors are thus all related to deep geothermal projects. Actors also recognized that there are certain terminologies (for example 'fracking' or 'explosion free zones') that the public can be sensitive to and that, should something happen, the public opinion could be quickly negatively altered.

An interesting finding from the interviews is that, according to one of the actors, local residents are sometimes proud of having geothermal project in their area. However, the following quote shows that the geothermal industry is still rather new and there is limited experience with deep geothermal projects in residential areas:

*"Currently many geothermal projects take place in the agricultural areas, where residents are positive. The question is whether this will also be the case once the projects will be launched in more populated areas."*

The interviews have shown that people expressed several concerns that were also mentioned in the literature study as being disadvantages of the technology. As people associate the technology with the oil and gas industry when seeing a drilling derrick, this could prove to be an important aspect to focus on when creating more awareness.

## 4.2 Interview with laypeople

Semi-structured interviews with three different laypeople were conducted. These interviews took place in different locations than the locations chosen for this study. This will be shortly further discussed in paragraph 7.3. Convenience sampling was applied, where the author went house by house for interviews. At the beginning these interviews, the interviewees were given background information on ultra-deep geothermal energy projects. This information sheet was based on the information found in the literature study and based on the findings from the interviews with actors from the industry. Interviews were once again transcribed using NCH Express Scribe Transcription Software. During the interviews, questions were asked such *as 'have you already heard of geothermal energy?', 'What would you think and how would you feel if there would be a UDG project placed in your village/area?', 'Would you object to such a project, and why?', 'Would you be worried about a UDG project in your area?', 'Do you think it will influence your daily life?',* and *'what do you think about the distributive fairness?'*.

### 4.2.1 Distrust in procedural fairness

It was found that the interviewees distrusted the municipalities and governments when it came to sustainable energy technologies and fair procedures. Part of this came from interviewees previous experiences with projects in their area. Procedural fairness is thus an important factor to measure, and to measure differences between areas with and without CSI.

### 4.2.2 Stimulation

Interviewees seemed to be more emotional and adverse of using stimulation in order to improve the permeability of the deep underground. They were afraid for damages to their houses and for seismic activities. The interviews confirmed that using stimulation is a sensitive topic and the general consensus about it is negative. As was found in the literature study, whether stimulation is necessary or not can differ from location to location and can change during projects. For this reason, the scenario description that people will be given during the survey will explicitly say that stimulation might be necessary, as to keep it as realistic as possible and not to steer people too much into one direction.

### 4.2.3 Nuisance during construction

Interviewees were most worried about the nuisance they would be exposed to during the construction phase. Especially the drilling sounds triggered negative feelings. Other people expect the nuisance to be over once the construction is finished.

### 4.2.4 Support vs objection

Some respondents indicated they would object if a project would be constructed near their living area, especially because of the drilling sounds. They were unsure whether they would also protest if the project would be somewhere else in town. Whilst others would not protest, since they see it as a form of sustainable energy and would think it is pleasant to use sustainable heating from a geothermal source.

## 4.3 Reflection of interviews & input for survey

Most of the findings from the interviews with the actors confirmed the findings from the literature study, such as in the case of the lack of clear consensus on what separates deep geothermal from ultra-deep geothermal projects. A finding that came forward in the interviews with actors is that residents might find nuisance from having an installation in their living area, as it somewhat looks like a semi-industrial installation. This could have a social impact on how people perceive the quality of their living area and will therefore be mentioned in the information sheets provided in the survey study.

Furthermore, it was found that laypeople have a low trust in impact assessments and question the integrity of the local governments. Laypeople expect to face nuisance during construction and from the above ground installation. They are also skeptical about using stimulation. Lastly, whether people would support or object to a project seemed to be mainly driven from personal considerations, as they were unsure whether they would protest to a project if it were in a different location in their municipality. As some expected to experience high nuisance, this will also be measured in the questionnaire. The measurement ‘perceived nuisance’ can thus be seen as an addition to the already determined potential antecedents of emotions as discussed in chapter 3.4.

As a participation paradox was identified, an extra question in the survey was added concerning how important people find it to be involved in decision making processes, instead of only their expectations on procedural fairness. This could potentially create extra insight into the participation paradox issue.

# 5. Questionnaire design

A survey study was conducted to analyze differences in emotions and antecedents of emotions between the two before mentioned dimensions (distance and location with CSI). The literature study and the interviews helped construct the information sheet and scenario description provided in the survey, as well as the survey questions themselves. This chapter describes how the survey study was constructed and conducted. Furthermore, it describes the validity of the sample. Lastly this chapter describes which question items from the survey could be combined to form groups of items which can be used as antecedents of emotions, as this would increase the power of the statistical analyses.

## 5.1 Survey outline

A survey was created that measured the concepts as described in chapter 3 and seen in Figure 4. Additionally, the items 'project support' and 'project protest' were added. All concepts were measured by at least two items, but preferably three or more, items in the survey. Respondents were able to provide their answers on a five-point Likert scale where possible. Depending on the question, the scales ranged from *very undesirable* to *very desirable*, *not at all* to *totally*, *very negative* to *very positive*, *very unfair* to *very fair*. A 6$^{th}$ option was given for '*don't know'* or '*not applicable'*, this was later substituted into the value '*neutral*' (3). The questions have been based on yet unpublished work provided by Nicole Huijts and colleagues. Lastly, the eight emotions as described in paragraph 3.1.1 were measured on a five-point Likert Scale, based on documents provided by Nadja Contzen from University of Groningen. For the emotions, the scale ranged from '*a little*' to '*very strong*'.

Appendix 3 shows all the items that were asked in the surveys along with the specific answer possibilities, in their respective order. It also shows how the responses were coded. Initially, the respondents were given a small introduction on the relevance and purpose of the study. In the second section, respondents were asked some basic demographic question, such as their gender, age and educational level. In the third section, respondents were given an information sheet and picture (appendix 1) concerning UDG. This information sheet covered all the relevant background information of UDG, including the way it works, its advantages and disadvantages. After this, respondents were asked if they had any prior awareness of UDG and how they perceived the benefits of UDG. In the fourth section, respondents were given a scenario description (appendix 2), where they were asked to imagine a UDG project to be taken place at either 600 meters or 5 kilometers from their living area. These two distances have been selected based on literature, as described in paragraph 2.4 and 3.3. Respondents were given extra information of what this would mean for them in terms of costs, risks, and benefits. After this, 22 questions were asked that covered the remaining concepts. In the fifth section, respondents were asked how strong they experienced the eight emotions, where they were also given the option ‘not applicable’. Respondents were specifically asked to state their emotions on the end of the survey as to make sure they had given the technology and scenario, by answering all the other questions, sufficient though. In the last section, several validation questions were asked. Respondents were given five statements and were asked whether they thought this was correct or incorrect, based on the information they were given in the information sheet and scenario description.  An overview of the sections in the survey is given in Figure 5.

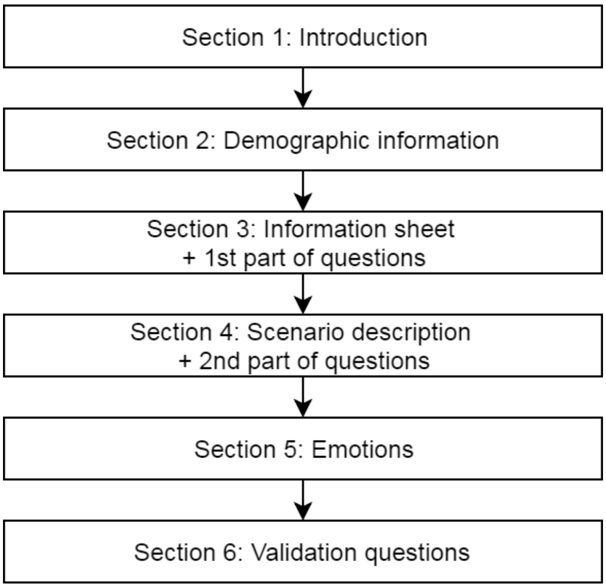


**Figure 5: Structure of survey**

## 5.2 Sample validity

The two surveys were distributed evenly by PanelClix, which is an international online market research panel. Both survey 600m and survey 5km were distributed in the location with and without cumulative social impacts. In total 436 respondents completed the surveys, which yielded a response rate of roughly 21 percent.  The survey with ‘distance 600m’ was completed 211 times and the survey with ‘distance 5km’ was completed 225 times. The inputs from several respondents were removed since information was missing about any of the eight given emotions (respondents responded ‘not applicable’ to all eight emotions). Furthermore, the inputs from several respondents were removed since they reported to be living in locations that were not in the area of interest for this study.

As mentioned in paragraph 5.1, five validation questions were asked in the last section of the survey. These questions concerned information that was provided in the information sheet and scenario description, which were both given in the survey. Respondents were given five statements and were asked whether they thought these statements were either correct or incorrect. Respondents who gave more than two incorrect questions were excluded from the survey as to increase the validity of the responses. In other words, when respondents were not able to provide three or more correct answers, their inputs were removed from the data set. A benefit of this check is that respondents who did not read the information sheets and/or scenario description are more likely to be filtered out of the data set, thereby increasing its internal consistency. In the end, 358 out of the original 436 respondents remained. Table 1 shows how these respondents are fairly distributed amongst their locations and scenario distances.

**Table 1: Distribution of respondents among location and scenario distance**

| Number of respondents provided | Location with CSI | Location without CSI | Total |
|---|---|---|---|
| Distance 600m | 86 | 91 | 177 |
| Distance 5km | 95 | 86 | 181 |
| Total | 181 | 177 | **358** |

### 5.2.1 Representativity to Dutch society

Demographic characteristics obtained from the surveys was compared to demographic characteristics of the Dutch society, to see whether results from this study can be representative for the Dutch society. Demographic characteristics that were obtained from respondents were their gender, age and educational level. It was found that the distribution of gender in both surveys can be seen as moderately representative of the Dutch society (CBS, 2018a). This is also shown in Table 2.

**Table 2: Gender distribution of surveys compared to Dutch society**

| % | Survey 600m | Survey 5km | Dutch society |
|---|---|---|---|
| Male | 50 | 47 | 49 |
| Female | 50 | 53 | 51 |
| Total | 100 | 100 | 100 |

When looking at the distribution of educational levels of the respondents and the distribution of the Dutch society, it was found that higher educated people are overrepresented in the sample of this study and that respondents with a primary school level are underrepresented (CBS, 2018b). This can be seen in Table 3.

Table 3: Educational level of surveys compared to Dutch society

| % | Survey 600m | Survey 5km | Dutch society |
|---|---|---|---|
| Primary school | 4.5 | 6.0 | 11.6 |
| High school | 28.3 | 23.8 | 30.2 |
| MBO | 22.6 | 23.2 | 29.6 |
| HBO / University | 44.6 | 47.0 | 28.6 |
| total | 100 | 100 | 100 |

Lastly, respondents' age distribution was compared to the Dutch society, as can be seen in Table 4. It was found that the age distribution 0-18 was severely underrepresented in our sample, this can mostly be explained by the fact that a minimum age restriction of 12 years is set to be a member of an online panel. Respondents in the age category of 26-35 and 56-65 are slightly overrepresented, whereas respondents in the other categories seem to be the same as the Dutch population (CBS, 2018c).

Table 4: Age distribution of surveys compared to Dutch society

| % | Survey 600m | Survey 5km | Dutch society |
|---|---|---|---|
| 0-18 | 0.6 | 0.0 | 21,1 |
| 18-25 | 8.5 | 12.1 | 10,0 |
| 26-35 | 18.6 | 17.7 | 12,3 |
| 36-45 | 12.4 | 14.4 | 12,5 |
| 46-55 | 17.6 | 17.1 | 15,0 |
| 56-65 | 23.7 | 19.9 | 12,9 |
| 65+ | 18.6 | 18.8 | 17,3 |
| Total | 100 | 100 | 100 |

Based on above mentioned comparisons, it can be concluded that results from this study can be seen as fairly representative of the Dutch society to a certain extent, but not completely as people with a higher education are overrepresented in the data. As a comparison is made between four groups in this study (location with CSI 600m distance, location without CSI 600m distance, location with CSI 5km distance, location without CSI 5km distance), the next paragraph discusses whether there are significant differences in demographic characteristics between these groups, as this would mean results could not be compared with each other.

### 5.2.2 Representativity of demographic characteristics between measured dimensions

Since a comparison between scenario distances is made in this research, it was checked whether the demographic data of respondents from both scenario distances and both locations is comparable. A Chi-square test of independence was calculated, where the frequencies of male and females at different distances and locations were compared. This has also been done for the frequencies of households which were or were not connected to a city heating network. No significant interactions were found. The results of this can be found in Table 5.

**Table 5: Results of Chi-square test**

| Characteristic | Dimension | Pearson X2 | df | N | P-value |
|---|---|---|---|---|---|
| Gender[1] | Distance | .273 | 1 | 358 | .601 |
| Connection with heating network[1] | Distance | .057 | 1 | 358 | .812 |
| Gender[1] | CSI | 1.906 | 1 | 358 | .167 |
| Connection with heating network[1] | CSI | 1.168 | 1 | 358 | .280 |

1: Continuity correction applied

A Mann-Whitney test was performed since the educational level and age distribution was measured on an ordinal level, see Table 6. The tests indicated that there are no significant differences in age distribution or level of education among respondents from both scenarios distances and no difference in age distribution among respondents in both locations. A difference was found in educational level among respondents between the location with and without CSI. It was found that the respondents in the location with CSI were significantly higher educated than the respondents who filled in the survey living in an area without CSI.

Overall it can be concluded that results obtained from further analysis can be compared between the different dimensions as the demographic data of respondents between the dimensions is comparable, with an exception of education between the two locations. This is a sensitivity and will be further discussed in the review of the study in chapter 7.

Table 6: Results of Mann-Whitney

| Mann-Whitney test | Location | Median | Z-value | P-value |
|---|---|---|---|---|
| Age | CSI | 4.66 | -1.356 | .175 |
| | No CSI | 4.89 | | |
| Education | CSI | 5.15 | -2.580 | **.010** |
| | No CSI | 4.76 | | |
| Age | 600m | 4.84 | -.690 | .490 |
| | 5km | 4.71 | | |
| Education | 600m | 4.92 | -.595 | .552 |
| | 5km | 4.99 | | |

## 5.3 Factors derived from survey

A principal-axis factor (PAF) extraction was conducted to examine the underlying structure of items in the survey that related to the antecedents and emotions as discussed in chapter 3.

### 5.3.1 Factors of items for antecedents

A PAF with a direct oblimin rotation was conducted on data from the 358 valid respondents. Based on the Kaiser-Meyer-Olkin measure of sampling adequacy, Bartlett's test of sphericity and the communalities, factor analysis was deemed suitable for 25 items, 2 items were excluded from the extraction as their communalities were below 0.3. Results from these three checks can be found in appendix 4.

Loadings less than .25 were excluded from the output. Initial eigenvalues of the remaining items indicated that there are 6 factors. Several variables that loaded on two factors were present in the six-factor solution. Four iteration processes were performed where the variables that loaded on more than one factor were stepwise deleted, until a simple structure was achieved.

An orthogonal rotation method was not used as some correlations in the factor correlation matrix (of the oblimin rotation analysis) were in a grey area, with values between .30 and .50. This could indicate that orthogonal rotation was less suitable. This matrix is shown in Table 7. Since this check was not conclusive on its own, the pattern matrix of an oblimin rotation was compared to the rotated factor matrix of an orthogonal rotation. Factor loadings were somewhat the same, however another item had to be removed in order to achieve a simple structure. This item was deemed important and relevant for that factor, and thus the results from the oblimin rotation were used.

**Table 7: Factor correlation matrix with an Oblimin rotation of measured items.**

| Factor | PF | PB | PRN | TI | PA | DF |
|---|---|---|---|---|---|---|
| PF | 1.000 | .322 | -.295 | -.343 | -.130 | .421 |
| PB | .322 | 1.000 | -.352 | -.287 | -.001 | .172 |
| PRN | -.295 | -.352 | 1.000 | .269 | .146 | -.350 |
| TI | -.343 | -.287 | .269 | 1.000 | .035 | -.045 |
| PA | -.130 | -.001 | .146 | .035 | 1.000 | -.231 |
| Df | .421 | .172 | -.350 | -.045 | -.231 | 1.000 |

Extraction method: Principal Axis Factoring    Rotation method: Oblimin with Kaiser Normalization

PF = Procedural Fairness, PB = Perceived Benefits, PRN = Perceived Risks and Nuisances, TI = Trust in Industry,

PA = Prior Awareness, DF = Distributive Fairness

Lastly, two other items were seen as being unrelated to the factors and were therefore also excluded. One of these factors also had a low loading of .315. Items that were excluded from the extraction are not inadequate items, but simply measure something different than the variables within the factors. In the end, 19 items remained in the simple structure with an oblimin rotation.

Internal consistency for each of the factors was examined using Cronbach's alpha. The alphas were moderate to high and can be found at the bottom of Table 8. This indicated that the items in the factors are sufficiently closely related to be used as factors in further analysis. No substantial increases in alpha for any of the scales could have been achieved by eliminating more items. The final results of the factor analysis can be seen in Table 9, along with the mean and standard deviation of the items. An explanation of all the factors is given below the table. As can be seen there are two items that have a loading in the grey area (just below .5), however as these items fit with the rest of the items in that factor they have not been excluded. The high loading items were combined the factors by averaging the scores.

**Table 8: Factor loadings of measured items from Principal Axis Factor Analysis**

| Item | Factor loading | | | | | | Mean | St. Dev. |
|---|---|---|---|---|---|---|---|---|
| | PF | PB | PRN | TI | PA | DF | | |
| Municipality will consider the well-being of citizens throughout the decision-making process | .868 | | | | | | 2.84 | 1.023 |
| Municipality will include opinions of citizens throughout decision making process | .830 | | | | | | 2.92 | 1.079 |
| Citizens will get sufficient voice in the municipality | .721 | | | | | | 3.20 | 1.038 |
| A project can still be adjusted once its plans are announced by the municipality | .499 | | | | | | 2.81 | 1.082 |
| Degree to which UDG will contribute to energy transition | | .859 | | | | | 3.44 | 1.015 |
| Degree to which UDG will benefit the environment | | .811 | | | | | 3.51 | 1.034 |
| Degree to which UDG will contribute to solving climate problem | | .713 | | | | | 3.77 | .955 |
| Degree to which UDG will help predict costs of heating | | .557 | | | | | 3.32 | 1.070 |
| Expected degree of risks for people living in the AoI | | | .827 | | | | 3.30 | .871 |
| Expected degree of personal nuisance due to the project | | | .765 | | | | 3.26 | 0.976 |
| Expected degree of nuisance for all living in AoI | | | .751 | | | | 3.02 | 0.883 |
| Expected degree of personal risks due to the project | | | .746 | | | | 3.30 | .871 |
| Degree to which I expect there is the intention to place a UDG system which is as safe as possible | | | | -.849 | | | 4.09 | .971 |
| Degree to which I expect there is the intention to maintain the highest safety standards | | | | -.840 | | | 3.98 | 1.001 |
| Trust in impact assessments | | | | -.407 | | | 3.27 | .965 |
| I have heard/read/saw about sustainable heating from UDG | | | | | .801 | | 1.69 | .464 |
| I was already familiar met UDG as a form of sustainable energy | | | | | .722 | | 1.62 | .486 |
| Degree to which it is fair/unfair that not all households in AoI of project might be able to use sustainable heating from project | | | | | | .842 | 2.37 | .815 |
| Degree to which it is fair/unfair that households in AoI experience more risks and nuisances than others in the municipality | | | | | | .724 | 2.55 | .867 |
| **Cronbach's Alpha** | .837 | .860 | .823 | .792 | .731 | .766 | | |

PF = Procedural Fairness, PB = Perceived Benefits, PRN = Perceived Risks and Nuisances, TI = Trust in Industry, PA = Prior Awareness, DF = Distributive Fairness

**Factor 1: Expected procedural fairness**

Four items loaded onto Factor 1, with factor loadings ranging from .499 to .868. The items all related to procedural fairness respondents expect to get. During the survey, respondents were provided information which stated that, concerning renewable energy projects, municipalities generally plan information and participation evenings that civilians can attend. After this, respondents were asked to which degree they expect a) they would be able to participate in decision making, b) municipalities to protect the wellbeing of the citizens, c) municipalities to listen to the voices of civilians, and d) a project could still be adjusted once the plans are announced. These four statements all show a high loading on this factor.

**Factor 2: Perceived benefits**

Another four items loaded onto Factor 2, with factor loadings ranging from .751 to .827. Items in this scale measured respondents' perceived benefits of the ultra-deep geothermal energy technology in terms of the environment and energy security. This factor was therefore labelled 'Perceived benefits'. Respondents were asked to what extent they thought that heat from an ultra-deep geothermal energy source instead of via natural gas would be better or worse in terms of the environment, climate change, contribution to the energy transition and the predictability of the costs of heating one's house.

**Factor 3: Perceived risks and nuisances**

Four items loaded onto the third factor, with factor loadings ranging from .557 to .859. The items in this factor all relate to perceived risks and nuisance respondents expect themselves and others would be exposed to in case of an ultra-deep geothermal energy project. Therefore, this factor was labelled 'Perceived Risks'.

The perceived personal risks and nuisance was measured by two items, concerning the degree to which people expected to be at risk and the degree to which people expected to experience nuisance. Furthermore, respondents with 'scenario 600m' were asked how they perceived the safety of others within the area of influence regarding an ultra-deep geothermal energy project. Respondents with 'scenario 5km' were also asked how they perceived the safety of people within the direct area of influence of the project.

It was originally expected that these questions would load into two different factors, namely one factor about personal risks and nuisance and one factor about the risks and nuisance of others. However, all items loaded into one factor and thus measured the same thing. A possible explanation for this is that people do not differentiate between the two distances in terms of risks and nuisance and thus do not see differences.

**Factor 4: Trust in industry**

Three items loaded onto Factor 4, with factor loadings ranging from .407 to .849. Before measuring these items, extra information was provided to respondents. In the survey respondents were told that impact assessments are always performed with large projects such as the described geothermal project. It was also briefly explained what an impact assessment is.

**Factor 5: Prior Awareness**

Two items loaded onto Factor 5, with factor loadings of .722 and .801. Both items related to respondents' knowledge on the ultra-deep geothermal energy technology. Respondents were asked if they were already familiar with ultra-deep geothermal energy as a source of sustainable energy and if they have heard, read or saw something about ultra-deep geothermal heating in the last three months. Respondents were either able to respond with 'yes' or 'no'. People who reported to have not been familiar with UDG before the survey, but who reported to have read/heard of saw something about UDG in the three months before the survey was taken, as well as people who have stated the opposite were seen as having 'limited' prior awareness.

**Factor 6: Distributive fairness**

The last two items are loaded onto Factor 6, with factor loadings of .724 and .842. Respondents were asked to which degree they thought it was fair/unfair that a) households that cannot make use of sustainable city heating might suffer from the disadvantages of ultra-deep geothermal energy projects, and b) households who live in the area of influence of an ultra-deep geothermal project will experience more risks and nuisances during and after the project construction.

### 5.3.2 Relevant items not in factors

Two items that were removed during the principal-axis factor extraction method concerned the degree to which people expected that the quality of their living surroundings would change, and the degree of how important people would find it to be able to be involved when a municipality announced plans to realize an ultra-deep geothermal energy project. These two items have been included in further analysis as separate variables, as they were deemed still relevant for further analysis.

Based on the factors derived from the survey and these two variables, a new model is created. This conceptual model can be seen in figure 6 and will be used in further analysis.

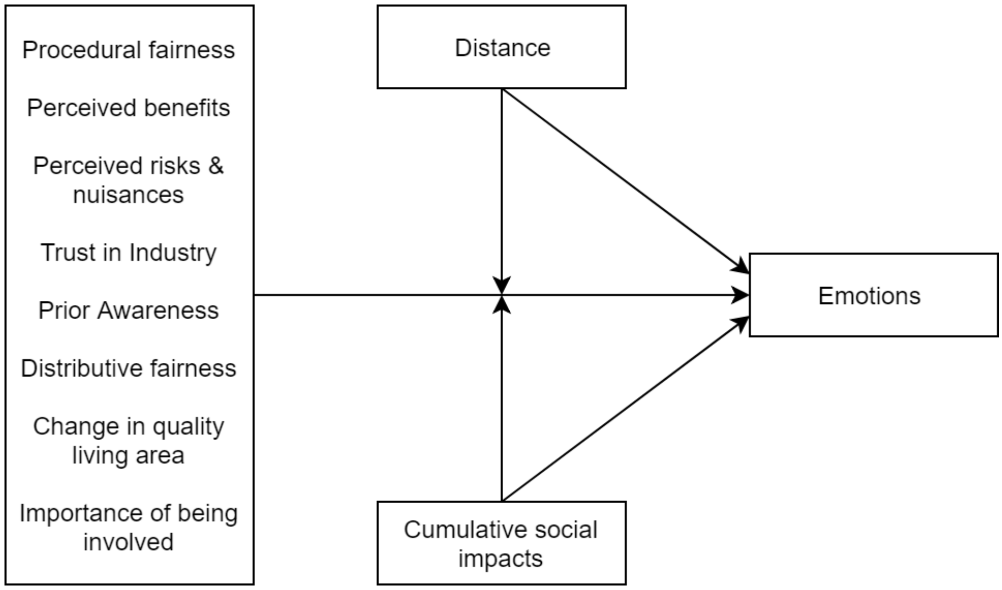


**Figure 6: Final conceptual model tested**

Means and standards deviations of the six described factors and the two separate variables are given in Table 9. The mean scores of the factors were obtained by averaging the high loading variables on a factor. As can be seen in Table 9, the importance of being involved has a high mean score, indicating that people find it very important to be involved. During the interviews, see paragraph 4.1, it was mentioned that there is a participation paradox. Actors found that people are only interested in being involved once a project becomes more concrete and they see the implications of a project, and not in the initial exploration phase. This creates the suggestion there is an external factor present which makes people being less involved in the initial exploratory phase. For example, it could be that people have a difficult time visualizing and understanding geothermal projects and its implications and thus wait for a project to become more tangible.

Furthermore, both procedural and distributive mean scores are below the neutral score of three, where distributive fairness has, with a score of 2.46, the lowest mean score. This means that to some extent, people do not expect to receive procedural and distributive fairness.

Table 9: Mean and standard deviations of factors and extra items

| Measurement | Mean | Std. Deviation |
|---|---|---|
| Procedural Fairness | 2.94 | .865 |
| Perceived Benefits | 3.51 | .824 |
| Perceived Risks and Nuisances | 3.27 | .773 |
| Trust in Industry | 3.78 | .823 |
| Prior Awareness | 1.65 | .422 |
| Distributive fairness | 2.46 | .758 |
| Expected change quality living surroundings | 3.08 | .933 |
| Importance involvement | 4.15 | 1.017 |

### 5.3.3 Factors of emotions

A PAF extraction with a direct oblimin rotation was conducted to examine the underlying structure of the measured emotions. Based on the Kaiser-Meyer-Olkin measure of sampling adequacy, Bartlett's test of sphericity and the communalities, factor analysis was deemed suitable for the eight emotions. Results from these three checks can be found in appendix 5. The factor correlation matrix, see Table 10, indicated that an orthogonal rotation could be used as factor correlations are below .30.

Table 10: Factor correlation matrix with an Oblimin rotation of measured emotions

| Factor | PE | NE |
|---|---|---|
| PE | 1.000 | .118 |
| NE | .118 | 1.000 |

Extraction method: Principal Axis Factoring

Rotation method: Oblimin with Kaiser Normalization

PE = Positive Emotions, NE = Negative Emotions

The final results of the factor analysis of the eight emotions can be seen in Table 11. The emotions 'happy', 'proud' and 'hopeful' load into the first factor, which is therefore labelled 'positive emotions'. The emotions 'fear', 'anger', 'powerless', 'surprised' and 'irritated' load into the second factor, which is therefore labelled as 'negative emotions'. The emotion 'surprised' has a low loading of .444, which is rather low. However, the emotion does fit with the rest of the emotions in the factor and is thus kept instead of excluded from the factor. The high loading items were combined in the factors by averaging the scores.

Table 11: Factor loadings of measured emotions from Principal Axis Factor Analysis

| Item | Factor loading | |
|---|---|---|
| | PE | NE |
| Proud | .820 | |
| Hopeful | .788 | |
| Happy | .761 | |
| Fear | | .814 |
| Irritated | | .804 |
| Powerless | | .789 |
| Anger | | .752 |
| Surprised | | .444 |
| **Cronbach's Alpha** | .839 | .820 |

PE = Positive Emotions, NE = Negative Emotions

## 5.4 Coding scheme

The antecedents and demographic characteristics that have been measured at ordinal or nominal level have been recoded using effect coding. This has the advantages that, in the regression analysis that will be discussed in chapter 6, all category means are tested against the overall mean value of the specific emotion being tested.

Table 12 shows how the variables have been recoded. As can be seen, one group is always coded as having a positive value of '1' and this group is being compared to the other group which is coded as '-1'. A clear example of how this works can be seen by looking at the coding structure of the Gender variable. For those characteristics or variables that can be distinguished by three categories, the second or third groups are individually compared to the first group. This means that with age, the first group (age 0-35) is coded as '-1', the second group (age 36-55) as '1' and the third group (age 56+) as '0', in the case where the second group is compared to the first group.

**Table 12: Coding scheme or variables measured at ordinal or nominal level**

| Variable | Group 1, effect coded as -1 | Group 2, effect coded as 1 | Group 3, effect coded as 0 |
|---|---|---|---|
| Gender | Male | Female | - |
| Household connection to city heating network | No connection | Connection | - |
| Location | CSI not present | CSI present | - |
| Scenario distance | 5 kilometres | 600 meters | - |
| Education | Primary school – MBO | Havo,Vwo,HBO,University | - |
| Middle age | Age 0-35 | Age 36-55 | Age 56-65 and above |
| Older age | Age 0-35 | Age 56-65 and above | Age 34-55 |
| Prior awareness | No | Yes | Limited |
| Limited prior awareness | No | Limited | Yes |

# 6. Results

This chapter will discuss the analysis performed on the data obtained from the surveys and will answer the research and sub-research questions. Paragraph 6.1 describes which emotions are experienced most often and the least and which emotions are experienced the strongest. The relationship between positive and negative emotions on project acceptance of objection is discussed in paragraph 6.2. Paragraph 6.3 describes the effect of demographic characteristics on the measured emotions. The effects of the dimensions location and distance on the relationship between antecedents and the measured emotions are discussed in paragraph 6.4. Furthermore, paragraph 6.5 describes the combined effects of the demographic characteristics and antecedents on the relationship between antecedents and the measured emotions. Lastly, the management implications of the results obtained from this study are discussed in paragraph 6.6.

## 6.1 distributions of measured emotions

The emotions happy, proud, hopeful, fear, anger, powerless, surprised and irritated were measured by asking the respondents to which extent they experienced these emotions when thinking about the ultra-deep geothermal energy project as described in the scenario description of the survey. Four respondents experienced only one emotion, whereas the rest of the respondents experienced multiple emotions. This is in line with the findings in academic literature, see chapter 3, which stated that multiple (and conflicting) emotions could occur simultaneously.

An oversight of the responses to these emotions is given in Table 13, which shows the responses in percentages, mean scores, standard deviation and valid and missing scores. Under valid scores, are all scores from 1 to 5, whereas the missing score table represents the 'not applicable/not present' response. It can be concluded that the negative emotion fear is being experienced the most often, as only 16.2 percent of the respondents indicated that they did not experience this emotion. The negative emotions anger and irritated are experienced the least, as 44.7 and 40.8 percent of the respondents indicated that they did not experience these emotions, respectively.

When looking at the positive emotions, the emotions happy and hopeful are experienced relatively often, whereas the emotion proud is experienced less. When looking at the degree to which the emotions are experienced, it can be concluded that the negative emotions are experienced stronger than the positive emotions, where the emotion powerless is experienced the strongest, followed by the emotion surprised. That the emotion powerless was experienced strongly was according to expectations, as it was mentioned in section 3.1.1 that a study on emotions concerning gas quakes in Groningen showed this emotion was also experienced strongly in the area of interest for this study

(Perlaviciute, et al., 2017). Furthermore, the high mean score of feeling powerless seems to correspond with the high mean score of 'importance of being involved' in Table 9. It can thus be concluded that people find it very important to be involved but that they also feel powerless and thus feel like they cannot create a lot of influence on processes.

**Table 13: Percentages of degree of emotional responses**

| N=358, values in % | Happy | Proud | Hopeful | Fear | Anger | Powerless | Surprised | Irritated |
|---|---|---|---|---|---|---|---|---|
| **Missing scores** | | | | | | | | |
| 0 (not present) | 25.7 | 39.4 | 22.3 | 16.2 | 44.7 | 29.9 | 22.3 | 40.8 |
| **Valid scores** | | | | | | | | |
| 1 (A little) | 13.4 | 12.8 | 17.0 | 25.4 | 15.1 | 19.6 | 16.2 | 17.0 |
| 2 (Moderate) | 33.2 | 21.8 | 23.7 | 27.1 | 17.6 | 14.5 | 17.6 | 13.7 |
| 3 (Reasonably strong) | 14.5 | 15.1 | 22.1 | 14.0 | 10.1 | 11.5 | 20.7 | 11.5 |
| 4 (Strong) | 9.8 | 6.7 | 9.5 | 12.8 | 6.1 | 12.3 | 16.8 | 9.2 |
| 5 (Very strong) | 3.4 | 4.2 | 5.3 | 4.5 | 6.4 | 12.3 | 6.4 | 7.8 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
| Mean (Scores 1-5) | 2.41 | 2.47 | 2.51 | 2.33 | 2.48 | 2.76 | 2.74 | 2.61 |
| Std. Deviation | 1.068 | 1.147 | 1.161 | 1.208 | 1.313 | 1.467 | 1.243 | 1.388 |

## 6.2 Emotions affecting UDG support or protest

The second sub-research question asked what the relationship between emotions and support or protests against ultra-deep geothermal projects is. As this thesis is focused on positive and negative emotions that people experience when being confronted with ultra-deep geothermal energy projects, an analysis on the prediction between emotions and support or protests for UDG projects provides valuable information. A multiple linear regression analysis was conducted to predict the effects of positive and negative emotions on UDG project support or protest. For UDG support, a significant regression equation was found (F(2,355) = 192.040, $p < .000$), with an explained variance ($R^2$) of .517. For rejection of the technology, a significant equation was also found (F(2,355) = 78.258, $p < .000$), with an explained variance ($R^2$) of .306. Results of the regression analysis can be found in Table 14.

Having positive emotions strongly predicts support for UDG projects (standardize beta value of .652) and having negative emotions strongly predicts objection against UDG projects (standardized beta value of .496). Furthermore, having positive emotions results is a negative predictor of technology rejection and having negative emotions is a negative predictor of technology acceptance.

**Table 14: Results from multiple regression analysis of technology acceptance / objection**

| Standardized and (significance) values provided | UDG project support | UDG project protest |
|---|---|---|
| Positive emotions | . 652 (.000) | -.241 (.000) |
| Negative emotions | -.302 (.000) | .496 (.000) |
| Explained variance (R2) | .517 | .306 |

## 6.3 Effects of demographic characteristics on emotions

The third and fourth sub-research questions asked to which extent people's emotions differ, when being confronted with an ultra-deep geothermal energy project, when living in areas with or without cumulative social impacts and depending on the distances between their living area and a project location. To answer this, a multiple linear regression analysis was conducted to predict the effect of respondent's demographic characteristics on their positive and negative emotions, in the context of location with/without cumulative social impacts and scenario distances.

The basic demographic characteristics that were measured are; gender, level of education and age. Furthermore, the variables 'household connection to a city heating network' and 'location with or without cumulative social impacts' were added. Lastly, the scenario distances were added into the model and an interaction effect was created between location and distance, as to see whether this had a mediating effect. The results from the multiple regression analysis are shown in Table 15, where the standardized beta and significance levels are provided, along with the explained variance of the model.

Women showed significantly less positive emotions than men when being confronted with an ultra-deep geothermal energy project. A study on geothermal acceptance on an island in Greece showed that women are almost 60 percent less likely to accept a geothermal installation on their island (Olympia & Sofia, 2010). As having positive emotions will lead to more acceptance in comparison to negative emotions, the results for gender as seen in Table 15 confirm the findings from Greece and vice versa.

Furthermore, there are significant differences in positive and negative emotions between people whose households are or are not already connected to a district heating network. People whose houses are connected to a district heating network tend to score higher on both the negative and the positive emotions. In the survey it was told that sustainable heating from an ultra-deep geothermal source can be easily connected to a city heating network, and this most likely resulted in positive emotions for those whose houses are already connected to a city heating network as they experience the benefits from geothermal energy immediately. This also means that households that are not connected to a city heating network will not benefit from an ultra-deep geothermal project until they are connected. Why households that are already connected to a city heating network also show stronger negative emotions is more difficult to explain. It could be that they are afraid of higher costs or see some other disadvantage that has not been tested in the survey.

Results from the analysis also showed that the different scenario distances do not significantly differ in their contribution to the emotions, as well as the interaction effect between scenario and location with or without cumulative social impacts. This thus means that people who were given the '600 meters' scenario do not show different level of emotions than those who were given the '5 kilometers' scenario, and that this is true for both the locations with and without cumulative social impacts.

As was stated in the theoretical framework in chapter 3, the NIMBY concept states that people are more negative towards projects in their local residential area than they would elsewhere, even though that project can be beneficial for the local area. As the results from the analysis shows that there are no differences in negative emotions, it can be suggested that people do not differ between the two measured distances and thus see a project being carried out at five kilometers distance also as the local area. This creates the question at what distances people will start differentiating between a local and non-local area.

The most interesting finding from the analysis is that people show different negative emotions when living in an area with cumulative social impacts, compared to people living in an area without cumulative social impacts. As the standardized beta-value is positive, this means that people who are living in an area with CSI tend to have stronger negative emotions when being confronted with an ultra-deep geothermal project. This thus confirms that the presence of an impact from a different technology may change how another technology may be experienced, as stated by Franks et al. (2010). Furthermore, it shows the importance of cumulative impact assessments and especially in regions where environmental and/or social systems have reached a tipping point.

Lastly, chapter 5.2 indicated that there are differences in educational levels in the sample between the groups living in an area with or without CSI. For this reason, an additional interaction effect was created between education and CSI, as to see whether the difference educational level would result in differences in the emotions. No significant effects came forward, it can thus be concluded that all results are comparable between the different groups

**Table 15: Results from multiple regression analysis of demographic data**

| Standardized beta and (significance) values provided | Positive emotions | Negative emotions |
|---|---|---|
| Females | **-.192 (.000)** | -.010 (.856) |
| Household connected to city heating network | **.185 (.001)** | **.195 (.001)** |
| Higher education | .051 (.346) | -.094 (.075) |
| Middle age | -.013 (.800) | .030 (.617) |
| Older age | -.034 (.585) | -.021 (.737) |
| Location with CSI | -.039 (.557) | **.158 (.003)** |
| Scenario distance: 600 m | -.023 (.645) | .037 (.478) |
| CSI*600m | -.003 (.944) | .032 (.538) |
| Higher education*CSI | .041 (.444) | -.021 (.697) |
| Explained variance ($R^2$) | .081 | .073 |

This paragraph has answered the third and fourth sub-research questions, which asked to what extents people's emotions differ when being confronted with an ultra-deep geothermal energy project in different scenario distances and locations. It can be concluded that there are no differences in emotional responses to a UDG project between people living at a distance of 600 meters and people living at a distance of 5 kilometers to the project site, and that this also does not differ for the locations with or without CSI. Furthermore, it can be concluded that people in an area with a CSI show significantly stronger negative emotional responses when being confronted with a UDG project than those living in an area without a CSI. This means that when looking at the possibility of starting ultra-deep geothermal energy projects in areas with cumulative social impacts, the executing parties have to take into account that people will be more negative towards it and that they may thus find more resistance. This also means that, especially in these areas, it is important to include people in the process, as this will most likely lead to more responsible and accepted projects.

## 6.4 Antecedents of emotions

The fifth sub-research question asked how the relationship between antecedents and the emotions changes under different scenario distances or under locations with or without cumulative social impacts. For this reason, the antecedents of emotions were tested using multiple regression analysis. This was tested using the model as seen in Figure 6. Interaction effects were created between the potential antecedents of emotions and between the dimensions location and scenario distances.

Adding interaction effects created extra variables, which increased the likelihood of effects becoming significant, and thus it increased changes on type 1 errors (rejecting the null hypothesis while it is actually true). For this reason, a Partial F-test has been conducted first, which tested whether the explained variance of different models significantly differed. The first model is the reduced model, which includes only the potential antecedents of the emotions. The second model includes the location with CSI dimension and its respective interaction effects. The third model includes the distance dimension and its respective interaction effects. Results from this partial F-test can be seen in Table 16.

Looking at Table 16 it can be concluded that the reduced first model can be used to analyze the antecedents of the positive emotions, as the second and third model do not show significant differences. The positive emotions can thus be predicted by the before mentioned antecedents as there are no significant differences in antecedents of emotions between locations with or without a CSI for these positive emotions or between different scenario distances. Table 16 also shows that the second model (location dimension) can be used for the negative emotions. Adding the dimension distance and its interaction effect to the model did not result in significant changes, and thus there are no significant differences in antecedents of emotions for the dimensions distance with respect to the dimension location.

**Table 16: Results from partial F-test**

| Emotion | Model | R Square Change | F Change | Df1 | Df2 | Sig. F Change |
|---|---|---|---|---|---|---|
| Positive emotions | 2 | .010 | .601 | 10 | 336 | .813 |
| | 3 | .015 | .817 | 11 | 325 | .623 |
| Negative emotions | 2 | .041 | 1.934 | 10 | 336 | **.040** |
| | 3 | .024 | 1.035 | 11 | 325 | .415 |

### 6.4.1 Antecedents of positive and negative emotions

A multiple linear regression was estimated to predict the positive emotions based on the factors ‘procedural fairness’, ‘perceived risks and nuisances’, ‘perceived benefits’, ‘trust in industry’, ‘prior awareness’, ‘distributive fairness’, ‘expected change in quality living area’, and ‘importance of being involved’.

Multicollinearity diagnostics were assessed using SPSS’ collinearity statistics function. All correlations amongst variables were within an acceptable range, with a minimum tolerance of .527, and a maximum VIF value of 1.117. For the positive emotions a significant regression equation was found (F(9,346) = 29.221, $p$ < .000), with an explained variance ($R^2$) of .432. Results from the regression analysis can be seen in Table 17

Several conclusions can be drawn from Table 17. The antecedents ‘procedural fairness’, ‘perceived benefits’, ‘prior awareness’, ‘distributive fairness’, and ‘expected change quality living area’ are all significant predictors to having positive emotions. As all their beta values are positive, their contributions to having positive emotions are also positive. In other words; people experience significantly more positive emotions when they expect more procedural and distributive fairness, perceive more benefits from the ultra-deep geothermal technology, and when they expect changes in the quality of their living area because of the project. The strongest indicator of positive emotions is the expected change in the quality of the living area, with a beta value of .323. The perceived benefits of the technology only predicts the positive emotions limitedly, with a beta value of .098.

People also experience more positive emotions when they have prior awareness of the ultra-deep geothermal technology. Interestingly, people who have limited prior awareness do not experience more positive emotions. This shows that it is important for actors within the industry, whether those are actors from the private industry or from public institutions, to actively inform the public about the relative new technology beyond the normal scope of informing public, as this will result in more positive emotions amongst the public.

To test which antecedents significantly affect the negative emotions, and specifically how this differs in locations with or without cumulative social impacts, a multiple regression analysis was conducted using interaction effects. This means that interaction terms between the antecedents as stated in Figure 6 and the independent variable ‘location with cumulative social impact’ were created.

As this study on the antecedents of the emotions does not test hypothesis but has an explorative character, the insignificant interacting antecedents have been stepwise deleted from the interaction model, until only significant interaction effects remained. For the negative emotions, a significant regression equation was also found, with an explained variance of .270. Results from the regression analysis can also be found in Table 17.

Based on the data as found in Table 17, people will experience more negative emotions when they see more perceived risks for themselves and/or others, but will experience less negative emotions when they have more trust in the industry. The effect of the expected change in the quality of the living area of people is affected by the cumulative social impacts of an area. As it turns out, people who live in an area with cumulative social impacts show more than average negative emotions when they perceive more change, in comparison to people who live in an area without cumulative social impacts. This can be related to the concept of ‘place attachment’ as discussed in the theoretical framework in chapter 3. People’s emotional bonds to their living area might already be affected by the social impacts of different used technologies in the area, and this could explain why people experience more negative emotions when they expect additional changes in the quality of their living area due to a new technology. No other antecedents of emotions significantly differ between respondents living in an area with or without CSI.

**Table 17: Results of multiple regression analysis of antecedents of emotions moderated by CSI.**

| Standardized and (significance) values provided | Positive emotions | Negative emotions |
|---|---|---|
| Procedural fairness | **.116 (.019)** | .005 (.930) |
| Perceived benefits | **.098 (.032)** | -.051 (.327) |
| Perceived risks and nuisances | -.080 (.124) | **.259 (.000)** |
| Trust in industry | .087 (.072) | **-.279 (.000)** |
| Prior awareness | **.122 (.029)** | .011 (.861) |
| Limited prior awareness | .014 (.799) | .060 (.336) |
| Distributive fairness | **.169 (.000)** | -.016 (.769) |
| Expected change in quality living area | **.323 (.000)** | -.028 (.660) |
| Importance of being involved | .014 (.753) | .083 (.089) |
| Location with cumulative social impact (LCSI) | n.a. | - |
| Procedural fairness * LCSI | n.a. | - |
| Perceived benefits * LCSI | n.a. | - |
| Perceived risks and nuisances * LCSI | n.a. | - |
| Trust in industry * LCSI | n.a. | - |
| Prior awareness * LCSI | n.a. | - |
| Limited prior awareness * LCSI | n.a. | - |
| Distributive fairness * LCSI | n.a. | - |
| Expected change quality living area * LCSI | n.a. | **.367 (.021)** |
| Importance of being involved * LCSI | n.a. | - |
| Explained variance ($R^2$) | .432 | .270 |

## 6.5 Demographic characteristics and antecedents

The previous paragraphs discussed the effects of the demographic variables and antecedents on the emotions separately. This paragraph will discuss the results when these are combined in a regression analysis. The advantage of combining the demographic characteristics and the antecedents in one regression analysis is that the results will be controlled for potential differences between the groups. The regression analysis is conducted following the model as given in Figure 7.

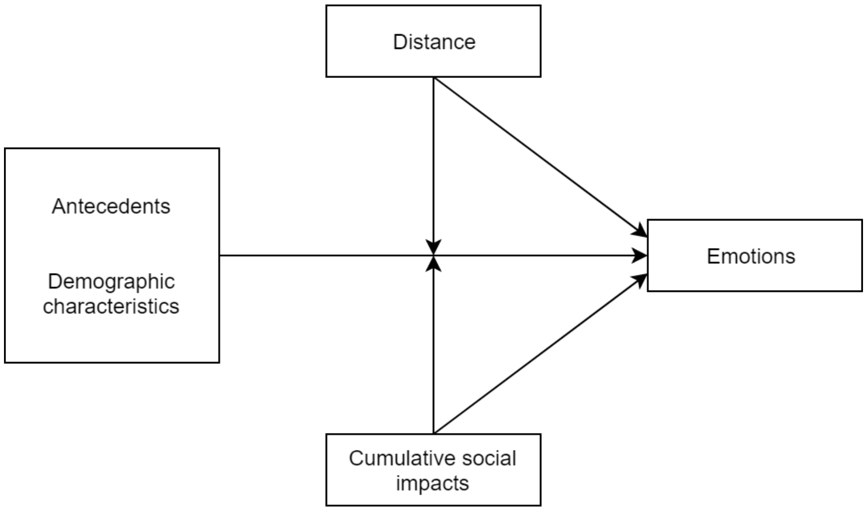


**Figure 7: Effect of distances and LCSI on antecedents of emotions corrected for demographic differences**

A partial F-test has been conducted which tested whether the explained variance of different models significantly differed. The first model is the reduced model, which includes only the potential antecedents of the emotions and the demographic characteristics. The second model includes the location with CSI dimensions and its respective interaction effects with the antecedents and the demographic characteristics. The third model includes the distance dimension and its respective interaction effects. Results from this partial F-test can be seen in Table 18. It can be concluded that, as in paragraph 6.3, the positive emotions can be predicted by the antecedents and demographic characteristics only, and the negative emotions by the antecedents, demographic characteristics and the CSI dimension.

**Table 18: Results from partial F-test**

| Emotion | Model | R Square Change | F Change | Df1 | Df2 | Sig. F Change |
|---|---|---|---|---|---|---|
| Positive emotions | 2 | .015 | .591 | 15 | 326 | .881 |
| | 3 | .034 | 1.310 | 16 | 310 | .189 |
| Negative emotions | 2 | .061 | 2.106 | 15 | 336 | **.010** |
| | 3 | .024 | .750 | 16 | 310 | .741 |

Multicollinearity diagnostics were assessed using SPSS' collinearity statistics function. All correlations amongst variables were within an acceptable range, with a minimum tolerance of .460, and a maximum VIF value of 2.174. For the positive emotions a significant regression equation was found (F(14,341) = 20.330, $p$ < .000), with an explained variance ($R^2$) of .455. For the negative emotions, a significant regression equation was also found, with an explained variance of .347. Results from the regression analysis can be found in Table 19.

**Table 19: Results of multiple regression analysis of antecedents and demographic characteristics on emotions, moderated by CSI.**

| Standardized and (significance) values provided | Positive emotions | Negative emotions |
|---|---|---|
| Procedural fairness | **.109 (.027)** | -.017 (.762) |
| Perceived benefits | .084 (.064) | -.051 (.316) |
| Perceived risks and nuisances | -.083 (.117) | **.248 (.000)** |
| Trust in industry | .076 (.127) | **-.239 (.000)** |
| Prior awareness | **.112 (.045)** | .011 (.865) |
| Limited prior awareness | .005 (.924) | .064 (.301) |
| Distributive fairness | **.160 (.001)** | -.022 (.676) |
| Expected change in quality living area | **.339 (.000)** | -.109 (.094) |
| Importance of being involved | .033 (.448) | .076 (.118) |
| Females | **-.099 (.019)** | -.082 (.085) |
| Household connection to city heating network | .031 (.506) | **.247 (.000)** |
| Higher education | .016 (.711) | -.066 (.167) |
| Age middle | .057 (.224) | -.020 (.701) |
| Age older | **-.131 (.010)** | -.012 (.834) |
| Location with cumulative social impact (LCSI) | n.a. | **.246 (.000)** |
| Household connection to city heating network*LCSI | n.a. | **.201 (.000)** |
| Explained variance ($R^2$) | .455 | .347 |

As can be seen in Table , the antecedents ‘procedural fairness’, ‘prior awareness’, ‘distributive fairness’ and ‘expected change quality living area’ are still significant predictors of having positive emotions. The same goes for the demographic characteristics ‘gender’, and ‘older age’. However, the concept ‘perceived benefits’ and ‘household connection to a city heating network’ are not significant predictors anymore. The strongest predictor for having positive emotions is one’s expected change in the quality of their living area. Furthermore, females show slightly less positive emotions than males and older people show less positive emotions than younger people. When looking at the negative emotions, it can still be concluded that people who live in an area with CSI show significantly stronger negative emotions than people who live in an area without CSI. Furthermore, it seems that the same antecedents and demographic characteristics are predictors as when the analyses were performed separately. However, the antecedent ‘expected change in quality living area’ is now not different for areas with or without CSI.

People now do show significant different negative emotions when being connected to a city heating network and living in an area with or without CSI. People who live in an area with CSI show stronger than average negative emotions when their households are already connected to a city heating network. An explanation for this can be found when looking more specific into the location that represents the area with cumulative social impacts. As was stated in chapter 0, a proposed geothermal energy project in the area by the utility company Warmtestad was cancelled after criticism from the Dutch State Supervision of Mines. Warmtestad planned to expend and increase the sustainability of their current city heating network by means of the proposed geothermal project. It is likely that people in the area with CSI and which houses are connected to a city heating network show more negative emotions, in comparison with people in areas without CSI, as they relate the given scenario description to the Warmtestad case. Figure 8 shows all the significant effects of the antecedents and demographic differences on the positive and negative emotions.

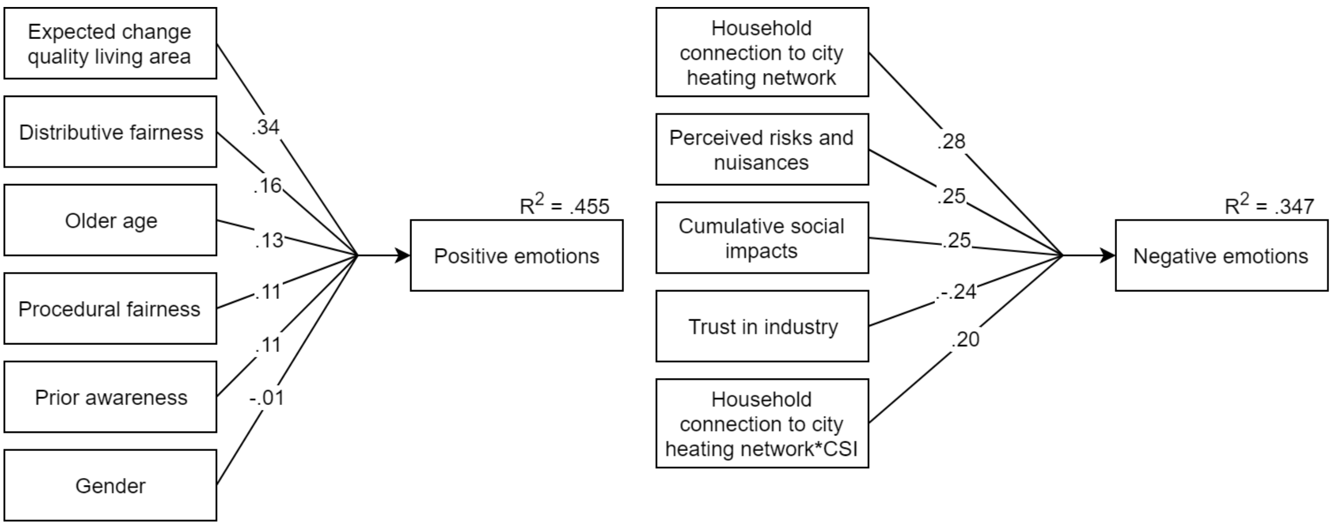


**Figure 8: Significant direct and indirect effects of antecedents and demographic characteristics on positive and negative emotions**

# 7. Conclusion and recommendations

This chapter concludes this research and discusses all the answers to the research questions. Furthermore, management implications of the results of this study are given. Lastly, the limitations of this research are discussed along with some recommendations for further research.

## 7.1 Research design and discussion of results

The objective of this study was to research whether people showed different emotions and different level of emotions when being confronted with an ultra-deep geothermal energy project, depending on whether they live in an area with or without cumulative social impacts and depending on how close such a project location would be to people's living area. Furthermore, the objective was to identify different antecedents that trigger people to have positive and negative emotions about ultra-deep geothermal energy projects. How the relationship between these antecedents and emotions differed under locations with or without cumulative social impacts or distance was also analyzed.

The first sub-research question asked which considerations could be identified that affect people's emotions when being confronted with ultra-deep geothermal energy projects. Based on a literature study using snowballing technique and several academic journal databases several concepts were identified that could influence people's emotions. These concepts are *'perceived risks', 'place-attachment', 'prior awareness', 'trust', 'perceived benefits'*, and '*distributive and procedural fairness'*. Interviews conducted with actors active in the geothermal industry and with laypeople confirmed some of these concepts.

Based on data obtained from the literature study and interviews a survey study was generated and conducted. Items from this survey were grouped using principle-axis-factoring analysis. From this analysis the following six factors were obtained, which will be henceforth referred to as antecedents; procedural fairness, perceived risks and nuisance, perceived benefits, trust in industry, prior awareness and distributive fairness. Two extra items were added to the analysis that read 'expected change in quality of living area' and 'importance of being involved'.

The second sub-research question asked what the relationship between emotions and support or protests against ultra-deep geothermal projects is. A regression analysis showed that having positive emotions strongly predicts support for ultra-deep geothermal (UDG) projects, whereas having negative emotions strongly predicts objection against UDG projects. Likewise, having positive emotions is a significant negative predictor of objection to UDG projects and negative emotions a significant negative predictor of support for UDG projects.

The third and fourth sub-research questions refer to how people showed different emotions when they lived in an area with or without cumulative social impacts or when they were given a scenario description where an ultra-deep geothermal project would be constructed at 600 meters or at 5 kilometers from their living area. The following emotions were measured in the survey: happy, fear, proud, anger, hopeful, powerless, surprised and irritated. The emotion fear was experienced most often, whereas the emotion anger was experienced the least. The emotion powerless was experienced the strongest, which confirmed findings from the literature study. Principle-axis-factoring analyses showed that these emotions could be grouped into two factors, being 'positive emotions' and 'negative emotions'. Statistics showed that these emotions could be experienced simultaneously, which was also confirmed by literature.

Based on a multiple regression analysis, it can be concluded that people do not show different levels of either positive or negative emotions when living closer to a project site, and that this does not differ between areas with or without cumulative social impacts. People who are living in an area with cumulative social impacts do tend to have stronger negative emotions when being confronted with an ultra-deep geothermal energy project, but regardless of the scenario distance. This means that when looking at the possibility of starting ultra-deep geothermal energy projects in areas with cumulative social impacts, the developing parties and local governments have to take into account that people will be more negative towards it, in comparison to other regions. As it is argued by academics that emotions should play a vital role in debates and project developments, this specifically applies to areas with cumulative social impacts. This is because this will lead to more responsible project outcomes and thus will most likely increase public acceptance.

The fifth sub-research question asked whether there are differences in the relationships between the antecedents and emotions, depending on the location. A partial F-test showed that for the positive emotions there was no mediating effect between the locations and distances. In other words, the relationship between the antecedents and positive emotions does not differ between areas with and without cumulative social impact or between the measured scenario distances. People experience significantly more positive emotions when they expect to get more procedural and distributive fairness and when they expect positive changes in the quality of their living area because of geothermal projects. Furthermore, the results showed that people tend to show more positive emotions when they are older and when they have more awareness about ultra-deep geothermal technology.

When looking at the relationship between the antecedents and the factor 'negative emotions' it was concluded that there are no significant differences in antecedents between areas with and without a cumulative social impact. Negative emotions are experienced stronger when people see more perceived risks and nuisances for themselves and others, but they are experienced less strong when people perceive more trust in the industry. Furthermore, people whose households were already connected to a city heating network tend to experience stronger negative emotions, and these negative emotions are even stronger for people living in an area with cumulative social impacts.

As all sub-research questions have now been answered, the main research question of this study can also be answered. The main research question asked what the effect is of cumulative social impacts on people's emotions and the relationship between the antecedents and the emotions when being confronted with ultra-deep geothermal projects. The considerations that affect people's emotions when being confronted with an ultra-deep geothermal energy project are 'procedural fairness', 'prior awareness', 'distributive fairness', 'expected change quality living area', 'perceived risks and nuisances', and 'trust in industry'. Furthermore, it turned out that whether or not people's households were connected to city heating networks also affected people's emotions. The second part of the main research question asked what the management implications are of the results obtained from this study. Several management implications are identified, such as the strong need to include people in decision making from the first explorative part of a project, the need to create awareness about the benefits of the technology and the need to build trust. These management implications are further discussed in the next paragraph.

## 7.2 Management implications

In this thesis it was found that having positive emotions results in more project support and negative emotions in more objection to a project. As was stated in chapter 0, technology acceptance is a first and crucial step in obtaining a social license to operate (SLO), however this does not mean it automatically predicts a successful project outcome. The main goal of this study was to analyze whether or not people look differently to ultra-deep geothermal energy projects when they live in areas with cumulative social impacts. This has been confirmed by multiple regression analyses. It was found that people who live in an area with cumulative social impacts show the same level of positive emotions and antecedents of emotions compared to people who live in an area without cumulative social impacts. It was also found that people living in an area with cumulative social impacts show stronger negative emotions when being confronted with ultra-deep geothermal energy projects, and they specifically experience the emotions *powerless* the strongest and the emotion *fear* most frequently. Antecedents of negative emotions between people living in areas with and without cumulative social impacts are the same, however people whose houses are already connected to a city heating network show even stronger negative emotions when they live in an area with cumulative social impacts. This confirms the arguments made by Franks et al. that the presence of one impact or technology may change how another technology and its impacts may be experiences and thus cumulative impact analysis are necessary and important. Based on these findings, several management implications are identified that can contribute to responsibly creating more technology acceptance in the ultra-deep geothermal industry.

### 7.2.1 Including local residents

From the survey study it was found that people find it very important to be involved in decision making processes while at the same time they feel very powerless. This suggests that people feel they can be of little influence on project developers and (local) governments. At the same time, it was mentioned during interviews with actors in the geothermal industry that they experience a so-called participation paradox, where it was experienced that laypeople are only interested and show their concerns and thoughts once plans are more concrete and rather large investments have already been made and (impact) studies performed. According to these actors, adjusting project (plans) at this stage is more difficult than in the initial exploration phase. There thus seems to be a contrast between what people want and how they act.

The combination of above mentioned factors results in the suggestion that actors in the geothermal industry (both private and public) should actively try to include local residents in decision-making processes from the start and should find a creative solution to overcome the 'participation paradox' issue. This will likely also increase the trust that people have or develop for the industry and local governments. A suggestion for this could be by developing and launching an interactive digital app or platform that goes beyond the scope of a standard informative website or brochure. Through such a platform local residents, governments and project developers could interactively communicate with each other, lowering the threshold to go to information meetings. It was also found in both the literature study and during interviews that people might show negative reactions on having a semi-industrial installation placed close to residential areas and that expected changes in the quality of people's living area is a significant contributor in having negative emotions. Additionally, in such an interactive platform it can be visualized how a UDG project will look like in a local neighborhood during its construction and once it's finished. Such a platform could thus increase people's awareness on how a landscape might change because of a project and can create more awareness about the technology in general.

### 7.2.2 Creating awareness

One of the advantages of UDG is that it is a stable energy source and it can create independency from other energy sources and/or countries. The Netherlands is slowly decreasing its natural gas production until 2022 and will completely stop the production of natural gas in the years after that (Rijksoverheid, 2018). As installing individual heat pumps and making other adjustments to houses, so they become 'all electric', asks for huge investment costs by residents (ECORYS, 2018), this creates a potential for the UDG industry. For this reason, it can be argued that the industry should actively work together in creating more awareness of the technology and its benefits as this enables laypeople to make more informed decision. Having more prior awareness also leads to more positive emotions, as was found in this study.

### 7.2.3 Building trust

Trust in the industry is a significant and strong negative predictor of having negative emotions. One way of creating trust is by engaging non-biased third parties to present facts about the geothermal industry, such as independent knowledge institutions or universities (WESC, 2018). This also relates to the findings from the interviews where the actors involved in the geothermal industry indicated they experienced that residents sometimes think messages and information provided by developers is influenced. In the wind energy industry it is regularly seen that wind farms change ownerships during project developments or once the projects are finished and it is suggested that this creates confusion and mistrust among local residents (WESC, 2018). This suggests that when looking at ultra-deep geothermal projects, care should be taken to ensure the same actor or actors are involved from the beginning until the end of a project as this increases the trust people put in these actors. Preferably these actors are also the ones that exploit the geothermal reservoir once the construction is finished.

## 7.3 Reflection & limitations

To the author's best knowledge, this is the first thesis or research that studies how an areas cumulative social impacts influence people's emotions and antecedents of emotions when being confronted with ultra-deep geothermal energy projects, or with any other renewable energy projects for that matter. As the demographic characteristics of the data obtained from the survey was seen as reasonably comparable to that of the Dutch society, the findings in this research could be seen as reasonably representative. Only the percentage of higher educated responses was unrepresentative compared to the Dutch society, but regression analysis showed that this did not affect people's positive or negative emotions.

As a 2 by 2 study was performed (where two dimensions were measured at two different locations), the results of this study are not directly representative to other locations or technologies. It might be possible that when different locations were chosen as areas with and without cumulative social impacts, or when a different technology was chosen the findings will be different. It was not possible to include more locations in this thesis research due to budget and time constraints.

The author has tried his best to construct an information sheet and scenario description that was as objective and realistic as possible, but there is always a possibility that respondents answers might be affected by the way the information is provided. Furthermore, it might be possible that different information will be provided by (social) media, developers or local governments when ultra-deep geothermal energy projects are being realized in real life. This could affect both people's emotions and their responses to the question items and by that the degree and direction of the antecedents of the emotions.

It might also be possible that people living in areas without cumulative social impacts have been influenced by media and other sources regarding the impacts of certain technologies on a society. In other words, it might be possible that people in the Ede/Wageningen area have been influenced by media and other sources regarding (social) problems in the Groningen area due to natural gas production, and that this influenced the way they look at new technologies. This raises the question to what extend the media plays a role in distinguishing between areas with or without cumulative social impacts.

## 7.4 Recommendations

Several recommendations can be made based on the results of this study and the discussed limitations. First of all, I recommend that this study is performed again in 2022 or later, as it is planned that the extraction of natural gas in the Groningen area comes to a stop by then. I think it will bring valuable data on how emotions towards new projects and technologies can vary over time and how this will vary in areas with (hopefully diminishing) cumulative social impacts due to a different technology. Besides that, the ultra-deep geothermal industry will have grown significantly by then and there might be a lot more public awareness.

Furthermore, I recommend that a similar study should be conducted where multiple locations of areas with and without cumulative social impacts are included, and preferably where multiple renewable energy technologies are measured. This would make the results more generalizable so that one could talk about 'emotions and acceptance of renewable energy projects in areas with cumulative social impacts' instead of specifically ultra-deep geothermal projects. As the Netherlands is rather small this would most likely result in an international oriented research. Increasing the locations and technology types also means significantly increasing the sample size, as otherwise the number of respondents per groups becomes too small. Additionally, I would recommend including researching how financial compensation and incentives (such as financial participation) could impact people's emotions and by that acceptance of a technology.

In this thesis it was found that there are no differences in emotions between people who were asked to imagine an ultra-deep geothermal project to be taken place at a distance of 600 meters or 5 kilometers from their houses. This raises the question at which distance people will start differentiating between their local area and non-local area, and thus at which distances people do start showing different emotions. My recommendation is that this should be researched, as it will provide valuable information on the impact radius of ultra-deep geothermal projects, so that developers know in which radius they should engage with the public

Lastly, I recommend interviewing laypeople at the chosen areas of interest of a study. In this study, the findings obtained from the interviews have been mainly used as input for the development of the survey study. However, if the interviews would have taken place in the areas of interest, the results obtained from the survey study could have been reflected back to the interviews, thereby increasing the strength of the analysis.

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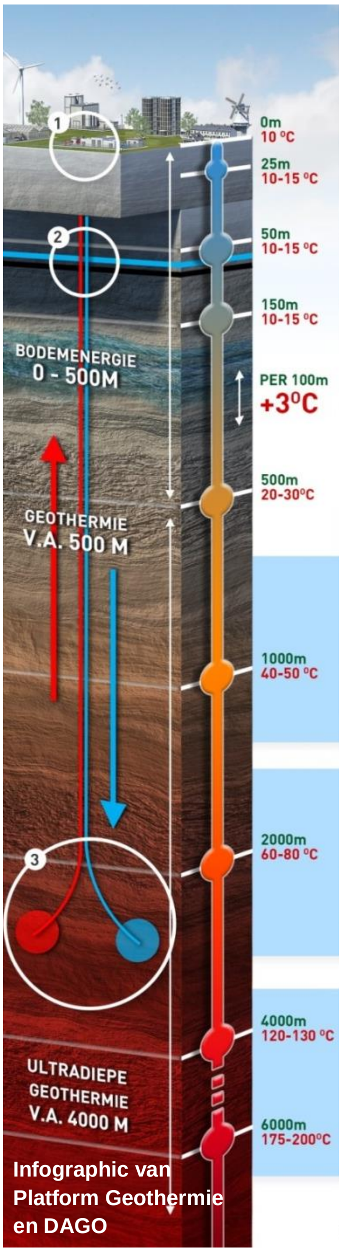
# Appendix 1: Information sheet on UDG provided during interviews and survey study (in Dutch)

## Achtergrond informatie

Geothermie, ook wel aardwarmte genoemd, is een veelbelovende optie om Nederland van duurzame warmte en op termijn mogelijk zelfs duurzame elektriciteit te voorzien. Bij ultra-diepe geothermie wordt heet water uit de diepe ondergrond omhoog gepompt en gebruikt als warmtebron voor industrie en woongebieden.

Bij ultra-diepe geothermie spreekt men over dieptes van meer dan 4 kilometer, oplopend tot wel 8 kilometer diep; op deze dieptes wordt water van minimaal 120°C omhoog gepompt.



Infographic van Platform Geothermie en DAGO

Het hete grondwater dat vanuit de diepte omhoog wordt gepompt zit in een gesloten buizensysteem. Het grondwater wordt naar boven gepompt, de warmte wordt eraan onttrokken en daarna gaat het water weer direct de grond in. Via een warmtewisselaar wordt de warmte aan het opgepompte water onttrokken. Dit is een installatie waarmee de warmte van het zoute grondwater wordt overgedragen aan gewoon water. Dit verwarmde water wordt vervolgens via een bestaand of te ontwikkelen warmtenet verspreid naar de woningen en/of industrie. Het afgekoelde zoute grondwater wordt vervolgens onder druk terug in dezelfde diepe bodemformatie gepompt. Het opgepompte grondwater komt dus niet vrij in het oppervlaktewater. De twee ondergrondse putten liggen voldoende ver van elkaar af, om te voorkomen dat het afgekoelde water zich meteen mengt met het warme water, zie nummer 3 in de figuur.

Bij ultra-diepe geothermie kan het voorkomen dat de diepe ondergrond niet voldoende water doorlaat. In dit geval is stimulatie van de ondergrond nodig. Door middel van stimulatie worden haarscheurtjes in het gesteente van de aardlaag gecreëerd. Dit verbetert de doorlaatbaarheid en maakt zo het gesteente beter geschikt om het warme water door te laten. In Nederland is chemische of hydraulische stimulatie hiervoor het meest geschikt.

Geothermie wordt gezien als een hernieuwbare bron van energie. Het is echter wel zo dat het ondergrondse water op lange termijn afkoelt. Gemiddeld kan een geothermiebron ongeveer 30 jaar meegaan.

Voordelen die veelal genoemd worden (onder andere door de industrie, wetenschappers en de overheid) bij geothermie projecten zijn;

- Zeer lage $CO_2$ uitstoot tijdens productie van duurzame warmte;
- Betrouwbare en constante warmtebron en onafhankelijk van het buitenland;
- Voorspelbare energieprijzen;
- Weinig horizonvervuiling in tegenstelling tot sommige andere duurzame energiebronnen (bijvoorbeeld windmolens).

Nadelen die veelal genoemd worden zijn onder andere;

- Overlast tijdens de aanleg van boorputten voor een periode van 6-8 maanden, binnen een straal van ongeveer 600 meter van het project. Denk hierbij aan het 24/7 aanwezig zijn van licht van bouwlampen, zwaar verkeer en boorgeluiden;
- Risico's op ontploffing tijdens het boren en risico op aardbevingen tijdens mogelijke stimulatie en de productie van warmte. Deze risico's worden echter als klein geschat door het Staatstoezicht op de Mijnen;
- Daarnaast is er nog een risico op lekkage bij de put of de pijplijnen. Bij de productielocatie kan dit gaan om warm zoutwater, soms in combinatie met aardgas. Staatstoezicht op de Mijnen heeft aangegeven dat de risico's hiervoor aanzienlijk kunnen zijn;
- Het aanwezig zijn van een (kleine) semi-industriële installatie in de directe woonomgeving. Dit kan verschillen per project.

# Appendix 2: Scenario description provided during survey study (in Dutch)

## Scenario beschrijving: Ultra-diepe geothermie in uw gemeente

**We geven u nu een beschrijving van een ultra-diep geothermieproject dat in de toekomst mogelijk bij u in de buurt zou kunnen plaatsvinden (het is dus hypothetisch).**

Stelt u zich voor dat uw gemeente een ultra-diep geothermieproject wilt realiseren. Bij dit project wordt naar minimaal 4 kilometer diepte geboord. Vanuit die diepte wordt heet water, met een minimale temperatuur van 120°C, omhoog gepompt.

Voor het project zal op één locatie binnen uw gemeente een geothermie put aangelegd worden. Woningen die al zijn aangesloten op een bestaand warmtenetwerk (denk aan stadswarmte) zullen gebruik gaan maken van de duurzame warmte geproduceerd uit de warmtebron. Daarnaast kunnen nieuwbouw wijken hier ook direct op aangesloten worden. De kosten voor het verwarmen van woningen met duurzame warmte uit een geothermie bron zal vergelijkbaar zijn met de huidige kosten voor het verwarmen van woningen met gas. Bestaande woningen die nog niet aangesloten zijn op een warmtenetwerk kunnen vooralsnog geen gebruik maken van de duurzame warmte uit de bron.

Met de warmte uit de bron kunnen naar schatting ongeveer 20.000 woningen duurzaam verwarmd worden. Het is op dit moment nog onbekend of de doorlaatbaarheid van het gesteente op dieper dan 4 kilometer voldoende is. Er is dus een mogelijkheid dat stimulatie van de ondergrond nodig is. Doordat de samenstelling van de ondergrond momenteel nog onbekend is, is het ook mogelijk dat de potentie van de bron (20.000 woningen duurzaam verwarmen) anders uitvalt. Als gevolg van de plaatsing zal de overlast en de risico's tijdens en na de aanleg ongelijk verspreid zijn over de inwoners van de gemeente. Dit houdt in dat mensen die in de directe omgeving van de projectlocatie wonen (op minder dan 600 meter afstand) meer overlast en risico's ervaren.

> Stelt u zich voor dat de projectlocatie zich op een afstand van 5 kilometer van uw woning bevindt. <

**{OR}**

>Stelt u zich voor dat bovenstaand project in uw directe woonomgeving wordt uitgevoerd, waarbij u dus op een afstand van minder dan 600 meter van de projectlocatie woont. <

**Er volgen nu enkele vragen met betrekking tot bovenstaand scenario.**

# Appendix 3: Questions survey (in Dutch)

**1:** Wat is uw geslacht?

Man (1) Vrouw (2) Geen van beide/Allebei (3) Wil ik niet zeggen (4)

**2:** Mijn hoogst afgeronde opleiding is...

Basisschool of lagere school (1) Lager beroepsonderwijs (2) Middelbaar algemeen onderwijs/beroepsonderwijs (MAVO, VMBO) (3) Middelbaar beroepsonderwijs (MBO) (4) Middelbaaronderwijs (HAVO, VWO) (5) Hoger beroepsonderwijs (HBO) (6) Wetenschappelijk onderwijs (Universiteit) (7) Anders (8)

**3:** In welke gemeente woont u?

**4:** tot welke leeftijdscategorie behoort u?

< 18 (1) 18 – 25 (2) 26 – 35 (3) 36 – 45 (4) 46 – 55 (5) 56 – 65 (6) 65+ (7)

**5:** Is uw woning momenteel aangesloten op een warmtenetwerk (denk aan stadswarmte)?

Ja (1) Nee (2)

**6:** Was u, voordat u deze enquête ontving, al bekend met ultra-diepe geothermie als een vorm van duurzame energie?

Ja (1) Nee (2)

**7:** Heeft u in de afgelopen 3 maanden in de media iets gehoord, gelezen of gezien over duurzame warmte geproduceerd uit ultra-diepe geothermie bronnen?

Ja (1) Nee (2)

**8:** Ik denk dat warmte uit een ultra-diepe geothermiebron, in plaats van opgewerkt door gas, …

**A:** Veel slechter voor het milieu zal zijn (1)(2)(3)(4)(5) Veel slechter voor het milieu zal zijn
**B:** Zeer weinig zal bijdragen aan het oplossen van het klimaat probleem (1)(2)(3)(4)(5) Zeer veel zal bijdragen aan het oplossen van het klimaat probleem
**C:** Totaal niet zal bijdragen in de energietransitie (de overgang van energie uit fossiele brandstoffen naar energie uit duurzame bronnen) (1)(2)(3)(4)(5) Zeer veel zal bijdragen in de energie transitie
**D:** De voorspelbaarheid van de kosten voor het verwarmen van mijn woning zeer negatief zal beïnvloeden (1)(2)(3)(4)(5) De voorspelbaarheid van de kosten voor het verwarmen van mijn woning zeer positief zal beïnvloeden

**9:** Wat vindt u van het idee van een ultra-diep geothermieproject bij u in de gemeente (op ongeveer 5 kilometer van uw woning)? // Wat vindt u van het idee van een ultra-diep geothermieproject in uw directe omgeving?

Zeer onwenselijk (1) Onwenselijk (2) Neutraal (3) Wenselijk (4) Zeer wenselijk (5) Weet ik niet (6)

**10:** Lijkt de ultra-diepe geothermie technologie u veilig?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**11a:** In welke mate denkt u zelf risico's te lopen?

Totaal niet (1) Niet (2) Neutraal (3) Veel (4) Zeer veel (5) Weet ik niet (6)

**11b:** In welke mate denkt u last te krijgen van hinderlijke overlast?

Totaal niet (1) Niet (2) Neutraal (3) Veel (4) Zeer veel (5) Weet ik niet (6)

**Als u nu aan alle directe omwonenden van dit project denkt:**

**12a:** In welke mate denkt u dat dit project risico's oplevert voor alle directe omwonenden?

Totaal niet (1) Niet (2) Neutraal (3) Veel (4) Zeer veel (5) Weet ik niet (6)

**12b:** In welke mate denkt u dat dit project hinderlijke overlast geeft voor alle omwonenden?

Totaal niet (1) Niet (2) Neutraal (3) Veel (4) Zeer veel (5) Weet ik niet (6)

**13:** In hoeverre verwacht u dat het genoemde geothermie project de kwaliteit van uw woonomgeving zou beïnvloeden?

Zeer negatief (1) Negatief (2) Neutraal (3) Positief (4) Zeer positief (5) Weet ik niet (6)

**14:** Verwacht u dat het genoemde geothermie project de waarde van uw woning zou beïnvloeden?
(indien u een woning huurt kunt u 'niet van toepassing (n.v.t.) invullen)

Ja (1) Nee (2) Weet ik niet / n.v.t. (3)

**15:** In hoeverre verwacht u dat het genoemde geothermie project de waarde van uw woning zou beïnvloeden?

Zeer negatief (1) Negatief (2) Neutraal (3) Positief (4) Zeer positief (5) Weet ik niet (6)

**16a:** Wat vindt u ervan dat alleen de huishoudens die nu al aangesloten zijn op een warmtenetwerk en nieuwbouw woningen gebruik kunnen maken van de duurzaam geproduceerde warmte uit de geothermie bron?

Zeer oneerlijk (1) Oneerlijk (2) Neutraal (3) Eerlijk (4) Zeer eerlijk (5) Weet ik niet (6)

**16b:** Omwonenden die niet (meteen) aangesloten kunnen worden hebben mogelijk wel last van de nadelen van ultra-diepe geothermie. Wat vindt u hiervan?

Zeer oneerlijk (1) Oneerlijk (2) Neutraal (3) Eerlijk (4) Zeer eerlijk (5) Weet ik niet (6)

**16c:** Huishoudens die in de directe woonomgeving van de projectlocatie wonen zullen tijdens en na de aanleg van het project meer overlast en risico's ervaren. Wat vindt u hiervan?

Zeer oneerlijk (1) Oneerlijk (2) Neutraal (3) Eerlijk (4) Zeer eerlijk (5) Weet ik niet (6)

**Bij duurzame energie projecten worden door gemeenten en uitvoerende partijen vaak informatie en inspraak avonden georganiseerd. De volgende vragen gaan over de eerlijkheid van procedures die u als burger verwacht te krijgen.**

**17a:** In welke mate denkt u dat burgers in de gemeente voldoende inspraak zullen krijgen?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**17b:** In welke mate denkt u dat de gemeente het welzijn van alle burgers zal meenemen in de besluitvorming?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**17c:** In welke mate denkt u dat de gemeente de mening van alle burgers zal meenemen in de besluitvorming?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**17d:** In welke mate verwacht u dat een project, zoals beschreven, nog aangepast kan worden op het moment dat de plannen bekend gemaakt zullen worden?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**17e:** Hoe belangrijk zou u het vinden om inspraak in de gemeente te krijgen indien er plannen zijn om een ultra-diep geothermie project te realiseren?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**Bij grote projecten, zoals het beschreven geothermie project, worden altijd 'Impact analyses' uitgevoerd. Dit zijn analyses die toetsen wat de effecten van zulke projecten op de omgeving zijn**

**18a:** In hoeverre zou u de impact analyses die uitgevoerd worden vertrouwen?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**18b:** In hoeverre verwacht u dat er, zowel tijdens de aanleg als tijdens de productie, de intentie is om de hoogste veiligheidsmaatregelen in acht te nemen?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**19c:** In hoeverre verwacht u dat er de intentie zou zijn om een zo veilig mogelijk geothermie systeem te plaatsen?

Helemaal niet (1) Niet (2) Neutraal (3) Enigszins (4) Helemaal wel (5) Weet ik niet (6)

**19a:** In hoeverre zou u protesteren / actie ondernemen indien het beschreven geothermie project in uw directe woonomgeving gerealiseerd zal worden?

Totaal niet (1) Niet (2) Neutraal (3) Veel (4) Zeer veel (5) Weet ik niet (6)

**19b:** In hoeverre zou u het project steunen indien het beschreven geothermieproject in uw directe woonomgeving gerealiseerd zal worden?

Totaal niet (1) Niet (2) Neutraal (3) Veel (4) Zeer veel (5) Weet ik niet (6)

## Gevoelens

U hebt zojuist een informatieve tekst over ultra-diepe geothermie en een scenario beschrijving doorgelezen. Daarna hebt u meerdere vragen beantwoord over een mogelijk geothermie project in uw omgeving. We willen nu graag weten welke gevoelens het geothermie project bij u oproept.

**20:** Geeft u alstublieft aan in welke mate u de volgende gevoelens voelt als u denkt aan het beschreven geothermie project in uw gemeente (op een afstand van 5 kilometer van uw woning/600 meter). Klinkt u op 'Niet van toepassing' als u een gevoel helemaal niet ervaart.

**20a:** Blij, **20b:** Angst, **20c:** Trots, **20d:** Boos,
**20e:** Hoopvol, **20f:** Machteloos, **20g** Verrast,**20h:** Geirriteerd

Een beetje(1) Matig (2) Redelijk sterk (3) Sterk (4) Heel sterk (5) N.v.t. (6)

## Ten slotte..

We zijn benieuwd naar welke informatie over ultra-diepe geothermie en het scenario is blijven hangen. Er volgen nu enkele stellingen. Geef per stelling aan of u denkt dat deze 'juist' of 'onjuist' is.

**21a:**Tijdens het beschreven project wordt naar maximaal 2 kilometer diepte geboord.

Juist (1) Onjuist (2)

**21b:**Geothermie projecten hebben een zeer lage CO2 uitstoot tijdens productie van duurzame warmte

Juist (1) Onjuist (2)

**21c:**De risico's en overlast zijn gelijk verspreid over de gemeente.

Juist (1) Onjuist (2)

**21d:**Er is een mogelijkheid dat stimulatie van de ondergrond nodig is.

Juist (1) Onjuist (2)

**21e**Een geothermie bron gaat ongeveer 30 jaar mee.

Juist (1) Onjuist (2)

**22a:** Vond u het gemakkelijk of moeilijk om zich de technologie en scenario beschrijving voor te stellen?

Zeer moeilijk (1) Enigszins moeilijk (2) Neutraal (3) Enigszins gemakkelijk (4) Zeer gemakkelijk (5)

**22b:** In welke mate vond u het gemakkelijk of moeilijk om de vragen te beantwoorden?

Zeer moeilijk (1) Enigszins moeilijk (2) Neutraal (3) Enigszins gemakkelijk (4) Zeer gemakkelijk (5)

# Appendix 4: Tests for suitability of PAX, concept questions

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | ,876 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 2326,961 |
| | df | 351 |
| | Sig. | ,000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| Q9 | ,492 | ,575 |
| Q10 | ,456 | ,657 |
| Q11_1 | ,552 | ,550 |
| Q11_2 | ,644 | ,707 |
| Q11_3 | ,559 | ,558 |
| Q11_4 | ,477 | ,467 |
| Q15_1 | ,717 | ,680 |
| Q15_2 | ,724 | ,696 |
| Q16_1 | ,768 | ,780 |
| Q16_2 | ,744 | ,709 |
| Q20_2 | ,604 | ,580 |
| Q20_3 | ,562 | ,523 |
| Q21_2 | ,683 | ,604 |
| Q21_3 | ,720 | ,843 |
| Q21_4 | ,526 | ,428 |
| Q22_1 | ,538 | ,489 |
| Q22_2 | ,640 | ,689 |
| Q22_3 | ,624 | ,720 |
| Q23_1 | ,543 | ,518 |
| Q17 | ,820 | ,816 |
| Q19 | ,762 | ,706 |
| Q23_2 | ,721 | ,661 |
| Q13 | ,826 | ,814 |
| Q14 | ,700 | ,652 |
| Q20_1 | ,178 | ,113[1] |
| Q21_1 | ,636 | ,674 |
| Q21_5 | ,246 | ,197[1] |

Extraction Method: Principal Axis Factoring.

[1] Deleted from PAX

# Appendix 5: Tests for suitability of PAX, emotions

**KMO and Bartlett's Test**

| | | |
|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | ,767 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 430,443 |
| | df | 28 |
| | Sig. | ,000 |

**Communalities**

| | Initial | Extraction |
|---|---|---|
| Happy | ,550 | ,621 |
| Fear | ,646 | ,701 |
| Proud | ,600 | ,742 |
| Anger | ,596 | ,608 |
| Hopeful | ,557 | ,674 |
| Powerless | ,635 | ,651 |
| Surprised | ,286 | ,284 |
| Irritated | ,645 | ,730 |

Extraction Method: Principal Axis Factoring.