Bridging the policy implementation gap: a draft design method for assessment frameworks

Applied to the case of urban geothermal energy development

SEN233: Master thesis

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by

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Cover: Drilling rig for a geothermal well in The Hague (Haagse Tijden, 2010)

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Preface and acknowledgments

”To everything there is a season, a time for every purpose under heaven: A time to weep, and a time to laugh; a time to mourn, and a time to dance. What profit has the worker from that in which he labors? I have seen the God-given task with which the sons of men are to be occupied. He has made everything beautiful in its time. Also He has put eternity in their hearts, except that no one can find out the work that God does from beginning to end. I know that nothing is better for them than to rejoice, and to do good in their lives, and also that every man should eat and drink and enjoy the good of all his labor — it is the gift of God.”
Ecclesiastes 3:1,5,9-13

Right now, you are looking at a hard-fought, long awaited, and final version of my master thesis, the final contribution to my graduation as a master in science. It may not be perfect, it for sure is not in fact, but I am glad and satisfied about the end result. It has been a long journey that started well over a year ago when the first contours of this study came into being. It took me an extra half year of preparation and an extra summer of research longer than the prescribed period of 6 months, but finally, it is here. This brings me to one of the big issues for my thesis process: time. At times I praised myself for developing my own graduation topic, a topic which I enjoyed and was interested in, and at other times I cursed myself for picking a research approach that seemed to lead to freaking nowhere. But at all times, the thesis required more time than anticipated. More than once the deadlines had to be postponed resulting in frustration, demotivation, and then picking it up again. But finally yes, for every purpose there is a time under heaven, also for graduation.
The subject of how policy making effects urban geothermal energy development is a combination of my double academic background, a bachelor degree in applied earth science, and a master degree in technology, policy, and management. I have made this switch because I realized that I am not an engineering pur sang. I like the regularity and logic of exact science, but I love people and everything that makes us unpredictable and nonsensical. The part of my thesis that I enjoyed the most was the literature on uncertainty, and the description of fundamental uncertainty: non-predetermined structural change because of creativity and unintended consequences, resulting in ”complete ignorance about the future, without degrees”. It is the study and understanding of complexity that I am most grateful for to have learned in my master’s degree. It was when studying the literature of uncertainty that I came to the same conclusion as the Ecclesiastes did millennia ago: we are blessed with an understanding that can conceive the extensiveness and intricacy of all knowledge that is out there, but yet are inherently incapable of understanding the complexity of it all. And one of the primal sources for this complexity is the creativity and unintended consequences of our own actions, how ironic. God has put eternity in our hearts, except no once can find out the work that God did from beginning to end. But this irony should not lead to despair, it is the complexity of life that makes it beautiful, and it are the simple things that make it bearable. During my thesis, simple things like salsa lessons and sports, friendships and family, and many other good things made it all enjoyable. And they also helped me finding joy in the little things of a thesis like interesting literature, intriguing interviews, and new insights. It made the labor all worth it.
In my thesis I speak about strategies on how to deal with uncertainty and I have given a few, but there is one that I could not give in my official report, which I would like to give here: that is trusting the One who does know it all from beginning to end. Let me testify of what God did during my thesis. I have dreamt of traveling the world after my studies since I have been able to understand what studying or traveling is. My dad told his stories of traveling throughout Asia time and time again and I wanted to do the same. And I will. I wanted to save some money for the trip during my thesis, but this required me to find a second job, I already had one to cover some living expenses, whilst also doing your thesis. Not easy, but doable. I wanted to save 2000 euros. But then God spoke to me: ”what if you don’t save up 2000 euros for the trip, but save 2000 euros to give away on my direction, and I will take care of your trip”. This was a crazy idea of course, but I was certain of it and thus I agreed to do so. At the time, already a promise was made that I would be payed a yet undefined amount of money for my thesis

from the Mijnraad, but the expectations were tempered. In the summer of 2022, I finally heard what the payment was going to be. It was an exact net salary of 4000 euros!! 2000 to give away, 2000 to travel with, and I did not have to work a single extra hour!! And this is only one example of what God did in my life. The best measure for uncertainty in life, is the Source of life.
Next to thanking God, there are many more persons that I should thank. First of all my supervisors Aad and Mark, who have been patient, understanding, and a real help in finding my way in the research process. Without you, I could for sure not have done it. I would also like to thank my friends, especially my fellow thesis sufferers, and in particular Leen. Thank you for all the nice walks and talks, your season and time of graduation will be there too, sooner than you might think.
I would like to end with one final reflection on the simultaneous complexity and simplicity of life. The complexity of life, the fundamental uncertainty that we all need to deal with, is not something that should lead to despair. The complexity of life makes it beautiful, and this beauty can be seen in its most powerful form in the simple things of life. Think about the setting of the sun, a beautiful but simple image, free to watch for every man. Yet, in this simple image there is the grandness of the universe and the futility of ourselves, the closing of a day or season and the anticipation of something new, the interconnectedness of all the earth and her inhabitants, and the brilliance of all optical laws bringing about this image. Complexity makes life interesting, the simple expressions of this complexity make it beautiful. At some places my research might be too simple, at others yet still way to complex, but I hope that I have been able to grasp some of that simplicity in my research. The challenges of the energy transition are complex and the problem it represents is dire. But well, when have the world problems not been so, there is nothing new under the sun. Let us labor to find solutions, let us be intrigued by the challenges and questions, and let us in the mean time enjoy the simple things in life.
If you made it this far, thank you for reading all this nonsense. Good luck with the rest of it.

Chris Smouter
Delft, February 2023

Executive summary

The pressure on urban energy infrastructures is rising as urban areas continue to grow while at the same time the energy supply is transitioning to alternative sustainable sources. To deal with this problem, renewable urban planning is on the rise and many nations worldwide have set ambitious sustainability targets to transform their cities and become CO2 neutral. However, although these targets have resulted in many sustainable policies, the **implementation of sustainability policies is lagging**, hindering the energy transition. One of these policy fields where implementation is falling behind on the targets, is the geothermal energy sector of the Netherlands, specifically in the urban environment.
To overcome this implementation gap, this study investigates the role that assessment frameworks might be able to play. Assessment frameworks are policy implementation tools which are used in many different fields of policy in the Netherlands, including the energy transition. Already first attempts of designing an assessment framework for urban geothermal energy development have been finished and several organizations are working towards this goal. One of these organisations is the Mijnraad, an advisory board for the Dutch ministry of economic affairs and climate change. This master thesis has been funded by the Mijnraad with the intend to explore the key issues of urban GE development that need to be included in an assessment framework. In investigating this topic, a **knowledge gap on assessment frameworks** was noticed that although assessment frameworks are widely applied in Dutch policy making, no existing frameworks yet exist that direct the design of assessment frameworks. A second **threefold knowledge gap** was defined on the matter of urban geothermal energy that needs to be investigated to explore the key issues of urban geothermal energy: spatial planning and public values, social acceptance, and uncertainty. To explore both the design of assessment frameworks and the key issues of urban geothermal energy development, the **main research question** investigates how assessment frameworks can support local policy making in dealing with the complexity of urban geothermal energy development in the Netherlands. The **aim** of this research is to develop a draft design method for assessment frameworks and to create a knowledge basis from which local assessment frameworks on urban GE can be further designed.
Because of the wide and double research focus, the research design was chosen to be exploratory. This means that the research aims at creating a draft design method and a basis for urban geothermal energy assessment frameworks, and not yet a fully finished design method or assessment framework. To investigate both these topics, a **double research path** has been chosen, developing both a draft design method and exploring the case of urban geothermal energy, and eventually applying this draft to the case of urban geothermal energy. The draft design method for assessment frameworks has been developed by researching existing assessment frameworks and by studying literature on public decision-making. The case of urban geothermal energy has been investigated by conducting multiple rounds of interviews with several diverse representatives of the urban geothermal energy sector.

The double research path lead to the following **findings**. Assessment frameworks intervene in policy subsystems by structuring and adding to existing legislation. They follow a three part chapter frame: context, intervention, and clarification. The context chapter connects the intervention to the historical and recent developments of the policy subsystem, explaining the motivation and background of the assessment framework. The intervention chapter presents the structuring and overview of the existing legislation and the additional legislation created by the assessment framework. The clarification chapter explains each intervention specification in detail and justifies the choices made to come to these specifications. The specifications of the intervention should be based upon a trade-off of public values, and these trade-offs should be made debatable by being explicit and traceable. To achieve this, the intervention can be designed along the lines of a value hierarchy, specifying values into norms, and norms in eventual final intervention specifications. The **draft design method** takes a 4 step process to design an assessment framework along the lines of a value hierarchy: gathering norms by analyzing the public debate; deriving values from these norms and specifying additional norms by a stakeholder participation process to ensure an adequate representation of each value by the norms; specifying the norms into final intervention specifications by the local decision-makers; and lastly clarifying and

justifying each final specification, making the trade-offs between the different values and norms explicit and traceable, and hereby reflecting on the balance between long and short term values and ambitions of the municipality. For the third step of designing final intervention specifications, which are either objectives, goals, or constraints, four principles have been proposed to guide this specification step from norms to intervention specifications. The final specifications should be locally specific and based upon plural and conditional sources; use static or flexible strategies to deal with uncertainty; consist of policy instruments which are both procedural and substantive; and mind the discretion space for civil servants to implement the assessment framework effectively.
For the case of urban geothermal energy development, four **key issues** have been identified with an additional potential key issue for the future. These are: collective action, which concerns the directing of the different actors involved to let each actor effectively work on their task and responsibility; effective citizens communication, which addresses the challenge of social acceptance and how to collectively communicate a story that generates trust and support for the project; lead times, which concerns the long and still inefficient processes of permit procedures and inter-governmental and private-public relationships; and financing, which addresses the challenges of investment in a relatively new and inherently uncertain industry. Spatial planning has been identified as a potential future key issue, since multiple well locations within one municipality are starting to take place which requires the clearing and reservation of multiple patches of land within crowded urban spaces. The direction that an assessment framework could best take to deal with these key issues, is to create clarity on distributed responsibilities for the issue of collective action, to create uniformity and new process rules for the issue of effective citizens communication, to create an overview of expertise and a road-map for public-private communication for the issue of lead times, and to create clear process rules and additional legislation for the issue of financing. For the potential future key issue of spatial planning, creating clarity on the vision of the municipality for spatial planning of geothermal projects seems the most fitting intervention purpose for now. Another important finding is which issues are not included in the 4+1 key issues. The scope of this study looked at local assessment frameworks and the role of municipalities. Therefore, certain issues are also out of scope. For instance, the hazard of ground subsidence due to induced seismic activities is not within the scope of municipalities, since this falls under legislative authority of the national government. Although urban geothermal energy legislation is in development and some issues might not yet be covered sufficiently by national legislation, requiring local assessment frameworks to fill these gaps, in general the principle applies that an assessment framework for urban geothermal energy should cover the key issues, and not more than those.
From these findings, the following **recommendations** can be made. The design method for assessment frameworks is still only a draft, and refinements are needed. The next step in developing this draft into a full design method is to work out all four steps extensively. This could for instance be done for the case of urban geothermal energy. For the development of local assessment frameworks for urban geothermal energy, it is advised to help municipalities in creating an assessment framework by doing **preliminary work in order to make the four step process accessible**. It is advised to work out step 1 and 2 on a general basis, executing an extensive analysis of the public debate to gather a comprehensive list of norms for geothermal energy development. Next, a stakeholder participation process can be organized with representatives of the national sector, deriving values, specifying additional norms, and creating a list of suggested final intervention specifications. Lastly, a draft can be created for the context chapters of local assessment frameworks, explaining the national context of the energy transition and collective heat supply. In doing so, the draft design method can be simplified for municipalities in which they only need to: 1) connect the drafted context chapter to their local energy transition policies, like the heat transition plan; 2) evaluate with their citizens if the list of values and norms is adequate; 3) design intervention requirements based upon these values, norms, and the suggested interventions; and then 4) consult again with their citizens if the political choices made are clear and just.

The added **value of this research** is in the distillation of the typology and design principles of assessment frameworks, and the overview it presents on the key issues of urban geothermal energy developments for local decision-makers. However, the research has been of exploratory nature, which results in **limitations** on the findings and recommendations. The design method that is presented by this study is yet only a draft, and needs refinement on all four steps of the design process. Also, the direction that an assessment framework could best take to deal with the key issues of urban geothermal

energy are interpolations, based upon the typology and goals of assessment frameworks, and the problem interpretation of each key issue. Both aspects could only be investigated to a limited extent due to time restrictions, further research on these matters is needed to commit to any of these directions of assessment framework design.

Contents

Nomenclature

Abbreviations

Abbreviation	Definition
AF	Assessment Framework
GE	Geothermal Energy
RE	Renewable Energy
SA	Social Acceptance

1 Introduction

1.1. Problem situation

1.1.1. Urban energy transition

More than half of the world's population lives in urban areas and this is only expected to grow (World Bank, 2020). This creates an enormous challenge for cities to provide their residents with desirable living accommodations and crucial services like mobility, healthcare and education. On top of that, cities experience shifting environmental conditions due to climate change. The consequences of climate change entail extreme participation and temperatures, inland and coastal flooding, drought, and disruption of flora and fauna. All these issues together result in complex challenges for urban sustainable development and place cities at risk (IPCC, 2022). To deal with these challenges, renewable urban planning is happening in cities all over the world to combat climate change and to work towards a zero-carbon society. As of March 2021, 156 countries have developed national urban policies in line with the 11th sustainable development goal of the United Nations: sustainable cities and communities (United Nations, 2022). Also the Netherlands have developed plans and policies for the urban energy transition. In 2019, a national climate agreement was approved which stated that 1.5 million houses were to be made sustainable by 2030 (Dutch parlement, 2019).
However, the UN also noticed in that report that at that time, less than half of these countries reached the implementation stage of these policies. This lack of implementation, also called the policy-implementation gap, is due to the complexity of sustainable policy implementation. Policy implementation is in itself already complex (Wanna et al., 2010; Hudson et al., 2019) and it is also recognized that the goals of environmental policies themselves are complex (Ostrom, 2009; Kirschke et al., 2017). The complexity of sustainable urban policies is both structural and dynamic. It is structurally complex because it involves multiple disciplines of knowledge, like spatial planning, climate adaptation, and energy technology. It is dynamically complex because the policy implementation context continuously changes. Sustainable energy technologies are in constant technological development and global or national events influence economic or social feasibility of these different sustainable technologies (Sengers et al., 2010), resulting in an ever changing "best" solution. The implementation of sustainable policies is thus a complicated matter and requires ambitious sustainability goals to be translated into tangible projects. One of these goals in sustainable urban development is the development of renewable energy, which requires the expansion of the energy network whilst at the same time shifting from fossil to renewable energy sources. Cities have a key role in the energy transition, since about 75 percent of all energy produced is consumed in cities (Dodman, 2009). It is therefore of great importance that the urban renewable policies will reach implementation.

1.1.2. Geothermal energy in the city

One of the options for renewable energy is geothermal heat. A major part of the required energy in cities is used for heating of buildings. It is estimated by the International Energy Agency that heating buildings is responsible for about 25 percent of the global final energy consumption (IEA, 2022). Transitioning from fossil sourced heat to sustainable heat would thus be a major step towards a sustainable city.
Geothermal energy (GE) is produced by pumping hot water from depths ranging between 500 and 4000 meters. The energy from this water is then transferred to local systems via a heat exchanger, supplying energy to the built environment, greenhouse horticulture or light industry (Platform Geothermie et al.,

2021). Geothermal energy can either be supplied in the form of heat or power. For the supply of geothermal power or high temperature heat for light industry, Ultra Deep Geothermal (UDG) installation are needed, which extract water at depths of over 4000 meters at temperatures around 120°C, whilst for heating of the built environment and greenhouses, water reservoirs between 500 and 4000 meters will suffice (EBN, 2022b).
The Dutch government has decided that geothermal energy is one of the desired energy sources for the energy transition. According to the Ministry of Economic Affairs and Climate, geothermal energy has the potential *"to play an important role in the development of sustainable heat supplies, as well as in the transition to low CO2 energy sources"* (EZK, 2018). The goal for 2030 is to create a geothermal energy capacity of 15 PJ which is an equivalent energy consumption of 2.2 million households (Ministerie van Economische Zaken en Klimaat, 2022). However, like the globally observed implementation gap of sustainable urban policies, problems concerning the implementation of ambitious plans and policies is also present in the geothermal development in the Netherlands. Despite the subsurface potential and the fact that geothermal energy is gaining momentum given the high demand for sustainable heat in the Netherlands, the development of geothermal energy is falling behind and especially in the urban environment (Schoof et al., 2018; van Mersbergen, 2020).

1.1.3. Bridging the implementation gap

Because of the gap between ambitious sustainable targets and yet slow implementation of required plans to achieve these targets, a change is needed in the current implementation practices. An improvement in the implementation of urban geothermal energy policy should therefore be implemented that stimulates the development of the GE sector. In the Netherlands, a common applied policy implementation support tool is an **assessment framework** (afwegingskader in Dutch). They are widely used in the Dutch institutional environment in varying areas like North Sea development, governmental ICT procurement, and permitting for deep subsurface exploration (Ministerie van Infrastructuur en Waterstaat, 2022; M. Poel et al., 2009; CE, 2004). These frameworks set rules and create clarity on the assessment process and criteria in specific fields and are therefore part of the institutional setting of these fields. One of the reasons that are mentioned in the public debate for the lack in urban geothermal development, is the frustration of institutional procedures. Recently, a GE project in Nieuwegein was canceled because the long process of public decision-making lead to the evaporation of subsidy money. Another project in Ijselmuiden almost got canceled because receiving the permits took much longer than expected (Venderbosch, 2021; de Jonge, 2022). According to geothermal operators, these delays exist because the institutional environment has not yet developed a standard approach and assessment criteria for GE projects, and this causes inefficient lead times at national and local authorities for permitting procedures (de Jonge, 2022). An assessment framework for urban GE has the potential of resolving these frustrations by creating clarity on both the assessment process and the criteria for urban GE public procedures.
The institutional environment of geothermal energy is organized in a multi-level governance structure. The main responsible public agent for permitting is the ministry of Economic Affairs and Climate, while the local authorities are responsible for the urban planning (RVO, 2019) and have advisory rights on the permitting procedures (Gemeente Nieuwegein, 2021). At the national level, the institutional environment is developing towards a better approach for GE. The adaptation of the mining act to promote GE development has been set into motion in March 2022 (Rijksoverheid, 2022), and the SDE++ subsidy structure, which is specifically for renewable energy projects, is changed this March as well, dedicating more money to GE projects (EZK, 2022). Also at the local level, efforts are made to streamline the institutional procedures surrounding geothermal energy. Even though the GE project in Nieuwegein itself was unsuccessful, it did produce an assessment framework which was developed by the municipality (Gemeente Nieuwegein, 2021), and a coalition of companies and local authorities at the metropolis region of Amsterdam are investigating the responsibilities and roles for cooperation in the current legal setting (MRA, 2020). It is important however, that the local approach towards geothermal energy development is synchronized and based upon appropriate knowledge and expertise. If there are totally different rules for urban GE projects for every city, and if these rules are based upon false perceptions and flawed knowledge, no good would come from these assessment frameworks.

1.2. Knowledge gap

This matter highlights the main goal to which this study wants to contribute: a coordinated and well founded approach in regard to the development of urban GE assessment frameworks for municipalities in order to increase the success rate and efficiency of urban geothermal development. For the development of such an assessment framework, three main knowledge gaps are identified: the prioritization of public values in spatial planning, the social acceptance of urban geothermal energy required for operation, and the matter of uncertainty that surrounds geothermal technology and sustainable energy policy.

1.2.1. Spatial planning & public values

One of the characteristics of geothermal heat is that it requires its consumers to be close to the source (Stichting Warmtenetwerk, 2018). This means that if the geothermal plant needs to supply the built environment, it needs to be build within, or close to, the built environment. The national government has delegated the development of local heat transition plans to the municipal authority (RVO, 2019), and this makes the municipality responsible for the spatial planning of sustainable heat facilities. Spatial planning is defined by the European Commission as: *"The methods used largely by the public sector to influence the future distribution of activities in space. It is undertaken with the aims of creating a more rational territorial organisation of land uses and the links between them, to balance demand for development with the need to protect the environment, and to achieve social and economic objectives"* (CEC, 1997). Spatial planning therefore is a public service that needs to balance social and economic values. This is a difficult task, because promoting one value often degrades another, resulting in 'wicked' problems (Vigar et al., 2020). Traditionally, the three main public values for energy infrastructures were safety, reliability, and efficiency (WRR, 2008). With the energy transition, a new public value is added to this list: sustainability. The characteristics of public values makes assuring public values in policy complex. Public values are first of all ambiguous, what can be considered safe is always debatable. Secondly, they are inherently relative and in conflict. You cannot maximize safety without it compromising the efficiency of an energy project. And thirdly, the prioritization of the public values will shift over time. After an energy safety failure, like the Fukushima incident, safety will be prioritised, while the recent skyrocketing of gas prices has emphasised the efficiency of energy provision. Public values will thus always require trade-offs, and the energy transition especially requires trade-offs between long- and short-term values where the long-term values represent the sustainability value (WRR, 2008). Unfortunately, prioritizing long-term values is a difficult and ungrateful task because the rewards of long-term values come slow and are hard to link to a specific intervention (Mazzucato, 2018), which make it less attractive to make (policy) decisions that support long-term values. Therefore, research is needed to investigate how public agencies should make these trade-offs between long and short-term values.

1.2.2. Social acceptance of geothermal energy

A second characteristic of geothermal energy is that it requires subsurface operation, which is a delicate matter in the Dutch society due to the past experiences with gas exploration in Groningen. Due to the negative experiences with Groningen, resistance to any form of subsurface exploration can be expected and it is crucial to address these reservations (Jansma et al., 2020). It is supported by academic literature and geothermal operators that both technical and social factors need to be considered for an integrated approach for geothermal development and the successful development of geothermal energy (Zeng et al., 2021; Karytsas & Polyzou, 2021). However, although research on the social acceptance of renewable energy technologies has developed into a dedicated research stream, the social acceptance of wind energy has dominated the research field (Böttcher, 2020, chapter 3). Research to the social acceptance of geothermal energy is limited and has not yet covered the situation in the Netherlands (Karytsas & Polyzou, 2021). In order to develop a well founded approach for the development of assessment frameworks for urban GE, social acceptance should not only be investigated as a potential issue for the development of urban GE, but also be investigated for the design of assessment frameworks in itself. Therefore, research is needed that explores the social acceptance of decision-making and geothermal energy in the Netherlands.

1.2.3. Uncertainty

A third characteristic of geothermal energy is that its development is influenced by several factors of uncertainty. The first uncertainty is due to the fact that the source is in the deep subsurface. Even though seismic surveys are mapping the Dutch subsurface (SCAN, 2022), the full potential of a well cannot be accurately known until a full well is drilled and tests have been run (Alles over Aardwarmte, 2021b). At this stage in the development process, the greatest part of the investments are already made and this matter creates large risks for investment (de Groot et al., 2020). A second uncertainty is the long period of time over which the geothermal well will operate. A geothermal well is expected to produce heat for about 30 years (Platform Geothermie et al., 2021). Predicting the expected value of the supplied heat over such a long period of time is difficult. Local and global events have big impact on the price, as exemplified by the recent development caused by the conflict between Ukraine and Russia (Boere, 2022). Because geothermal energy is a relatively new energy technology, the investment climate for GE is not ideal and the business case is not yet profitable without subsidies (Alles over Aardwarmte, 2021b). All these uncertainties makes creating an institutional environment that supports geothermal development complex. There is a tendency among decision-makers to ignore uncertainties (Dessai & Wilby, 2011) or to reduce them to quantifiable risks, making them ”manageable” (Stirling, 2010). This should be avoided, so that the policy making cycle creates solutions for societal issues which address the full complexity of the issue. Research is needed to investigate how these specific uncertainties related to geothermal energy can be addressed by policy makers.

1.2.4. Assessment frameworks

On top of these three knowledge gaps for geothermal energy, there is also scarce academic knowledge on assessment frameworks, resulting in a fourth knowledge gap. Although literature is available on general strategies of dealing with uncertainty in policy making (Wester, 2022) and governmental influence on public values (Klievink et al., 2016; Gielen & Tasan-Kok, 2010), no studies have yet investigated the impact of assessment frameworks in shaping these processes in the context of renewable energy. To design an assessment framework for public policy implementation, it is at first important to understand the public decision-making process within it will be used. According to the policy cycle theory, there are five stages in policy making; 1) Agenda setting, 2) Policy formulation, 3) Decision-making, 4) Policy implementation, and 5) Policy evaluation (Howlett et al., 2009). This study aims at improving the policy implementation phase by contributing to the development of coordinated and well founded assessment frameworks for urban GE. These five phases of policy making are interlinked and heavily influence each other, and it is therefore important that the assessment framework is well integrated in all phases of policy making. It is also recognized within the public policy domain, that the civil servants who are responsible for the implementation of policies have great influence on the policy outcomes (Howlett et al., 2009). Since the lack of recent development in GE has been linked to the inexperience of public agents with geothermal policy (de Jonge, 2022), it is of great importance to develop an assessment framework to help the local authorities with the policy implementation of geothermal energy.

1.3. Research Questions and approach

The aim of this research is to provide an overview for local policy makers on the relevant considerations and trade-offs that need to be made when deciding if and how to develop a geothermal source for sustainable heat in the urban environment. This overview should then eventually lead to a standardised approach, in the form of assessment frameworks, for local implementation of GE projects in the urban environment and create clarity on the rules in play for all parties who want to act in the GE sector. A fully worked out assessment framework for urban GE is not the goal of this study, since the time for this study is limited and because of the double research goal of exploring both the nature of assessment frameworks as well as how they can aid the development of urban GE. Therefore, the end results of this study will constitute both a draft for a general design method of assessment frameworks, and a basis for the development of urban GE assessment frameworks. A fully worked out design method for AFs or a complete urban GE assessment framework will need to be developed by further research. The double research focus and the two different research paths that will be followed can be seen in figure 1.1. This section will elaborate shortly on the research questions that were formulated from the knowledge gap and the chosen research approach that will be followed in this master thesis.

1.3.1. Research questions

To address the knowledge gaps that follow from the problem introduction, the following main research question has been defined for the thesis:

How can assessment frameworks support local policy making in dealing with the complexity of urban geothermal energy development in the Netherlands?

The main research question is divided into four research questions. The first two research questions address the practice and nature of assessment frameworks. Examples of assessment frameworks are investigated to reveal what they are and how they work. Literature on public decision-making is studied to find a basis on which a 'draft design method for assessment frameworks' can be build. The next research questions then explore how an assessment framework could best be applied to urban geothermal energy. The insights of the first two research questions will then be applied to the specific case of urban geothermal energy. The third research question investigates which issues are most crucial for the development of geothermal energy at this moment in time in the Netherlands, and the fourth research question will investigate how these issues should be addressed by an assessment framework.

1. Which different types of assessment frameworks for local policy development are in use in the Dutch policy sector?
2. What are the guidelines for good assessment frameworks?
3. Which key issues need to be included in the assessment framework for urban GE projects?
4. How should an assessment framework be structured in order to address all key issues for urban GE development?

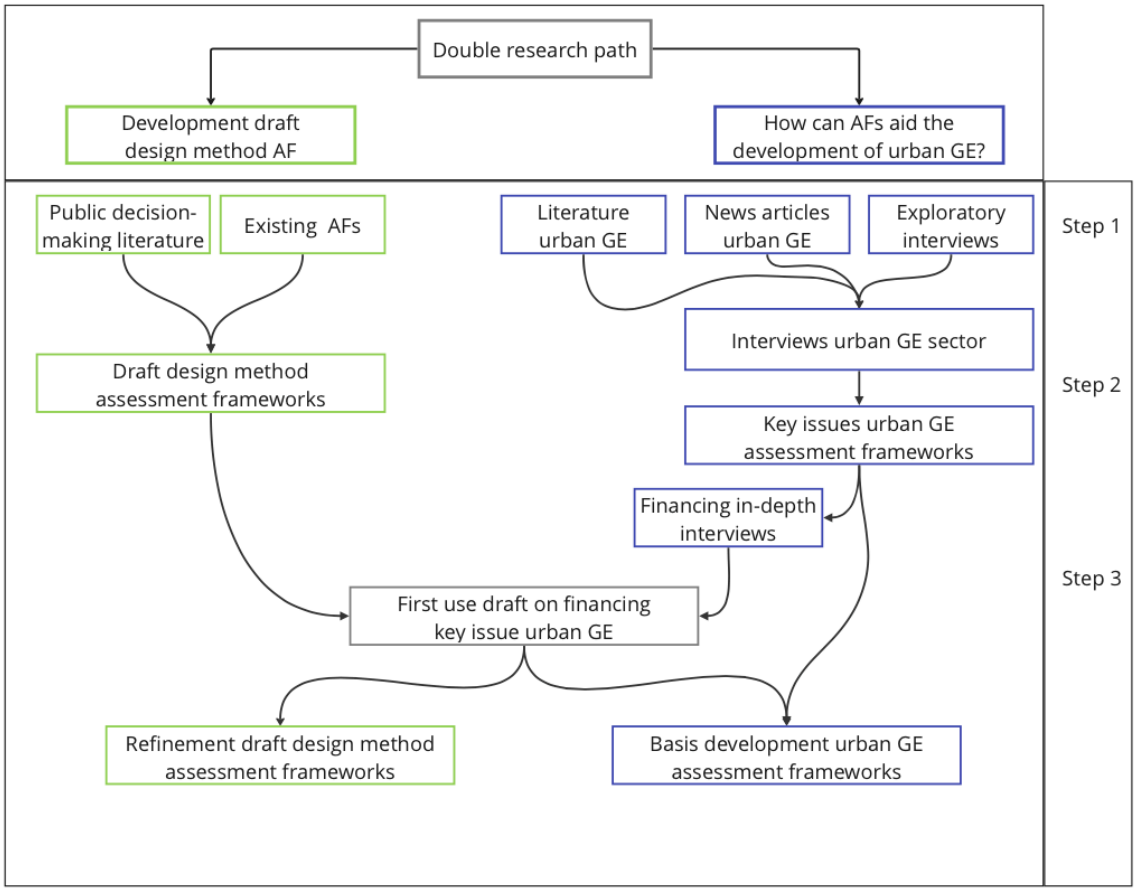

Figure 1.1: Double research path

1.3.2. Research approach

The assessment framework (AF) knowledge gap reveals that the first two research questions investigate something new, something for which no common structures are in use. There is no such thing as an 'assessment frameworks design method' that ensures that this policy implementation tool is constructed well. Therefore, the first step of this research is to create a first draft for an assessment framework design method. This draft is created by exploring both existing assessment frameworks as well as literature on public decision-making. Next, this design method is applied to the field of urban GE in order to refine the method and to answer the main research question of how assessment frameworks can support local policy making for the development of urban GE.
Urban GE has been investigated in three steps: the first step has been a preparatory step to explore the relevant topics of urban GE development. Three exploratory interviews, news articles, and literature on urban GE have been used to develop a list of main dimensions for urban GE development. The second step used this list for 14 in-depth interviews with diverse representatives of the urban GE sector resulting in the delineation of four key issues for local policy making and the development of urban GE at this moment in time. The third step tested and applied the draft for assessment framework design to one of these key issues: financing of urban GE projects. To investigate this key issue in more detail, four additional in-depth interviews were conducted specifically for the financing of urban GE projects.
By testing and applying the draft for an AF design method, refinements on the draft were made and notes for further research were gathered so that a fully worked out design method for AFs can be made in future research. By delineating the four key issues of local policy making and urban GE development, and by applying the lessons learned for the development of assessment frameworks, a basis for the development of urban GE assessment frameworks has been provided as well.

1.4. Societal and scientific relevance

The aim of this research is to contribute to the coordinated and well founded development of local assessment frameworks in the field of geothermal energy to be used by local policy makers. This assessment framework should lead to a faster and better implementation of GE in the urban area. This is of great relevance to society, since there is great urgency in the transition from fossil to sustainable energy (IPCC, 2022). Next to the societal relevance concerning the sustainability goals, this research also contributes to an improved understanding of policy implementation and specifically assessment frameworks. Assessment frameworks are widely used in the Netherlands and an improved understanding will lead to a better policy making process in general in the Netherlands. The research contributes to scientific literature by exploring the four knowledge gaps that were identified. By exploring the policy implementation of urban geothermal energy, the study also investigates the nature of assessment frameworks. Because of the exploratory research approach, a first generic academic synopsis is formed on assessment framework which will lead to interesting directions for future research.

1.5. CoSEM link

The master program of Complex Systems Engineering and Management (CoSEM) at the Technical University of Delft teaches students to design innovative solutions within complex technical environments (TU Delft, n.d.-a). The complexity that this study focuses upon is the socio-technical domain where technical innovations meet the institutional structures of national policies, societal complexity, and market structures. Within this master program, three different specialisation tracks are available and this research is aligned to the energy track. This research investigates the implementation of geothermal energy in the urban environment, with a focus on how this technology shapes society and how this effect should be guided by policy. Analysing normative systems, legislative processes and subjective interests is a complicated challenge due to factors like multi-actor complexity, changing infrastructure, and existing policy systems (Nilsson et al., 2011). This study requires an understanding in both public and private action, combines insights from several fields within management, and considers the interplay between technology and society. Therefore, the study design aligns well with the multidisciplinary toolkit of a CoSEM student. The underlying drive behind this research is also to accelerate the energy transition, which synchronizes with the TU Delft focus on sustainable research (TU Delft, n.d.-b).

1.6. Thesis structure

This section will explain the structure of the thesis and briefly discuss the chapters that follow. The second chapter will describe the methodology of the thesis and explain how an exploratory research approach is used for a double research path. The third chapter will investigate public decision-making and assessment frameworks to develop a draft design method for assessment frameworks, detailing what is required for designing a good assessment framework. In chapter four, the exploratory interviews and an overview of concepts and theory from the defined knowledge gaps for urban geothermal energy will be presented. From this data, a list of main dimensions will be constructed along which the questions of the in-depth interviews will be formed. Chapter five will present the first round of in-depth interview data in a structured manner, creating topics in which the different viewpoints of the actors will be presented per theme. From these topics, the key issues that need be included in an AF for urban GE projects will be presented. In chapter six, the best structure for an urban GE AF will be investigated by exploring the key issue of financing urban GE projects in more detail. This will be done by executing a second round of in-depth interviews. When all research questions are answered, a discussion will reflect on the limitations of the research, including future research recommendations, after which the conclusions will be presented.

2
Methodology

This chapter presents the research approach and the methodologies that were used in this research. First, the type of research is discussed, explaining the rationale, the methodologies used, and the case study set-up. Second, the data collection and analysis methods are discussed.

2.1. Type of research

The first two research questions address the practice and nature of assessment frameworks. Examples of assessment frameworks are investigated to reveal what they are and how they work, so that next it can be explored how an assessment framework could best be applied to urban geothermal energy. The insights of the first two research questions will then be applied to the specific case of urban geothermal energy. The third research question investigates which issues are most crucial for the development of geothermal energy at this moment in time in the Netherlands, and the fourth research question will investigate how these issues should be addressed by an assessment framework. It has been chosen to use a exploratory research approach, because this type of research *"tends to tackle new problems on which little or no previous research has been done"* (Brown, 2006), which is the case for the design of assessment frameworks.

2.1.1. Exploratory research approach

Exploratory research, as the name suggests, explores research questions and has therefore no intend of presenting final or conclusive solutions to the problems of investigation, and is usually conducted to study a problem that has not been clearly defined yet (BRM, n.d.). In this study, the problem of policy implementation is not unclear, but the proposed solution is: assessment frameworks. Therefore, the problem situation is shifted from policy implementation in general, to the design and usage of policy implementation tools. This is investigated by looking at the example of urban GE and the policy implementation gap that is experienced in this field. This results in a double exploratory research path, as can be seen in figure 1.1, in which one path develops a draft for an AF design method, and the other explores how AFs can aid the development of urban GE. This study recognizes the problem of policy implementation and also an in the Netherlands often applied instrument to overcome this problem: assessment frameworks. Because AFs have been applied to other RE development problems (Gemeente Renswoude, n.d.; Gemeente Zevenaar, 2020), and because governmental bodies are looking to AFs for the case of urban GE as well (Gemeente Nieuwegein, 2021; MRA, 2020), it assumes that assessment frameworks can also aid the implementation of urban GE projects. From that assumption onward, this study explores how AFs could aid the development of urban GE in the Netherlands.
The typical data collection methods that are used in exploratory research are divided in primary and secondary sources (Merkus, 2023). Primary sources come forth from your own research, like interviews or surveys, while secondary sources come forth from external sources, like literature or news articles. This study will make use from both. The draft design method will be based on literature, both scientific and 'grey' literature, the existing AFs that will be investigated. Together they will result in a draft that can then be tested and applied to the case of urban GE. How AFs can aid the case of urban GE development will be investigated using three sources: interviews, literature, and news articles. Together they investigate the case study of urban GE and explore how an assessment framework for urban GE could best be designed. These data sources will be investigated using qualitative research.

2.1.2. Qualitative research

Qualitative research collects and analyses non-numerical data in specific (Fossey et al., 2002a), and it goes beyond the question of ”what” happened, and dives deeper focusing on ”why and how” things happened (Mohajan et al., 2018). Good qualitative research illuminates research participants' subjective meanings, actions and social contexts, as understood by them (Fossey et al., 2002b). The methods that are used in qualitative research describe and explain experiences, interactions and behaviours of individuals within their social contexts. Since qualitative research investigates non-numerical data, the data sets often contain descriptive, textual or narrative information and this data is often gathered and represented in an unstructured or semi-structured manner (Mohajan et al., 2018).
A qualitative research approach was selected because of two reasons: the exploratory nature of the research and the data that is available. One of the objectives of the research is to investigate the nature of assessment frameworks. Which types of frameworks exist, how do they function, and how are they developed? This causes the research to be of exploratory nature, something qualitative research is very well suited for (Greenfield et al., 2007a). Another aspect is that assessment frameworks are developed and function within a political environment which in this specific case governs energy policies, a complex socio-technical system (Kumar et al., 2017; Unruh, 2000). To understand the workings of assessment frameworks, the actions, motivations and interactions from politicians and sector actors need to be explored. To do this, qualitative research methods like interviews, text analysis, and observations need to be applied. The data available on assessment frameworks and local renewable energy development is mainly to be found in policy documents, interviews, (local) government meeting reports, and other reports. This type of data is best processed using qualitative research methods, in contrast to statistical data or technical reports, for which quantitative methods are better suited (Fossey et al., 2002a). So it is because of the exploratory nature of the research, the need for understanding motivations, behaviours and interactions of politicians, and the expected semi-structured textual data inputs like interviews and policy documentation, that a qualitative research approach was considered the appropriate method to be used. It was decided to use a case study approach to investigate how assessment frameworks can aid local renewable energy development.

2.1.3. Case study

Because this research wants to use empirical data to test the draft design method for assessment frameworks, a research method is needed that is able to observe the practice of AFs. A case study has been chosen because they are ideal for linking theory, or in this case a framework, with empirical data (Eisenhardt, 1989). They are an often applied research method in social and specifically political sciences (A. L. George & Bennett, 2005; Gerring, 2004). It researches a phenomena by studying an example (case) of it in depth in order to gain a general understanding of the entire phenomena. One of the definitions used for a case study is *”an empirical inquiry about a contemporary phenomenon, set within its real-world context, especially when the boundaries between phenomenon and context are not clearly evident”* (Yin, 2013). This interplay between context and phenomena is one of the strong points of case studies. By examining the phenomena within its context, all internal and external factors playing a role will be in scope. However, the fact that the boundary between phenomena and context is not clear is also one of the major challenges of case study research. Since there is no clear delineation between phenomena and context, it is up to the researcher to define the boundaries. Since insights will develop over the course of the research, the boundaries between case and context will shift, adding or excluding (un)relevant factors to the case or context. In their book ”What is case?”, Ragin and Becker stated that the definition of what is the case will coalesce gradually and that it is not until the finalization of the research that a definite answer can be given. They state that ”the final realization of the case's nature may be the most important part of the interaction between ideas and evidence”. This means that it is this challenge of case specification that leads to the desired insights and end results of the research.
Because no frameworks exist on the workings of assessment frameworks, an interpretative case study approach is chosen. This approach suits best since it aims at collecting and understanding the different perspectives and processes of a complex phenomena and works towards theory building (Crowe et al., 2011). The specification of the case also highlights other strong points and weaknesses of case studies. Case study research gathers detailed and rich qualitative data, and this leads to the problem of data overload (Eisenhardt, 1989). It is therefore important that the continuous process of case specification narrows the research field in order to concentrate the gathered data. This automatically leads to the

cutting off of interesting branches of research within the study. The advantage of case study research is therefore the creation of many different interesting paths of future research.
In this study, the specification of the case concerned the question of what kind of AF the draft design method is meant for and what kind of policy implementation urban GE is an example of. Is the draft applicable to all kinds of AFs, or is it only applicable to the narrow scope that the challenge of urban GE falls under: Dutch, RE, and local/municipal? In the specification process it was chosen to focus on literature topics that are of specific importance to urban GE, narrowing the scope. However, except for the literature on spatial planning, all literature topics (uncertainty, policy-making, and social acceptance) cover areas that could be considered applicable to public decision-making in general. Therefore, future research is advised for investigating the wider scope of application of the draft design method.

2.1.4. Case selection

For this research it is chosen to study urban geothermal development as a case for local assessment frameworks. According to Yin, there are two main criteria for the selection of a case: availability of data and the case' potential of illuminating the research question. It is expected that there will be a rich body of data on urban geothermal development. Although it is a young industry with a limited history, recent developments show that a big diverse set of actors is currently focused on geothermal development (Schoof et al., 2018). The ministry of Economics and Climate is changing mining legislation to better fit geothermal permitting and changed subsidy rules to increase funding for GE (Pronk, 2022; EZK, 2022), a governmental company (EBN) decided to co-invest in GE for knowledge sharing and development (EBN, 2022a), an international conference on urban GE was recently held in The Hague (*Seminar geothermie terugkijken*, 2022), the first urban GE project is in production (*Haagse Aardwarmte*, n.d.), numerous other projects are in development (*Geothermie Delft*, n.d.; *Tijdpad | Warmte van Leeuwarden*, n.d.), and third party actors are joining the national debate (NOS, 2021). This results in numerous document for analysis (parliament, policy, company, and conference papers) and also many persons of interest for interviews. Since the Mijnraad provides a letter of recommendation for interviews, it is also expected that many will be open for interviews. The first criteria of data availability is therefore positive.
Secondly, a case selection should be based upon its potential for providing answers to the research question. The first two research questions are answered by desk research, while the third and fourth research questions are specifically focused on urban geothermal energy. It is hard to predict if the questions can be answered, for sure is that due to the exploratory nature of the study the answers will not be final or conclusive. Although this case study is ideal for the last two questions, they depend on the ability to develop a draft design method. The time constraint of six months that this master thesis is subject to, sets a limit to the depth of draft development, and requires a choice to focus on a limited set of input sources and output detail of the draft and case study. Because this research will focus on specific parameters within one case study, the type of case study can be classified as a singular embedded case study as can be seen in figure 2.1.
The set of parameters that will be researched in depth is not determined on forehand, but according to the flexible character of exploratory research, developed based upon the gathered data and the elicited concepts and relationships that emerge during the study. The case study is therefore in potential fit to answer the research questions, but will be limited in its explanation power due to the exploratory nature and time constraint.

2.2. Data collection

This section will explain the data collection methods that will be used in this research. The three data collection methods that have been used are desk research, exploratory interviews, and semi-structured in-depth interviews. The first part of the research will use desk research into literature and policy documents to develop a conceptual theory on assessment frameworks, while the second part of the research will use a second desk research into urban geothermal energy related literature and exploratory & in-depth interviews to develop a basis for urban GE assessment framework. A second round of in-depth interviews will be conducted to test and apply the draft design method for assessment frameworks.

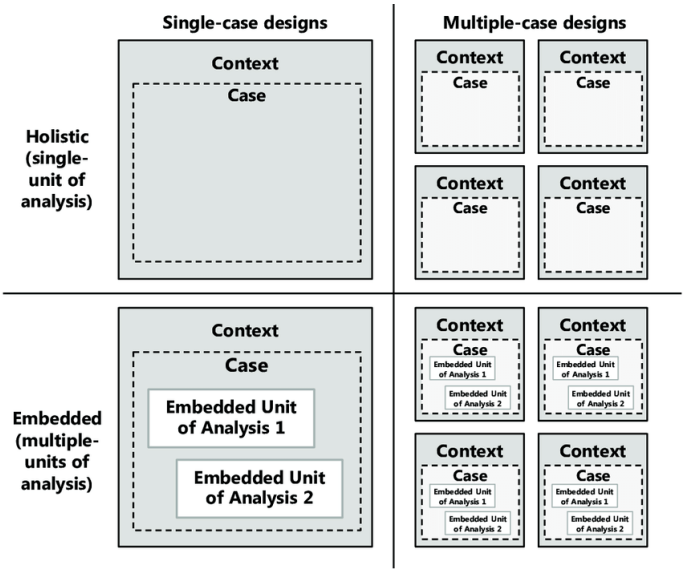

Figure 2.1: 4 types of case studies.
Retrieved from (Yin, 2013)

2.2.1. Desk research

Desk research will be used in both parts of the research. The first desk research will be used as input for the draft development. Since the academic literature on assessment frameworks is limited, grey literature on AF will be gathered, such as policy documents, newspaper articles, and governmental evaluations of AF's. To guide the draft development, a literature research will be carried out in the field of public decision-making to identify useful frameworks and concepts. The second desk research will investigate the three knowledge gaps related to urban geothermal energy as defined in section 1.2. These topics include spatial planning and the trade-offs in public values, social acceptance of urban sustainable energy, and uncertainty in public policy making.

2.2.2. Interviews

Interviews were chosen as a data collection method because they are able to provide qualitative data of people's perspectives and experiences (Bolderston, 2012). Two types of interviews are used in this research: exploratory and in-depth interviews. The exploratory interviews were used to gain initial insight in assessment frameworks and to explore the current most important topics in the Dutch urban geothermal energy sector. In-depth interviews were applied in two rounds. The first round of in-depth interviews were used to deepen the understanding of these topics and to identify the key issues that need to be included in an AF for urban GE development. These interviews can then be analysed to elicit the lines of thought about the challenges and assessments of the different actors. The second round of in-depth interviews deepen one of the key issues of urban GE development and are used for application and refinement of the draft. Microsoft teams meetings were used to interview the interviewees because it provides an automatic transcription option. Two interviews were held in person and transcribed using audio recordings of the interviews. To adhere to the code of good research and for obliging to the EU privacy legislation to prevent data leaks, all the interviews were asked to read and sign an informed consent form and all data was stored according to the data management plan.

Exploratory interviews

The exploratory interviews will be used to gain initial insight in urban geothermal energy. The reason for exploratory interviews is to gain insight in which domains should be covered by assessment frameworks. To design an assessment framework, it should first be defined what the scope of subjects is that should be assessed.

In-depth interviews

The in-depth interviews will be conducted in two rounds, with each round serving a different purpose. In the first round, the goal is to deepen the understanding of the main challenges and assessments

to be made in urban geothermal energy, so to understand the nature, context, and interplay of these challenges and assessments. Understanding their nature will help categorising general types of challenges and assessments and how assessment frameworks should deal with them. Understanding the context of the urban GE challenges and assessments will help in understanding the nuances and influencing factors for each of these types, while the interplay between them will highlight how these types of challenges and assessments influence each other. The interviews will be semi-constructed, without pre-defined questions but guided by a list of main dimensions developed by the literature research and exploratory interviews. A semi-structured manner is chosen because these type of interviews fit with exploratory research (BRM, n.d.), and because the draft is still in development during the first round of in-depth interviews (T. George, 2022). Moreover, by using a semi-structured interview style, questions can be adjusted or added and it allows for flexibility during the interviews, so that when (new) relevant topics emerge, the focus of the interview can change. This requires an open-ended structure of the interviews (Bolderston, 2012). The second round of in-depth interviews will focus on the key issue of financing that was identified by the first round of in-depth interviews. In this manner, the second round of in-depth interviews will serve the purpose of testing and refining the draft design method for AFs. Since these interviews will be conducted late into the thesis process, and due to the limited time, this second round will only have a limited amount of interviews and more strictly follow some leading questions to ease the analysis process. The key issue in focus for this second round, the financing of urban GE projects, was chosen based upon the findings from the first round of in-depth interviews.

Interviewee selection

In the end, a total of 21 interviews were conducted of which 3 were exploratory, 14 in-depth semi-structured interviews in the first round, and 4 structured in-depth interviews in the second round. This section will explain the rationale behind the selection of interviewees.

The goal of the exploratory interviews was to gain insight in the main dimensions of urban GE, and all of the exploratory interviewees were involved by GE developers. The projects related to these operators include a successful and canceled operation, and one under construction. The employees included a founder of a developer, a project leader, and a communication manager. This diversity ensured different perspectives and experiences. It was chosen to focus on operators, so that the different experiences could then easily be compared.

The first round of in-depth interviewees were selected based upon the advice of the Mijnraad and the insights of the exploratory interviews. During the interviewing process, additional actors were added based upon progressive findings. The goal of the interviewee selection was to speak actors from all actors that are involved. This included public officials from local, regional, and national governance, employees from first and third party public-private and private companies, associations promoting and organising sustainable heat, general energy transition experts, and a public mining enforcement authority. The second round of in-depth interviews focused on the financing issue of urban GE. Three out of four second round interviewees were selected out of the previous 17 interviewees based upon their knowledge and experiences with the parameters in focus, while a new actor was chosen to interview because the accompanying project had an interesting financing perspective. During and after the data collection, all data was analysed using atlast.ti. The process of data analysis will be discussed in the following section. An overview of the interviewed organisations and municipalities is represented in table 2.1.

2.3. Data analysis

In this section, the methods that were used for the analysis of the collected data are discussed. For every method, the activities required and the rationale behind them are explained.

2.3.1. Transcription of interviews

The interviews are recorded as audio file and are accompanied by automatically generated transcriptions. These transcriptions are then summarised in order to refine and condense the automatically generated transcriptions to create an overview of the interviews containing all the qualitative relevant data. In summarising the interviews, the researcher gets acquainted with the data and already starts a process of categorisation and interpretation of the data (Gale et al., 2013). In the process of summarizing, possibly valuable information might get lost due to omission of data or due to misrepresentation.

	Municipalities	Governmental agencies	Operators	Other
1	Delft	Ministry of Economic and Climate Affairs (EZK)	Geothermal Delft (GTD)	EBN (Semi-governmental energy investor)
2	The Hague	SodM (supervisor agency subsurface)	Haagse Aardwarmte (HA)	Dunea (Water authority)
3	Nieuwegein	Province Flevoland	Aardyn	Geothermal Netherlands (GNL)
4	Almere	Regional Energy Strategy	Shell* (Leeuwarden)	Foundation Heat Networks (fHN)
5	Leeuwarden			Eneco (Heat distributor)

Table 2.1: List of interviewed actors. Highlighted actors have been interviewed a second time in the second round of interviews with shell only in the second round.

However, this is unavoidable because the data processing and coding is performed on the summaries, and only the summaries will be stored confidentially for traceability. The full interviews cannot be processed, coded, or stored appropriately due to privacy considerations and the poor quality of automatic transcription. All the summaries will be sent for verification to all interviewees, but the focus will be on privacy considerations and not on omissions of possibly relevant data.

2.3.2. Categorising interview data

The categorisation of the data serves two purposes. First, categorisation helps with analysing the data and finding connections between the different data sources (Greenfield et al., 2007b). Secondly, categorisation creates a data overview that can easily be communicated, aiding the transferring of lessons learned from this study (Bolderston, 2012). Atlas.ti has been used as a qualitative data analysis tool. All interviews were analysed by a coding system to give the researcher an overview of overlapping topics between the different interviews. This coding system can be found in appendix A. It is important not to pre-define any coding categories, in order to prevent any prepossession towards the data (Goulding, 2002). This means that it is best to develop a coding system along the way of analysing the interviews, in order to interpret the data from the interviews justly. However, because the list of main dimensions guides the interviewing process, the coding categories that were developed do show similarities to these main dimensions. The effects that this might have had on the results will be reflected upon in chapter 7.

2.3.3. Conceptual model development and refinement

According to Eisenhardt, theory is developed by combining insights from previous literature, common sense and experience. These three elements are represented by the desk research, the combined research experience of the thesis student and the supervisors, and the interview data. The development of the draft design method for assessment framework will be carried out in two stages. First, a conceptual theory on AF will be generated by desk research. Secondly, this draft will be tested and refined by the case study. To guide this draft development, relevant theories from policy making and implementation will assist the data interpretation, and theory and concepts from the three knowledge gaps as defined in 1.2 will aid the development of an AF for urban geothermal energy.

In the next chapter, the first two research questions will be investigated via a desk research focusing on policy making and assessment frameworks.

3

Assessment frameworks: a conceptual theory

This chapter will answer the first two research questions: which different assessment frameworks for energy development are in use in the Netherlands and what are guidelines for good assessment frameworks? To investigate these questions, this chapter includes two data sets: a desk research on existing assessment frameworks, and a literature research into public decision-making.

3.1. Overview of existing assessment frameworks

This section will explore the general set-up of assessment frameworks in the Netherlands. Since no academic literature yet exists that provides an overview of assessment frameworks for policy-makers, this study aims at providing a first overview of the general build-up of assessment frameworks (AFs). AFs are widely used in the Netherlands in numerous areas like North Sea development, governmental ICT procurement, policy-making principles, and permitting for deep sub-surface exploration (Ministerie van Infrastructuur en Waterstaat, 2022; M. Poel et al., 2009; KCBR, 2020; CE, 2004). Because this topic is studied in the context of urban geothermal energy development, the AFs that are evaluated in this section all have a connection to this subject. Only a limited amount of AFs could be analyzed due to time constrictions. This section will explore six policy documents: five AFs that all have a connection to urban GE of which one was very recently developed as an assessment framework for GE in Nieuwegein (Gemeente Nieuwegein, 2021), and the sixth document is an urban GE guide for the metropolitan region of Amsterdam (MRA) (MRA, 2020). The four topics of the AFs related to urban GE are coherent with the knowledge gaps for urban GE of chapter 1.2 and include: municipal implementation of the new spatial planning law (VNG, 2020), energy participation at municipal level (Gemeente Renswoude, n.d.), permitting of complex oil and gas projects (CE, 2004), and general principles for policy-making and regulations (KCBR, 2020). While analyzing the documents, three concepts always emerged central to the nature of the AF: goal of the AF, foundational basis for the AF, and structure of the AF.

3.1.1. Goals of assessment frameworks

The goals of this small selection of AFs were already quite diverse. Analyzing the goals of the documents showed a fundamental distinction between AFs and a guide. All AFs aimed at intervening in the legal proceedings, either by defining working methods, criteria, or principals of good conduct. In contrast, the guide for GE in the MRA mainly aimed at providing information to civil servants. It must be noted that this observation is based on just 1 guide and 5 AF documents and the limited amount of data should give caution to the observation. This note is true for this entire section, but especially for this observation on guides as opposed to AFs. The next distinction between the goals is that the intervention that AFs aim for are different in nature. Some aim at changing the legal proceedings by clarifying and summarizing the legal rules and introducing an integral framework that when followed, should lead to the fulfilment of all these legal rules (KCBR, 2020; VNG, 2020). Other frameworks do not only aim at fulfilling the existing legal rules, but also aim to introduce additional rules. These additional rules are either locally specific (Gemeente Nieuwegein, 2021), or they propose general new rules that could be integrated within the legal rules in the next update of that specific branch of law (CE, 2004).

Assessment framework	Semi-applicable standard	Pilot or past projects	Consultation
Energy participation municipality Renswoude	X	-	-
Integral AF policy and regulations	X	-	Sector
Environmental planning vision VNG	X	X	Sector
Subsurface water flows NAM	X	X	Experts, sector & residents
Geothermal energy Nieuwegein	X	X	Experts & sector

Table 3.1: Foundational basis for assessment frameworks

3.1.2. Foundational basis of assessment frameworks

The basis on which these interventions are proposed do show a consistency in all documents. Three foundations for AFs can be identified: experience derived from pilot or past projects, a fuse of pre-existing standards or frameworks, and the consultation of experts, sector representatives and citizens. Some AFs were based upon a combination of all three foundations while others only had one. An example of a fuse of pre-existing standards or frameworks is the VNG assessment framework on the implementation of the new spatial planning law. This assessment framework is based upon the principals derived from the UN Sustainable Development Goals (United Nations, n.d.) and the MER, a Dutch framework quantifying the environmental impact of projects (Mer, n.d.). The basis for the assessment frameworks are summarized in table 3.1

3.1.3. Structure of assessment frameworks

The structures of the AFs showed similarities as well as big differences. The extent of the framework for instance ranged from 6 to 88 pages, showing a big diversity in detail and backing of the frameworks. The general build-up of the documents was quite similar, with almost all documents having 3 ”chapters”: context, intervention, and clarification and/or justification. Five out of six documents started with a motivation and context chapter, and 3 also included an extensive background information section, explaining key concepts and historical developments. Next, as a second chapter of an AF the intervention was presented, with then a third chapter clarifying concepts or justifying the choices that were made. The biggest diversity was in the interventions. One intervention presented basically conceptual new laws that could be implemented in the next policy cycle, while another intervention was simply seven questions that ensured users would follow a well thought-trough process. What all AF interventions had in common is that they presented a set of principles, divided into hard demands and guidelines of good conduct. The hard demands are either additional demands on top of the existing legal rules or a translation of an existing legal rule into a concrete demand. The guidelines are a description of norms that are expected to be followed, but the concrete translation of these norms into demands is left open. The AF interventions differed in the extent these demands and guidelines were worked out in specifics. The AF on energy participation simply left it at a shortlist with these demands and guidelines, resulting in the shortest AF document of 6 pages. The AF on policy and regulation making created seven questions as guidelines, leaving the implementation space still wide open, but already giving more structure. The AF on the spatial planning created an entire road map, a step-by-step process that could/should be followed in order to fulfill all required legal rules. The Nieuwegein AF on urban GE created a road map with detailed explanation of all demands and guidelines, and the AF on complex subsurface exploration worked out the proposed principles all the way to conceptual law, resulting in the longest framework of 88 pages. A summary of the intervention types can be found in table 3.2.

Assessment framework	Pages	Intervention type
Energy participation municipality Renswoude	6	Principles and clarity
Integral AF policy and regulations	40 (slides)	Principles and uniformity
Environmental planning vision VNG	56	Overview and roadmap
Subsurface water flows NAM	78	New proposed legislation
Geothermal energy Nieuwegein	88	New process rules

Table 3.2: The 5 explored assessment frameworks and their interventions

3.1.4. Main conclusions existing assessment frameworks

Overall we can conclude from these brief overview of AFs that they share a common pool of data sources, consisting of semi-applicable standards, past or pilot projects, and consultation of experts, stakeholders, and citizens. AFs also follow a similar textual build-up, having a three chapter structure of context, intervention, and clarification & justification. At their core, all AFs present a set of principals of both demands and guidelines, setting concrete requirements or setting out a general direction to follow. However, AFs do show a wide variety in goals and intervention design, ranging from a brief summary of guidelines to an entire road map and additional legal rules. The next section will explore the literature on public decision-making in order to find a foundation on which to draft a design method for assessment frameworks.

3.2. Public decision-making

Assessment frameworks are public decision-making support tools. They are widely used in the Dutch institutional environment in varying areas like North Sea development, governmental ICT procurement, and permitting for deep sub-surface exploration (Ministerie van Infrastructuur en Waterstaat, 2022; M. Poel et al., 2009; CE, 2004). To design an assessment framework for public decision-making, it is at first important to understand in what context it is used: the development and execution of policy. Policy science has been studied over a long time and created multiple definitions on public policy. According to Dye, public policy is *"Anything a government chooses to do or not to do"*, and Jenkins defines it as *"a set of interrelated decisions taken by a political actor or group of actors concerning the selection of goals and the means of achieving them within a specified situation where those decisions should, in principle, be within the power of those actors to achieve"*. Many more researchers have investigated the nature of public policy and their research shows that public policy is a complex phenomenon involving many decisions made by individuals and organizations within government which are influenced by others either inside or outside the state (Howlett et al., 2009). To simplify this complexity, models have been developed that describe public policy as a set of interrelated stages, from inputs (problems) to outputs (policies). The sequence of stages is often referred to as a policy cycle (Werner et al., 2007). Different versions of policy cycles have been developed, and the one followed here is related to the logic of applied problem-solving and developed by Howlett et al.. This policy cycle model can be seen in figure 3.1. In order to draft a design method for assessment frameworks, it is important to understand how these five stages of policy making effect assessment frameworks.

A five-stage model of the policy cycle

Phase of applied problem solving	Stage in policy cycle
1 Problem recognition	1 Agenda setting
2 Proposal of solution	2 Policy formulation
3 Choice of solution	3 Decision making
4 Putting solution into effect	4 Policy implementation
5 Monitoring results	5 Policy evaluation

Figure 3.1: The five stages of policy making
Retrieved from (Howlett et al., 2009)

According to this policy cycle, there are five stages in policy making: 1) Agenda setting, 2) Policy formulation, 3) Decision-making, 4) Policy implementation, and 5) Policy evaluation (Howlett et al., 2009). Agenda setting is the stage where problems or issues come to the attention of governments and where it is decided what the priorities are among these issues. The agenda setting stage therefore determines which issues should or should not be covered by an assessment framework. During policy formulation, the solution space for the problems is investigated to determine which solutions are possible and how solutions would function together. The policy formulation stage therefore determines which solutions will be considered for the issues that were set on the agenda for the assessment framework in the previous stage. In the decision-making stage, a preferred solution package is selected from all solutions that were suggested in the formulation stage. The decision-making stage therefore designs and formulates the assessment framework. During the implementation stage the assessment framework

is applied and based upon the evaluation stage either new issues or different issue prioritization might emerge for the agenda setting, new solutions might be considered for the formulation stage, or a different solution package might be decided upon in the decision-making stage, changing and improving the assessment framework.
All 5 stages of the policy cycle influence assessment frameworks, but it is the decision-making stage that has the greatest impact on assessment frameworks, since it formulates and designs them, while assessment frameworks mainly effect the implementation stage. To find a basis in literature for the draft design method for AFs, three literature fields will be investigated. First, the five stages of policy making will be investigated by literature on policy making, while the crucial stage of decision-making will be investigated by literature on robust and value-based decision making. It was chosen to focus on robust and value-based decision-making because the issues of climate change, the context for which the assessment frameworks are designed, are heavily influenced by uncertainty and require trade offs between short- and long-term values (Carlsson Kanyama et al., 2019; WRR, 2008).

3.2.1. Policy making

From the literature on policy making, three dimensions are derived that are of importance to the design of an assessment framework: path dependency, policy instruments, and discretion space for policy implementation.

Path dependency

The five different stages show that the decisions made in one stage, effect the other stages that follow. This is described as path dependency, the idea that previous conditions influence future ones (Pierson, 2000). This phenomenon has great effect on policy making. For instance, if during the agenda-setting it is decided that some factor is or is not part of the issue, then during the formulation stage any solution addressing this factor as well will be more or less valued. But not only within one circle is there path dependency, also cycles as a whole are effected by the results of previous policies. For instance, the precedent of housing damage due to subsurface exploration in Groningen and the policies created to deal with this issue have effected the perception of geothermal operation in the public (Alles over Aardwarmte, 2021a). Understanding the context within which new policies function is important. Howlett et al. stated that *"New and old goals must be coherent, in the sense of being logically related, while new and old instrument choices must be consistent, in the sense of not operating at cross-purposes"*. Understanding the ingrained paths of the policy system and context will influence the potential success or failure of a policy change or addition.

Policy instruments

In order to create successful policies, it is important to understand the policy context. Considering the policy context, the right policy measures must be taken. These measures will create or adjust one or several policies in order to achieve the overall policy goal. In exploring policy options, policy makers do not only consider what to do, but also how to do it. They consider which policy tools to use. These policy tools are also called policy instruments (Howlett et al., 2009). There are two types of policy instruments: substantive and procedural. Substantive policy instruments concern the content of the policy goal. In the case of urban GE, this could for instance be a policy instrument that indicates the amount of subsidies a GE project can get over which period of time under which conditions. Procedural policy instruments concern the process that is needed to follow for this particular policy. For instance, a policy instrument that indicates which actors will decide the amount of subsidies that will be provided. Substantive instruments intend to shape the policy outputs, while procedural instruments shape how these outputs are delivered. It is important to consider both substantive and procedural aspects, because both factors form constraints for the possible solutions. Substantive constraints can be considered 'objective'. A certain policy might be a solution to the issue, but simply unfeasible because of the limited resources that are available. Procedural constraints are more socially complex, because they can be considered 'subjective'. A certain policy might be objectively an effective solution to the issue, but deemed unfit because of established patterns of ideas and beliefs (Yee, 1996).

Discretion space

Since the aim of an assessment framework for urban GE is to help municipal civil servants with the implementation of geothermal energy in their municipality, it is important to understand the role civil servants play in policy implementation. Bureaucrats, which include civil servants of municipalities but also

civil servants in all branches of government or quasi-government organisations, often seek informal or formal negotiations with the ”target group”, the people whose behaviour is intended to change because of legislation (Howlett et al., 2009). This negotiation is not about the content of the policy, since this has already been decided upon by the elected decision-makers in the decision-making stage, but about the practicality and enforcement of the policy. *”Despite the rule of law, bureaucrats thus possess considerable influence, whether they seek it or not, in realising the policy initiatives they are called upon to implement”* (Howlett et al., 2009). The negotiation between bureaucrats and the target group will not change the policy itself, although it could be part of the evaluation stage and result in improved policies, but in the implementation stage it can change the implementation style of the policy. Bureaucrats have a certain discretion when it comes to the style of implementation (Calvert et al., 1989). They could either be very strict or flexible, using coercion or persuasion to enforce the policy goals. Policy making literature describes the role that civil servants have towards the target group, the regulators versus the regulated, along the lines of this discretion. Regulators will start with a flexible and persuasive style, since this cost the least resources. If this does not result in sufficient change of behaviour, a strict and coercive style is adopted. Since this cost much more resources for both parties, this is not ideal and when sufficient change in behaviour is achieved, regulators become more flexible and less coercive. This implementation style is constantly adjusted based upon the interactions between the regulators and the regulated. Civil servants need this discretion space for efficient implementation. To prevent derailing of policies, monitoring of the effects of this discretion is needed. The discretion space that leads to efficient local policy making will also result in local differences in policy making.

Main takeaways policy making literature

Policy making is a process that continuously iterates through the five stages of agenda setting, policy formulation, decision-making, implementation, and evaluation. The choices made in previous stages or previous cycles of policy making have great effect on the success of new policies. By understanding the path dependency that led to the current situation policy implementation will become more efficient. The context chapter of an AF is therefore of importance for both the design of the intervention by policy makers as well as the understanding and acceptance of the intervention by stakeholders. For the design of AF, both substantive and procedural policy instruments need to be used to achieve the right goals in the desired manner. In order to improve the efficiency of the implementation of AFs, discretion space is needed for civil servants in which they can adapt their implementation style based upon the sector development and unique circumstances of different projects.

3.2.2. Robust decision-making

This section will discuss the literature on robust decision-making. The main sources for this literature section on robust decision-making are three publications with different perspectives. The first paper is a literature review performed by Carlsson Kanyama et al. in the fields of robust decision-making, climate change and environmental planning. They recognized three core themes: characterization of uncertainty, information flow from science to decision, and the advised strategies & methods to deal with uncertainty. All three themes will be discussed in this section. The second paper is a deep dive on the characterization of uncertainty from an economics perspective by Dequech. The third paper is a short article from Stirling that discusses the implications of uncertainty on public decision-making and how the common practice of ”science-based” decision-making should alter to become more robust.

Characterization of uncertainty

To be able to give a scientific advice and proposed strategy to deal with uncertainty, distinction needs to be made between different kinds of uncertainties. Dequech made a threefold distinction (see figure 3.2): substantive vs procedural, weak vs strong uncertainty, and ambiguity and fundamental uncertainty.

<table>
<tr><td>Type of Uncertainty</td><td>Weak Uncertainty: unique, additive, and fully reliable probability distribution</td><td>Strong Uncertainty: absence of such a distribution</td></tr>
<tr><td rowspan="2">Substantive Uncertainty: lack of some relevant and good-quality information</td><td rowspan="2">Weak Uncertainty: uncertainty about which state will obtain</td><td>Ambiguity: uncertainty about probability, caused by missing information that could be known; predetermined list of states</td></tr>
<tr><td>Fundamental Uncertainty: possibility of non-predetermined structural change; non-predetermined list of states</td></tr>
<tr><td>Procedural Uncertainty: Complexity in relation to limited capabilities</td><td></td><td>Procedural uncertainty</td></tr>
</table>

Figure 3.2: Types of uncertainty: threefold distinctions
Retrieved from (Dequech, 2011)

Substantive uncertainty results from a lack of information that would be necessary to make decisions, whilst procedural uncertainty arises from limitations on the computational and cognitive capabilities to pursue unambiguously an objective, given the available information. One is the lack of information, the other the lack of capabilities. There are two root sources for procedural uncertainty: extensiveness and intricacy. The lack of computational and/or cognitive capabilities due to extensiveness has to do with the large amount of information that can and needs to be known for good decision-making, whilst intricacy concerns the density of structural linkages and interactions of the various interdependent systems that are involved in a specific uncertainty.
The next distinction, weak vs strong uncertainty, concerns a specific type of knowledge: probability. For weak uncertainty, a unique, additive and fully reliable probability distribution can be made, while strong uncertainty lacks such a distribution. The lack of such a distribution can be either due to the missing of some information, or because of the limited cognitive or computational capabilities of an agent. Strong uncertainty can therefore be both procedural and substantive. Weak uncertainty is per definition only substantive.
At last, a distinction is made between two different types of strong substantive uncertainty: ambiguity and fundamental uncertainty. Ambiguity concerns a situation in which all (perceivable) outcomes are known ex ante, but due to some missing information the probabilities of these outcomes are uncertain. Fundamental uncertainty is characterized by a social reality that involves creativity and is therefore subject to non-predetermined (NP) structural change. It is perceived by agents ex ante that due to missing information, outcomes can occur that are for them unexpected or unimaginable, and therefore the probability of the perceived and unperceived outcomes are also unknown. Fundamental uncertainty is always accompanied by procedural uncertainty, since actors are per definition limited in their cognitive and computational capabilities to deal with unknown unknowns.
When looking at this definition of fundamental uncertainty, it's basic elements imply *"complete ignorance about the future, without degrees"* (Dequech, 2011). However, as he stated himself immediately after giving this definition, this is not the best representation of reality, since there are limiting factors on this totalitarian view of uncertainty: institutions and simplification. How institutions and simplification shape and limit the fundamental uncertainty will be discussed in section 3.2.2.

Information flow from science to decisions

A problem with robust decision-making practices is that decision-makers often reduce the other three kinds of uncertainty to weak uncertainty, in order to 'simplify', justify, and defend their 'science-based' decisions (Stirling, 2010; Carlsson Kanyama et al., 2019). This is an unwanted practice, since it forces expert advice to be 'single and definitive', making policies and decisions less rigorous, robust, and democratically accountable (Stirling, 2010). This is specifically unfortunate because the handling of uncertainties is a major challenge for climate change adaptation and environmental planning, and these issues require robust decision-making (Carlsson Kanyama et al., 2019). To move away from single definitive reports that support only one clear policy conclusion, a change is needed in the flow of infor-

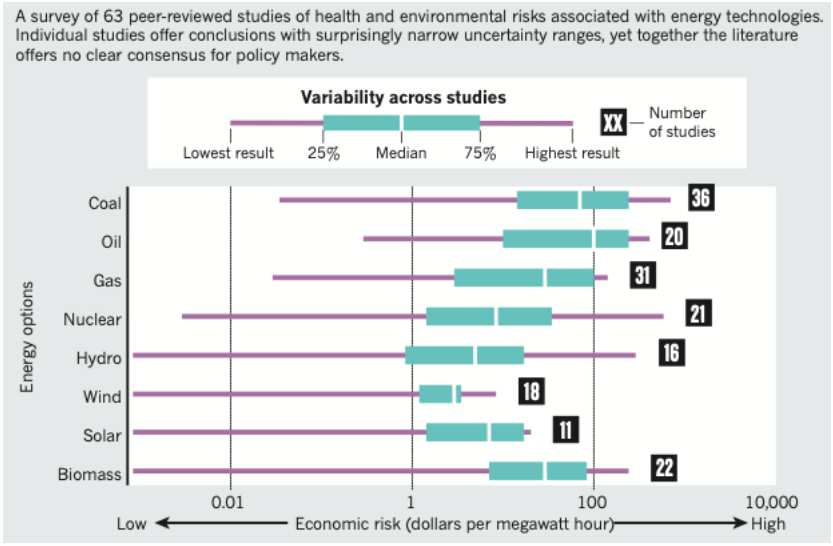

Figure 3.3: The perils of 'science-based' advice
Retrieved from (Stirling, 2010)

mation from scientists and experts to decision-makers (Carlsson Kanyama et al., 2019). The primary change in information flow from experts to decision-makers that is needed, concerns the nature in which the produced insights and knowledge is presented to the decision-makers. Stirling stated that knowledge, and therewith every expert advice, is intrinsically plural and conditional. This is the exact opposite of what is often required from expert advice for policy support, for which policy makers require single and definitive conclusions. Expert advice is plural, because knowledge fields and data sets will have a variety of alternative reasonable interpretations. It is also conditional, because each alternative interpretation has associated questions, assumptions, values and intentions (Stirling, 2008b). When this plural and conditional nature is recognized, decision-making based on expert advice can become more rigorous, robust, and democratically accountable; *"when knowledge is uncertain, expert should avoid pressures to simplify their advice. Render decision-makers accountable for decisions"* (Stirling, 2010).

Although literature on uncertainty identifies the importance of plural and conditional advice, they also notice a reluctance among policy makers, civil servants, and policy advisories to use advisory methods that incorporate these characteristics (Stirling, 2008b; Dequech, 2011; Carlsson Kanyama et al., 2019). Even when uncertainty is acknowledged, the tendency is to reduce uncertainties to 'measurable' risks (Stirling, 2010). Reducing uncertainties to risks is inadequate, *"a measurable uncertainty, or 'risk' proper ... is so far different from an unmeasurable one that it is not in effect an uncertainty at all"* (Knight, 1921). A risk based approach, or weak uncertainty based, will still lead to a single definitive conclusion. Since all options and their probabilities are known, it will result in one clear optimum. Dissenting reasonable interpretations need to be included in a policy advice to be complete (in which the definition of reasonable is off course debatable). They show the plural and conditional nature of all the current state of the art knowledge that is relevant for the policy decision. To come to a policy decision, a justification by the decision makers is needed for the interpretation chosen, leading to a higher accountability for public decisions. All scientific research, including this study, is limited due to the extensiveness and intricacy of all relevant knowledge fields. Stirling argues that humility is needed in science-based advice and decisions, since overconfidence can lead to errors, missing of potential harms and risks, and downright surprises. Many policy reports present their findings as if there were little doubt with no, or tiny, uncertainty ranges (Stirling, 2008a). Individual reports present clear single definitive results, but when taking many reports together a different story emerges. This is what Stirling calls the perils of 'science-based' advice and can be seen in figure 3.3.

One of the reasons for the single definitive results from policy reports, is the one-way instructive communication, which Carlsson Kanyama et al. call top-down communication. A one-way instruction is given from decision makers to scientist, resulting in a one-way 'instructive' policy recommendation from science to decision. This information flow needs to change unto a two-way dialogue as proposed by

Stirling, or what Carlsson Kanyama et al. call bottom-up/top-down process or 'a posteriori' decision support. A posteriori decision support is a process *"in which the identification of decision alternatives and vulnerable states is preceded by data gathering, numerical modeling, and optimization. This process represents constructive learning with stakeholder feedback in which problem formulations compete as multiple working hypotheses"* (Herman et al., 2015). This decision support process thus maintains an open dialogue between decision makers and experts, instead of a "instruct, leave them be, and receive an absolute result" approach. In the open dialogue, decision-makers (stakeholders) provide feedback that indicates which plurality and conditions they are most interested in, giving direction to the policy report. This direction is based upon the preliminary results provided by the experts and a value trade-off made by the politicians. Cataloging these decisions and being transparent about them will increase the democratic accountability of decision-making.

Uncertainty strategies & methods

The third theme in robust decision-making is that of uncertainty strategies and methods. As mentioned before, risk based or weak uncertainty based approaches are inadequate to deal with incomplete knowledge. The missing knowledge is due to social reality being subject to non-predetermined structural change because of creativity and unintended consequences, fundamental uncertainty is prevalent in policy making. The basic elements of fundamental uncertainty imply *"complete ignorance about the future, without degrees"* (Dequech, 2011), but there are limitations to this totalitarian view on fundamental uncertainty. The main strategies to deal with uncertainty is to first simplify uncertainty responsibly as far as possible, and then to use either flexible or static uncertainty strategies. To understand the methods and strategies that can be used when dealing with uncertainty, the limitations on uncertainty will first be discussed after which the methods and strategies shall be explained.

There are two sorts of limits on uncertainty: institutions and 'simplification' (Dequech, 2011). Institutions are systems of established and embedded social rules that structure social reality (Hodgson, 2006), and it is within this social reality that public policy making needs to deal with uncertainty. It is the structuring of social reality by institutions that can help predicting future developments. Institutions shape social reality and behaviour by encouraging particular actions, and discouraging others. This could either be due to what is considered socially acceptable, what is legally aloud or forbidden, or what happens to be possible considering the resource allocation at a moment in time. Examples of these institutions are subsidies, contracts, and market price fluctuations. Institutions have a double role in structuring future developments. On the one hand, they restrict creative actions by discouraging certain actions, while on the other hand they encourage creative actions within the boundaries they set (Dequech, 2011). For instance, laws have been accepted in the Netherlands that prohibit GE exploration when it interferes with drinking water reserves in the subsurface ("Kamerdebat", 2022), but also subsidy is reserved for GE development under certain conditions (EZK, 2022). Since the institutional set-up differs per country and region, fundamental uncertainty requires a situational approach (Dequech, 2011).
Another important limit on fundamental uncertainty is the concept of technological paradigms that predict expected paths of innovation (Dequech, 2011). Innovation is one of the primary sources of non-predetermined structural change. Innovation improves standing practices either by incremental steps or by big leaps, and this innovation can arise from within a technology or from the outside, possibly out-competing established technologies (Robinson et al., 2013). Although the big leaps in innovation are hard to predict, technological paradigms can be used to predict the incremental development of a technology. Dosi defined a technological paradigm as: *"an outlook ... of the 'relevant' problems and of the specific knowledge related to their solution"*. By understanding the outlook of problems and their associated solution thinking in recent research, he stated that a 'technological trajectory' can be expected. Therefore, technological trajectories provide insight in future developments and thereby limit fundamental uncertainty.

The first strategy in dealing with uncertainty, is to simplify. Simplification is a process in which strong uncertainty is reduced to weak(er) uncertainty. Now this is exactly where the previous sections warned against, but there are certain conditions under which it is tolerable. Simplification can either be done by increasing knowledge and/or capabilities, or by making assumptions to cover some of the incomplete knowledge. The difference between weak and strong uncertainty is either procedural or substantive. Procedural strong uncertainty is due to limits on the cognitive or computational capabilities of an ac-

tor. This means that what is strong uncertainty for one person, might be weak uncertainty to another (Dequech, 2011). By increasing cognitive (by teaching) or computational capabilities (by investment or innovation), strong uncertainty can be simplified. This is also one of the aims of the assessment framework for civil servants concerning urban GE development. By providing an overview and methods for the relevant knowledge and factors concerning urban GE, including their interrelations, both the extensiveness and intricacy complexities can be better managed, increasing the cognitive capabilities of civil servants.
Reducing complexity by making assumptions to make decisions is another simplification method that can benefit the decision-making process. For instance, the ambiguity in the well production in urban GE for parameters like permeability and reservoir temperature can be simplified to weak uncertainty. A limited range of values for permeability and reservoir temperature and their associated probabilities can be assumed based upon known data from wells in similar subsurfaces. However, a simplification based upon similar existing objective data is not always enough. In such a case, subjective probabilities and uncertainties can be assumed in order to make a decision in situations of incomplete knowledge (Dequech, 2011).
An example of how experts and decision-makers need to assign subjective probabilities to incomplete knowledge can be found in robust optimization (Bertsimas & den Hertog, 2020). The first step in robust optimization is making a pre-determined list of outcomes and corresponding probabilities, like the case for ambiguity of well parameters and expected profit margins of the well. After defining reasonable value ranges and probabilities for permeability, temperature of the reservoir, and the renewable heat price fluctuation, robust optimization finds the best solution which satisfies even in the worst case scenario of all parameters. However, this results in a very conservative solution assuming a worst case scenario which is very unlikely to occur. To deal with this, the budget factor (Γ) is introduced which limits the worst case scenario to a 'realistic' worst case. In doing so, the budget represents the maximum number of parameters that can deviate from their nominal value (Bertsimas & Thiele, 2006). In robust optimization, assigning a value to this budget factor represents the manager's or politician's attitude towards uncertainty. These 'subjective budget factors' need to be stated explicitly in policy decisions in order to make policy makers accountable for the political choices that are made. The name 'budget factor' is quite accurate in the sense that decision-makers need to decide how much risk they are willing to take or 'pay'. A 'budget cap' on risk and/or uncertainty needs to be set on forehand and during the project this can be 'spend' on the uncertainties. If one factor in the project turns out on the negative side of the expectations, the project might still continue if the manager thinks it is still worth the risk, i.e. it fits within the risk budget.
An important note on simplification is that although it has great potential in dealing with uncertainty, it is by definition impossible to assess the degree of simplification or the amount of complexity that is reduced (Dequech, 2011). Institutions only predict incremental and expected change, big leaps and unintended impacts are out of scope, let alone force majors. Assumptions for missing knowledge and their probabilities can only be made for the known unknowns, not for the unknown unknowns. It is impossible to state how much the total uncertainty is reduced, since the total uncertainty is uncertain. Institutions might create a pre-determined list of possible outcomes for which probabilities can be assumed, but fundamental uncertainty comes forth from non pre-determined structural change. The limits on uncertainty fall short because it misses the creativity and unintended impacts of people's actions (Dequech, 2011). Policy makers may still construct subjective probability distributions, as long as they *"acknowledge the unknowability of a list of all possible events and the consequently limited guidance that these subjective probability distributions give"* (Dequech, 2011).

The true consequences of fundamental uncertainty thus remain hidden for decision makers. Nonetheless, social reality requires people to deal with uncertainty. This section will describe the different strategies available for dealing with uncertainty. When policy-makers deal with incomplete knowledge and only have a limited perspective on potential wins or losses, a trade-off needs to be made. It is important to use methods that make these trade-offs explicit and leave them to the responsible agent. In case of uncertainty concerning policy decisions, the responsible agents are the politicians (Stirling, 2010; Healey, 2006). In his critique on current decision-making in times of uncertainty, Stirling presented a list of methods that suited a specific type of uncertainty, see figure 3.4. Although he uses a different distinction of uncertainty, his classification overlaps with the one of Dequeh. If all possible outcomes and their probabilities are known, it is a simple case of risk or weak uncertainty. When

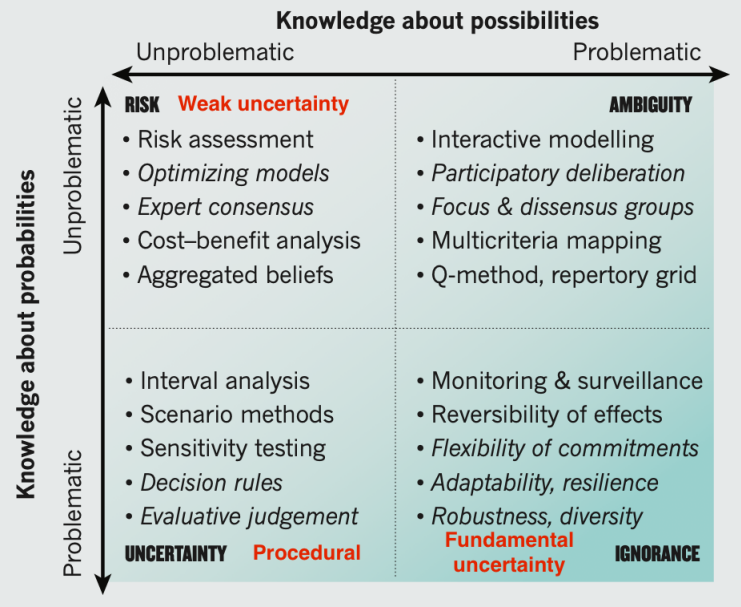

Figure 3.4: Methods for different types of uncertainty
Modified from (Stirling, 2010)

substantive information is missing but could be known, and therefore the possibilities of outcomes are unknown, it falls under ambiguity. When the substantive information and the accompanying possibilities are known but limited cognitive and computational capabilities make it impossible to assess their probabilities due to the extensiveness and intricacy of the information, it is procedural uncertainty. When no pre-determined list of possible outcomes can be formulated due to the complexity and unpredictable nature of human activities and therefore no accurate possibility assessment of even the perceivable outcomes can be made, it is fundamental uncertainty.

The first thing to note is that methods that use risk-based approaches can be valid, they just need to be applied when weak uncertainty is actually at hand. The same applies for methods that deal with ambiguity or procedural uncertainty. When fundamental uncertainty can be 'simplified' to ambiguity or procedural uncertainty, several methods are available to use. The methods and principles Stirling mentions are in accordance with the two types of uncertainty strategies suggested by Carlsson Kanyama et al.: static and flexible strategies. Static strategies are robust, they are predetermined and are satisfactory under the 'full range' of uncertainty, as far as that range can be seen. Flexible strategies consists of several different options for future scenarios, and a switch can be made between the options, depending on how the future unfolds. Although they seem to be the exact opposite of each other, together they comprehend the principles of flexibility, resilience, and robustness mentioned by Stirling. Depending on the institutional context, for instance the resources available to deal with an uncertainty, it can be chosen to only develop pre-determined projects that are robust and satisfactory to all reasonable and perceivable future scenarios, or it can be chosen to develop projects with greater uncertainty and/or for which different outcomes are considered satisfactory. A combination of both is also possible, in which all flexible options are at worst satisfactory.
When needing to find a solution during uncertainty, decision makers need to make use of spontaneous optimism and creativity (Dequech, 2011), the very thing that creates fundamental uncertainty. Studies in the field of knowledge integration, which is of great importance when dealing with the extensiveness and intricacy of information, have shown that for an interdisciplinary project to succeed, not only expertise is needed across the different disciplines, but also expertise on the integration of knowledge itself (Bammer et al., 2020). This means that policy makers need not only be advised from a diverse set of experts and explicitly stated dissenting interpretations within policy reports, but also need (to be advised on) expertise on integrating that knowledge. This expertise on knowledge integration is however problematic in the sense that this expertise is tacit (Collins & Evans, 2002) and it becomes therefore hard to make the assumptions based on this expertise explicit. Using a strategy with diverse

inputs and a combination of diverse decision-makers will at least increase the diversity of knowledge integrated, and documenting the reasoning behind the different trade-offs will at least help in making decision makers accountable when their integration of knowledge was flawed. Limiting factors on fundamental uncertainty can 'simplify' uncertainty in order to make simpler and more effective decisions. For all uncertainties, static and/or flexible strategies are most effective when they are based on flexibility, resilience, and robustness. In all decisions concerning uncertainty, every simplification based on assumptions needs to be made explicit in order to create meaningful accountability.

Main takeaways uncertainty literature

In conclusion, different types of uncertainty and their appropriate response strategies need to be recognized by decision makers, moving away from an overly narrow focus on risk (Stirling, 2010). By presenting expert advice in a plural and conditional frame, decision-makers can no longer justify their decisions by single definitive 'science-based' arguments, but are required to make decisions based on social and political trade-offs and make these trade-offs explicit. When dealing with uncertainty, the first strategy is to simplify uncertainty where possible and use static and/or flexible strategies to deal with fundamental uncertainty. For the design of AFs, it is important to distinguish the kind of uncertainty it needs to deal with, in order to apply the correct static and/or flexible strategy. When basing certain design requirements on scientific advice, it needs to be made explicit which social and political trade-offs are made in the design requirements. This prevents 'policy making by scientists' and keeps the politicians responsible for their choices in the design of assessment frameworks.

3.2.3. Value-based decision-making

To design assessment frameworks in the domain of public decision-making and sustainable policy implementation, public values are of great importance. Utility facility infrastructures, like the energy infrastructures, are closely related to public policy and public values. The reason for this is that infrastructures like sewerage, drinking water, electricity, telecom, gas, and heat, are critical for a healthy and prosperous society (Van der Woud, 2006). Therefore, these infrastructures have been subject to many public policy interference to develop and protect the common good, or public values and interests of society (WRR, 2018). Public values refer to the combined view of the public of what is to be considered valuable (Talbot, 2011), and for the development of energy innovation they can be considered a set of 'intersubjective' values that are relevant, given specific technological developments (Taebi et al., 2014). The characteristics of public values make the endorsement of them a complex task. Public values are ambiguous, relative, and contested (WRR, 2008). Because public values are relative, this will also lead to public value conflicts. If energy supply must be both safe and affordable, it is impossible to maximize one, without negatively effecting the other. In the challenge of the energy transition, two specific kinds of public values are in conflict: long and short term values. The short term values concern matters like innovation and efficiency while the long-term values concern matters like sustainability and energy security. The policy regime of energy infrastructures in the Netherlands has developed over a long period of time, and can be described by a two stage transition: first from state-controlled monopolies to privatized markets optimized for short term efficiency, and secondly a transition towards a public value driven market balancing short and long term objectives (WRR, 2008). Both transitions were a response to a market failure that had to be corrected, in which the first transition aimed at changing cumbersome state monopolies in innovative and competitive markets, while the second transition aims at energy security and sustainability. However, it is important that in the second transition the short term values are not neglected, but that a balance is found in which both long and short term values are enforced. The short term values that were highlighted in the first policy regime transition cannot simply be replaced by long term values, a balance needs to be found.

To take into account both long and short term values for the energy transition policy implementation, value-based decision-making is needed. From literature two concepts will be highlighted: 'value hierarchy' introduced by I. v. d. Poel, and 'responsible innovation' as described by Taebi et al.. Responsible innovation deals with innovation in the context of public values, which is the challenge of sustainable energy innovation, and value hierarchy enables product design in which value trade-offs are made explicit, and is also able to translate these values into norms and design requirements for both the technological and institutional site of energy development. This is shown in the paper of Dignum, Pesch, and Correljé in which they do this for the case of shale gas development.

Responsible innovation

Responsible innovation in its ideal form was defined as ”the endorsement of the relevant public values during the innovation process”, and these public values can be endorsed in both the design of technological systems as the societal context (Taebi et al., 2014). Realizing responsible innovation involves alongside science and engineering: i) the ethics, to investigate the role of values; ii) institutional theory, to understand the role of institutions; and iii) policy literature, to focus on stakeholder engagement (Taebi et al., 2014). During the process of innovation, a change in public values might occur when they become fluid under societal pressure. In this change they are shaped by the interactions of stakeholders involved or influenced by the innovation (Taebi et al., 2014). Therefore, responsible innovation aims to endorse public values in the design process by gathering the norms and values of all the users and effected actors of the artefact in design.

To identify the relevant values and norms for a subject, these values and norms have to be drawn from the ”relationships between an individual and society”. It is in the interactions of people that the meaning of a public value is revealed (Meynhardt, 2009). Therefore, the relevant value trade-offs concerning a subject must be extracted from the interactions between the different actors for in this case the GE sector. One way to investigate these interactions is by interviewing/consulting the actors in the sector. The other two sources for AFs, semi-applicable standards and past/pilot project, also provide information on the values and norms but less direct. Semi-applicable standards show how values have been traded off in previous policy making procedures and past or pilot projects show which parts did or did not work leading to updated insight in norms. By consulting or interviewing the different actors in a sector, a unique insight can be given on the relationships and interactions. However, the public debate rarely touches the direct values at stake nor address detailed design criteria, it rather centers at the middle level of norms (Dignum et al., 2020). Therefore, the values at stake need to be identified indirectly by first collecting the statements and arguments on what to do or not to do, i.e. the norms mentioned in the interviews. Next, these norms can be connected to underlying values.

In the design of technological systems and societal context, value conflicts might occur. Value conflicts occur when it is the case that if several values are ”considered in isolation, they evaluate different options at best” (Van de Poel, 2009). In these situations, the conflicts can be dealt with in two ways: either re-design the system or context to accommodate all conflicting values, or make a trade-off between them to assign priority to certain values. For responsible innovation, the analysis of potential value conflicts and their solution should form an integral part of the design process (Taebi et al., 2014). A design process that incorporates the different values at stake is called Value Sensitive Design (VSD). In order to connect norms to underlying values and to resolve potential value conflicts, the framework of value hierarchy can be used.

Value hierarchy

Value hierarchy is a frame that makes the value trade-offs that have to be made in the design of a product or framework tangible by connecting values to design requirements using norms. The hierarchy as proposed by I. v. d. Poel can be seen in figure 3.5. The conceptual and theoretical upper layer of values is connected to the concrete lower layer of design requirements with an intermediate layer of norms. Here, norms refer to ”all kinds of prescriptions for, and restrictions on, action” (I. v. d. Poel, 2013). The value hierarchy connects values directly to norms and design requirements, which makes the trade-offs that have to be made to come to a product design explicit, debatable and transparent (I. v. d. Poel, 2013).

The relation and derivation between values, norms, and design requirements can be organized both top-down and bottom-up. For constructing a value hierarchy, it is often required to work in both ways. These two approaches are described by I. v. d. Poel as a relation of *’specification’* and *’for the sake of’*. Specification means that from the top, the values are specified into norms, and then norms are specified into design requirements. The purpose of this relation is to investigate if a norm or design requirement is adequate in representing a value or norm. It answers the question: ’are the actions we do or request adequate considering what we determined to be valuable and worth striving for?’ The bottom-up relation is the ’for the sake of’ relation and justifies certain norms or design requirement by stating that they are done ’for the sake of’ a certain value. The reason for this relation is to make explicit and clear which deeper motives underlay actions. People often discuss on the level of ’what to do’ and not ’what to value’. Two persons might instantly agree on a norm like ’revenues should be divided justly’, but disagree in the specification into payment requirements. First, a discussion is needed on

what just division means to them and what they consider to be valuable in such a process. The 'for the sake of' relation makes explicit and answers the question: 'which deeper motive underlays the actions that we do?'
For the construction of a value hierarchy both these relations need to be investigated and used to come to concrete values, norms, and design requirements. In the design of a product, values are not just translated in the product design, but can also be translated in the design process (I. v. d. Poel, 2013). To come to concrete norms and design requirements, an important aspect in design are 'end-norms' (Richardson, 1997). These end-norms have three categories: *"objectives (strivings like 'maximize safety' or 'minimize costs' without a specific target), goals (that specify a target such as 'this car should have a maximum speed op 150 km/h') and constraints (that set boundary or minimum conditions)* (I. v. d. Poel, 2013). To prevent confusion between norms and design requirements, this study will rename 'end-norms' into 'final specifications'. The final specifications consist of both norms and design requirements, in which objectives fall under norms, since strivings coincide with 'kinds of prescriptions for, and restrictions on, action', while goals and constraints fall under design requirements, since they are demands. This distinction is also visible in the intervention design of existing AFs, which present a set of principles that consist of guidelines (objectives) and hard demands (goals and constraints).

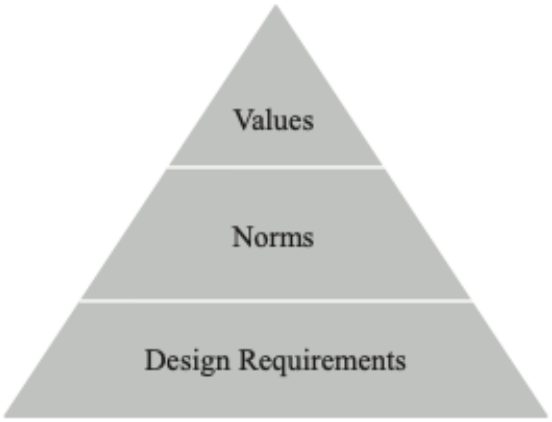

Figure 3.5: Values hierarchy, derived from (I. v. d. Poel, 2013)

Main conclusions value-based decision-making

The energy transition challenge requires an approach that secures both long and short term values. However, because the different public values are in conflict with each other, value trade-offs need to be made, prioritizing certain public values over others. These value trade-offs also need to be made in the design of an AF for urban GE. To create a design method for AFs in which these trade-offs can be made, the frame of responsible innovation can be used to gather the norms and values of all the users and effected actors of the assessment framework. These gathered norms and values can then be structured and translated into 'final specifications', i.e. objectives, goals, and constraints, by using the hierarchy of values of figure 3.5. Designing AFs along the lines of a value hierarchy will leave the political decisions to the politicians and make these decisions value-based, explicit, transparent, and debatable.

3.3. Draft design method for assessment frameworks

This section will propose a draft for a design method for assessment frameworks. This draft of a design method for AFs is based upon the lessons learned from existing AFs and public decision-making literature. A four-step process is suggested for the design of an assessment framework: 1) investigate the context of the subject and elicit the relevant norms; 2) derive values from the collected norms using the 'for the sake of' approach; 3) work out the list of values using the 'specification' approach into final specifications: objectives, goals, and constraints; and 4) clarify each final specification and make the value trade-offs in the design explicit and transparent.

3.3.1. Gathering norms and investigating context

The first step is to gather norms that are relevant for the AF subject, in this case urban GE. This step has a double purpose: developing the content for the context chapter of the AF, and gathering a list of norms for the value hierarchy. Gathering the norms can be done by using the principles of responsible innovation, investigating the public debate and the perspectives of all relevant stakeholders. For doing so, the context of the subject needs to be understood. By understanding the context and path dependencies of past decisions in this policy field, insights for effective policies can already develop. To find norms for the subject, the public debate and stakeholder perspectives should be investigated for any prescriptive on what should or should not be done. Any statement on advised or discouraged action can be considered a norm (I. v. d. Poel, 2013).

3.3.2. Deriving values from norms

The second step is the connection between norms and values. The reason for deriving values is to discover the deeper motives of stakeholders so that the value trade-offs that have to be made can be made explicit and debatable. Because values are rarely discussed directly in a public debate, the intersubjective set of values in a sector have to be derived from the norms that are discussed. This can be done by a bottom-up approach of value and norm relation, the 'for the sake of' relation. This second step concerns the question which deeper motives underlay the norms that are mentioned in the sector. Some of these value connections will be mentioned explicitly already by stakeholders, but to derive this relation the ethics of stakeholders need to be understood. To do this properly, a process of stakeholder participation is suggested in order to accurately uncover the deeper motives. Other options for deriving values are also possible. For instance, norms could also be connected to values by peer-reviewed expert desk research and literature on applied ethics and ethics of technology (Dignum et al., 2016). However, stakeholder participation seems more appropriate since not only a list of values is needed, but a description of each value as well, making sure that what is meant by each value is explicit and agreed upon. By letting stakeholders participate in defining the values, misconceptions can be prevented and support for the basis of the AF can be formed.

3.3.3. Designing the intervention

The third step connects the values to final specifications by the relation of 'specification'. This step concerns the question of which final specifications adequately cover the collective values. This step is the actual design of the intervention chapter, the main part of the assessment framework. To work out the values into a complete set of final specifications, two stages of specification must be carried out. First, the norms that were gathered are evaluated to see if this collections of norms are actually adequate in representing the values defined in step 2. This could reveal that additional norms are needed which have not been in scope of the public debate. If for each value can be said that they are adequately covered by the norms, the next stage specifies each norm into objectives, goals, and constraints. If again for each norm it can be said that they are adequately covered by the final specifications, the intervention design is complete. Because the norms and final specifications need to adequately represent a diverse set of values, there is no objective best solution. There is always some form of trade-off between two conflicting values whereby neither of those values can be optimised without compromising the other. Therefore, it is proposed that the adequacy of the norms and final specifications in representing the values is not measured by an objective measure, but is validated by a consensus of the stakeholders. However, four principles on what might be considered adequate can be given based upon the literature of public decision-making.

First, for designing final specifications that are adequate in covering the norms and values of the value hierarchy, it is crucial to adapt the policy solutions to the specific case and context. A final specification which is adequate in one city might be inadequate in another. This means that for optimal results, a locally tailored AF for urban GE is needed for every municipality. Insights from existing AFs show three sources for assessment frameworks: semi-applicable standards, past or pilot projects, and consultation. Using these sources, adequate final specifications can be constructed based upon past successes or expert and stakeholder advice. However, robust decision-making literature showed that expert advice should be presented in plural and conditional form. For final specification design it is therefore important to consider the conditional circumstances and diversity of insights in past success, expert, and stakeholder advice.

Secondly, for final specification design, uncertainty can be dealt with by either static or flexible strategies, or a combination of both. Flexible strategies in AFs can be applied by setting objectives, thus a final specification on the level of norms. By setting objectives a flexible and case specific solution can be created. Static strategies in AF can be applied by goals and constraints. By setting hard demands on the level of design requirements a standard can be demanded that is sufficient for every case.
As a third principle, the final specifications should consist of policy instruments that cover both substantive and procedural issues, making sure that both the process of project development and the project itself are guided by the policy.
Lastly, in designing the policy instruments, the discretion space has to be taken into account to leave room for case specific adaptations. Civil servants can use this room to create efficient implementation processes. This discretion space is needed for treating each project uniquely, as well as for changing up the general implementation style by making it more strict or lenient based upon the actions of the sector.

3.3.4. Clarifying and justifying final specifications

The last step in the design of an assessment framework, is the clarification and justification chapter. In this chapter, the final specifications are explained in more detail when needed, and the value trade-offs that were made to come to them are made explicit and are explained as well. This chapter shows how the long and short term values that play a role in the development of this policy field have been balanced to achieve adequate performance on the short term while at the same time this balance builds towards a bright future.
To be able to justify the value-based decisions, they first have to be made explicit. This can be done by the value hierarchy. By presenting the value hierarchy with the values, the norms including which values they translate, and the design requirements including which norms they translate, the full specification process can be seen in one glance. An example of how this might look like can be seen in figure 3.6. Every value is labeled, in order to indicate for each norm which values it serves. A distinction is made between norms, which are worked out in design requirements, and objectives, which are final specifications. Every norm is labeled so that also for each goal and constraint it can be indicated which norms it serves. By labeling the values and norms, all relations between values, norms, and design requirements are presented in one figure. However, labeling itself is not enough for justification since it only depicts which values or norms are taken into account, but now how. Therefore, it is suggested that for each final specification a justification is presented in this chapter, indicating which values are prioritized and why.
Lastly, besides a justification for each final specification, a general justification is needed for the total solution package of the assessment framework. This general justification should indicate how the combination of values represent both the short and the long term interests of the public, why the collection of norms satisfy in securing these values, and how the combination of objectives, goals, and constraints totals to a balanced practice that achieves adequate performance on the short term while at the same time builds towards a bright future on the long term.

To summarize, this draft proposes a four step process for the design of assessment frameworks. The first step is to gather an overview of norms from the public debate, so that secondly the values that play a role in the policy field can be derived from these norms using stakeholder participation. These first two steps aim at gathering guidelines for best practices, norms, and discovering the deeper motives behind these practices. The third step designs the final specifications for the assessment framework, the policy guidelines and demands. This draft has presented four principles for the design of adequate final specifications. Final specifications should be: locally specific; use static or flexible strategies to deal with uncertainty; be based upon plural and conditional sources; and consist of policy instruments which are both procedural and substantive, and mind discretion space. The last step makes the value-based decisions explicit and debatable by presenting a value hierarchy in which all relations between values, norms, and final specifications are shown. Now the draft design method for assessment frameworks is defined, the key aspects that need to be included in an assessment framework for urban GE development will be investigated.

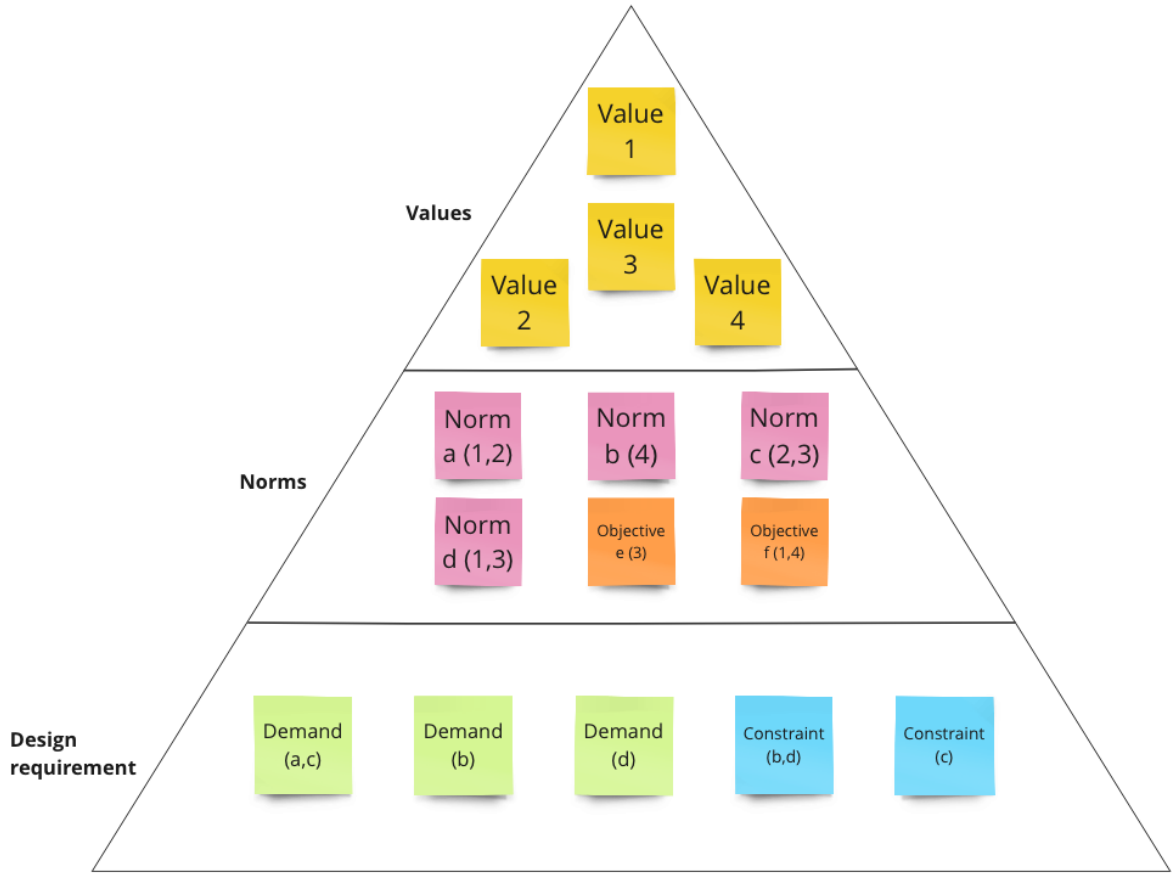

Figure 3.6: Design AF value hierarchy

4

Urban GE literature

This chapter will explore the urban GE sector in order to define a list of main dimensions that together can guide the interviewing process. To explore the sector, two instruments were used: exploratory interviews and literature research into the knowledge gaps of urban GE development as defined in section 1.2. First the exploratory interviews will be presented after which the chapter will focus on the knowledge gaps that were defined for geothermal energy. Since uncertainty is covered in detail in the previous chapter, this chapter will focus upon spatial planning & public values, and social acceptance of geothermal energy. The goal of this chapter is to define a list of main dimensions for urban GE to guide the interviewing process. The list of main dimensions is presented at the end of this chapter in table 4.1.

4.1. Exploratory interviews

Three exploratory interviews have been held and aimed at gaining insight in the urban GE sector. The goal is to delineate a list of main dimensions for urban GE development to guide the in-depth interviews. The interviews were conducted with three different GE well developers, all connected to a separate project. Two of the interviews were held with the responsible managers of finished projects, including a project leader and a founder of a GE developer, of which one project was aborted and one succeeded. The third interview was held with the communication officer of a project which is still in development. The qualitative interview data was compared over all three interviews to find emerging overlapping topics. Four different topics are identified to emerge from all three interviews: Responsibilities municipality, social acceptance, communication, and the role of well developers.

4.1.1. Responsibilities municipalities

All three developers mentioned that at this moment, when geothermal heat is still very new and sparsely applied, municipalities are lacking in knowledge and skill considering geothermal heat. They all agreed that this creates challenges and according to the developer of the aborted project, this lead to a wait-and-see attitude of the municipality involved. According to the communication officer this also leads to an increase of required communication efforts and costs, needing to explain the same principals and repeating procedures that were already done time and time again. It was said that municipalities cannot really be blamed for this, considering the broad range of responsibilities that they have and the expertise knowledge required for GE implementation, but that it is therefore wise that the authoritative governmental body on GE is the national government for now with only an advisory role for municipalities. At the same time, all three developers mentioned that despite this limited role and influence of municipalities concerning GE, in their experience the supportive or non-supportive attitude of municipalities for GE projects is a crucial factor. The success of an urban GE project depends on municipality support and the influence that municipalities have is thus yet very significant. Efforts of municipalities to increase their influence on GE development by any form of binding contracts with developers, like the IOK and SOK in the assessment framework of Nieuwegein, was discouraged by 2 of the developers. One argued that municipalities underestimate the gravity of a contract for commercial parties and the enormous barrier it would create for developers to start a project. The other developer said that a covenant indicating common intentions and cooperation guidelines would be adequate for the strengthening of the relation between municipality and developer, but that a contract and the associ-

ated enforcement tools only hinder much needed trust towards one another.
The main responsibilities of municipalities in the development of urban GE according to the developers, is the generation of social acceptance towards an urban GE project among local residents, and the guidance of the spatial planning aspect placing the geothermal well and infrastructure within (or near) the urban environment. Especially the generation of social acceptance was highlighted by the developers. To optimize this generation of social acceptance, it was stated that a strong relation is needed between developer and municipality to provide expert information and true connections & fair hearing for all local residents, creating one story out of the local heat transition vision and the business plan. Therefore, a wait-and-see attitude of a municipality will obstruct this process, emphasizing the crucial factor of municipalities.
From these comments, dimensions of importance are: the required knowledge and expertise for urban GE development, municipal attitude towards GE development, and the crucial role for municipalities concerning spatial planning and social acceptance. The following section will explore the developers' comments on social acceptance in further detail.

4.1.2. Social acceptance

The manager of the aborted project emphasized that total acceptance where everyone is happy with the project cannot be expected and some form of resistance will always be present. The successful project confirmed this, where social acceptance was generated by building a bond with each and every local resident, but one local could not be convinced, requiring a law suit. A follow up project after the successful one also encountered fierce resistance of 3 individuals. However, the third developer mentioned that in their project no fierce resistance was yet encountered. The manager of the aborted project also mentioned the dimension of how big a platform such "resistance residents" should get. For an inclusive process their voice needs to be heard, but a vocal minority can result in over-representation.
A second point that was made by 2 developers is the fact that there are two different levels of social acceptance: macro and micro acceptance. The macro level is about accepting GE as a good general solution for sustainable heat provisions, and the micro level about accepting the project specifics like location and construction & operation conditions. It was predicted that the macro acceptance will become less an issue due to a growing understanding of the need for sustainable change and due to current geopolitical developments prioritising energy self-sufficiency and efficient heat provision. One developer also mentioned that because of this macro and micro acceptance, a portfolio approach on GE development has serious benefits. This approach constructs multiple wells within a larger area, which enables an developer to only focus on micro acceptance after a first project is accepted and to gradually improve their cooperation with the local authorities to generate greater efficiency in project development.
From these comments, dimensions of importance are: expect and deal with resistance, and that social acceptance is required at multiple levels. To generate social acceptance, all developers mentioned that this requires sufficient time and clear communication as soon as possible. The comments on communication are summarized in the next section.

4.1.3. Communication

Just as there are levels of social acceptance, the developers also mentioned different stages of communication. A first development of urban GE in a municipality requires a communication plan that explains every detail of general GE development and the rough development plans including areas of interest for project locations, requiring communication that address all citizens. After this first stage of communication, a second stage addresses specific project information about exact locations and construction & operation procedures. It is for the second stage of communication that the developers expressed their concern. The sector of GE developers have created a communication protocol which states that developers should contact interested parties "on time and as soon as possible" (Geothermie Nederland, 2019). However, on time and as soon as possible is still open to interpretation, and the risk of communicating too early or too late is both present. The developers mentioned that communicating too early can result in many questions from the environment that cannot be answered yet, leading to resistance. It was mentioned by one developer that people often demand clear information on project parameters that cannot be given yet due to the inherent factors of uncertainty for urban GE, postponing communication will enable developers to communicate with less uncertainty. But the developers acknowledged at the same time that communicating too late can create time pressure for the environment

involvement process, hindering the generation of social acceptance and thus also leading to resistance. This dimension of ”communication timing” was still very much a learning point for all developers.
A second dimension on communication is the trustworthiness of information provision. A cooperation between developer and municipality is needed to reach the citizens and local residents, but if all the information that is provided is constantly contested, no positive results will be achieved. One developer mentioned that the trust in politics is declining in the Netherlands and that the trust in local politicians could also be fragile. The level of trust between the citizens and the local policy-makers is thus an important condition that needs to be taken into account when creating a communication strategy. Secondly, it was mentioned that one developer was warned by the municipality not to communicate too much to prevent this communication being framed as lobbying, creating the story of big companies versus small local citizens. In hindsight this was regretted since a lack of control on the narrative made it spin in a negative tone.
Previously, all topics and dimensions emerged from 2 or 3 interviews, where they were addressed either directly or indirectly. The next few points on communication however, all come forth from 1 interview. Since this interview was with the communication officer who is an expert on the matter and because the statements are not in conflict with the other interviews, it was decided to mention them as well. The communication officer stated that communication on the project should not only address local citizens, but also local companies and all involved civil servants, on the municipal, provincial, and national level. Secondly, it is crucial that the language is understandable without a degree or deep understanding in geology or law. The most important development that the communication officer noticed, is that there occurs a shift in the communication mindset surrounding energy projects. According to this statement, it used to be that energy projects could be developed at a distance from the public, out of the public view. For the communication strategies this mend that communication was only needed when the developer was legally required to do so. However, in urban development of GE the project developments are in full view of the public, and this results in much more questions and concerns by the public. To ensure the social acceptance needed for project progress, it is required to continuously provide information, even when this is legally not required. Although this will lead to higher costs on communication efforts, it was stated that this is financially efficient since project delay and legal procedures resulting from public resistance is much more costly. Even if companies do have the opportunity to push a project through, despite local resistance, the risk of losing a social license to operate new projects in the future would also be to costly, compared to extra communication costs in a project.
From these comments, dimensions of importance are: the development of communication plans, minding timing of communication and a shifting mindset of extensive and continuous communication, and the crucial factor of trust in communication.

4.1.4. Role of well developers

The previous three sections addressed mainly the role of municipalities in the development of urban GE. This section summarizes the role of developers and their main challenges. When asked about the main barriers for urban GE development, all three mentioned the simultaneous development of both the GE well as the heat network, the infrastructure to distribute the heat. In almost all situations of urban GE development, including these 3 cases, the development of the well and the heat network is dispersed over different consortia. The success of both projects depends on each other, but making investment decisions and project plannings work well together is a difficult task. The second major success criterion is the purchase contract by a customer supplier of heat, ensuring a steady revenue stream for the well developer. Without this assurance it is impossible for GE developers to commit to significant investment which are needed to start the project.
The main responsibility of geothermal developers is to develop the technique further to mature the field and create stable and feasible operation conditions. Three components of development were identified from the interviews: reliability, industry standards, and construction in urban area. A major problem for GE wells is reliability, downtime on production still happens frequently due to failures in the management system. At the moment, this needs to be compensated by expansive redundancy designs of wells and by arranging reliable back-up sources of energy. Industry standards are also still in development, which makes cross-industry cooperation difficult. One developer mentioned that the aligning of GE engineers and the heat network developer engineers was quite troublesome. Construction in the urban area is also mentioned as a point for development. A large surface area is needed for the construction of a GE well. One developer mentioned that plans are in development that significantly lower

the needed surface area, but that this will decrease the efficiency of the construction phase leading to a longer construction phase.
From these comments, dimensions of importance are: simultaneous development of heat networks, purchase contracts for heat, and the reliability of urban GE well performance.

The next two sections of this chapter will investigate the two remaining knowledge gaps of urban GE. The first knowledge gap to be investigated is spatial planning & public values.

4.2. Spatial planning & public values

When developing geothermal energy in the urban environment, the complexity of spatial or urban planning is inescapable and needs to be accurately addressed in order to create successful projects. Because geothermal heat needs consumers close by to the source (Stichting Warmtenetwerk, 2018), supplying geothermal heat to the built environment requires the geothermal source to be either within or close to the built environment. The national government has delegated the task of the heat transition to the municipal authority (RVO, 2019), making them responsible for the spatial planning of sustainable heat facilities. Much literature on spatial planning has been written, and from the literature reviewed in this research the most relevant topics for geothermal energy have been selected. The main sources for this literature section are the books of Healey, which focuses on the relation between urban complexity and spatial strategies, and Wilson and Piper, which focuses on the connection between spatial planning and climate change. Out of the spatial planning theory presented in these books, together with other related literature, a selection has been made of four crucial aspects and three key perspectives on spatial planning for urban GE. The four aspects are: spatial planning is dynamic, requires multi-functionality of space, is predominantly a public activity, and is constantly balancing both renewal and consistency. The three key perspectives on spatial planning are regionalism, self-consciousness, and a realisation that spatial planning is both substantive and procedural. The four aspects and three perspectives together result in either a supportive or obstructive spatial planning structure for urban GE.

4.2.1. Four aspects of spatial planning

The first aspect of spatial planning states that it is highly dynamic. Amin, Massey, and Thrift described this dynamic nature of urban planning as follows: *“What matters within cities...revolves around the fact that they are places of social interaction.... Cities are essentially dynamic.... Policy formulation must work with this; it must not think in terms of some final, formal plan, nor work with an assumption of a reachable permanent harmony of peace. The order of cities is a dynamic - and frequently conflictual - order.”*. This characteristic of spatial planning results in an ever-changing order, which requires a continuous re-evaluation about if the current space usage is still desired. This aspect of dynamics can best be optimized if the duration of a space usage claim is not too long, and this could become a barrier for space allocation to long lasting projects like geothermal plants. For policy-makers this aspect of dynamics is also very important. Spatial planning cannot be conceived as a simple linear process of policy formulation and implementation, where it alters one specific aspect of urban spatial configuration. Spatial planning has to consider the complexity of the configuration and emergent effects that policies create. It is better described as strategy formation and usage. *”Strategies, in the complex dynamics of urban areas, cannot be expected to ‘control’ emergent socio-spatial patterns. Instead, they are risky and experimental interventions, ‘thrown in’ to the ongoing dynamic flow of multiple relational webs, in the hope that some beneficial relations will be encouraged an other, potentially harmful, effects will be inhibited”* (Healey, 2006). The aspect of dynamics can only be ’shaped’, not controlled, in order to encourage beneficial and limit harmful effects.
The order of urban planning is thus dynamic and frequently conflicting. The definition of spatial planning by the European Commission (CEC) presented in section 1.2 stated that it aims to achieve social and economic objectives and embraces measures of co-ordination (CEC, 1997). One of the ways to deal with the dynamics of spatial planning is to keep searching for co-ordination measures in order to serve multiple objectives by one spatial usage. The aspect of multi-functionality. Especially when space is scarce, like in the urban context, this aspect of multi-functionality is needed to serve as many values, objectives, and purposes in one. Healey (1997) described it as the *’co-existence in shared spaces’*, co-existing values, purposes, people, and organizations sharing one space that create synergy. *“Ter-*

ritory of the urban is not just a container in which things happen but a complex mixture of nodes and networks, places and flows, in which multiple relations, activities and values co-exist, interact, combine, conflict, oppress and generate creative synergy" (Healey, 2006). In order to improve the 'spatial value' of geothermal well locations, it is thus important for geothermal developers and operators to seek out the different options for synergies. For instance, it was mentioned by one developer that the territorial claim for a geothermal plant is due for a big part to the need to perform maintenance operations next to the plant. Since maintenance is only need occasionally, this extra space which is only needed for maintenance could serve other values, objectives, or purposes for most of the time.
To coordinate this provision of many different objectives and values and to find the right combination or co-existence of these objectives and values in one space, spatial planning requires a governance perspective (Wilson & Piper, 2010; Healey, 1997). The third aspect of spatial planning is therefore that it is public by nature. This is also why the CEC definition mentioned that spatial planning constitutes the methods used largely by the public sector (CEC, 1997). In the development of 'new spatial planning', four principals have been proposed to improve spatial planning (Haugthon, Allmendinger, Counsell, & Vigar, 2010). They are: an emphasis on long-term strategic thinking; a mechanism for joined up policy-making; a central role in moving toward sustainable development; and an emphasis on inclusivity. The second principals highlights the need for joined-up policy-making, indicating that spatial planning is not a sole public endeavour. However, the other 3 principals, long-term thinking, sustainability, and inclusivity, all are public values for which the public authorities have the main responsibility (Wilson & Piper, 2010). This 'new spatial planning' refers to a shift in spatial planning due to the second regime change as described in section 3.2.3. This second regime change resulted in a focus on long-term public values and interests, and specifically the matter of energy sustainability and climate change (WRR, 2018). In their book on spatial planning and climate change, Wilson and Piper argued that spatial planning requires futures and scenario thinking, future possible pathways. It is not only the state's responsibility to integrate this future scenario thinking, but it is the state's task to help their civilians to think ahead and encourage a shift towards long-term thinking among companies, third sector organizations, and individual citizens (Giddens, 2009). In the case of geothermal energy, it is therefore the government's or municipal task to encourage geothermal developers and operators to think about all long-term values surrounding their project and to think in multi-functionality, seeing not just sustainable heat but more than that. At the same time, it is also their task to help third sector organizations and local citizens to think along with the geothermal developers and operators to pursue a crucial long-term value and deal with one of the biggest worldly challenges of the present, the sustainable energy transition.
Lastly, an important note within this public endeavour of balancing a diverse set of public values and objectives via spatial planning, is the double and conflicting task that is inherent to spatial planning: the need to both develop the urban area as well as protecting the current environment (Wilson & Piper, 2010). This aspect of development and protection means that every new project needs to have considerable benefits that outweigh temporal and permanent negative effects due to construction and potential loss of synergy for the existing urban environment. This aspect is also mentioned in the CEC definition, where spatial planning has to *"balance demand for development with the need to protect the environment"* (CEC, 1997). For geothermal projects, this means that they need to choose project locations that minimize construction nuisance and disturbance of the local environment, and maximize their social benefits in order to outweigh the minimized nuisance and disturbance.

4.2.2. Three key perspectives on spatial planning

Next to the four aspects, three key perspectives on spatial planning will be presented: regionalism, self-consciousness, and the substantive and procedural nature of spatial planning. The first two perspectives are closely related. Regionalism states that the interconnectivity of networks and services involved with spatial planning requires governance from higher level agents than cities, but lower level governance than nation states (Healey, 2006). The self-consciousness perspective states that spatial planning requires a knowing of the location, understanding its identity, in which the planning takes place. Healey states that *"Spatial planning refers to self-conscious collective efforts to re-imagine a city, urban region or wider territory and to translate the result into priorities for area investment, conservation measures, strategic infrastructure investments and principles of land use regulation."* Combining these two perspectives, show that spatial planning needs a wide enough perspective to see all relative interconnections, but yet from a close enough perspective to be grounded in and be perceptive to the local identity. For geothermal energy, this means that projects need to understand the wider perspective,

like their place within the Regional Energy Strategies (RES), and also connect with the local residents next to them. This connection with the local community is needed because the local social acceptance of a project is a determining factor for the success of a project (Karytsas & Polyzou, 2021).
Lastly, any new project shall not only need to consider the substantive status quo of the local spatial planning practices, i.e. the physical landscape, but also the the procedural status quo, the existing spatial planning process rules. The customs and procedures of spatial planning that have developed in a municipality can either be an aid or a blockage for the development of geothermal projects. On the one hand, spatial planning can limit new developments and innovation, enforcing status quo by process rules that prefer minimal disturbance of existing infrastructure. On the other hand, it can propel new developments and innovation by bringing order in the ever-increasing difficulty of managing co-existence in shared spaces of dynamic urban areas (Healey, 2006). Therefore, depending on the local spatial planning practices, the procedural rules of spatial planning could be considered either a problematic or supportive factor for the development of urban GE.

4.2.3. Main takeaways spatial planning literature

In conclusion, spatial planning requires a perspective that is both wide and close enough in order to coordinate a project successfully, taking into account the dynamic and public nature of spatial planning, and developing a multi-functional project while protecting existing spatial synergies. Finding a balanced perspective that is both wide and close enough, is crucial for gaining social acceptance for any project. The subject of social acceptance will be covered in detail in the next section.

4.3. Social acceptance of geothermal energy

Social acceptance (SA) is increasingly recognized as an important factor for renewable energy (RE) development (Wüstenhagen et al., 2007), including the development of GE (Karytsas & Polyzou, 2021). It is stated by multiple researchers that the development and operation of GE power plants are heavily dependent on the acceptance at the local community level (Karytsas & Polyzou, 2021; Cataldi, 2001; Popovski, 2003). To explore how social acceptance influences the development of urban GE, literature on social acceptance of renewable energy, and GE specifically, has been investigated. This section will first define what social acceptance for energy entails, and then the three main components of SA will be discussed.

4.3.1. Social acceptance: balancing welfare

Social acceptance is a term that is used a lot in the literature of energy and policy-making (Wüstenhagen et al., 2007), but rarely a definition is given. Most of the time, immediately a deep dive into its several components is presented, without giving a clear broad definition (Wüstenhagen et al., 2007; Karytsas & Polyzou, 2021; Flacke & De Boer, 2017). Social acceptance itself is something that can be applied to all sorts of subjects, not just energy or GE. Social acceptance means that other people signal that they wish to include someone or something in their groups and relationships (DeWall & Bushman, 2011). When applied to the inclusion of a certain technology or infrastructure, Cohen, Reichl, and Schmidthaler stated that *"Social acceptance of new infrastructure occurs when the welfare decreasing aspects of the project are balanced by welfare increasing aspects of the project to leave each agent at worst welfare neutral and indifferent to the completion of the project, or better off and supportive of the project."* From these two definitions, it can be seen that social acceptance is given by a pre-existing social group, and that it always deals with something new or external to that group where the motivation to include that new "thing" is based upon their individual and collective welfare. The object of social acceptance within energy is thus always innovation (Wolsink, 2019), something new. From the definition provided by Cohen et al., it can be seen that always two sets of impacts of a new project need to be considered: the decreasing and increasing aspects concerning welfare. It is the sum of both these aspects, that leads to either resistance or inclusion of the project. It is important that public decision-makers see the diverse factors that play a role in SA of energy technology. The awareness of SA among them is still low (or at least contested) (Wolsink, 2019) and what is known about SA is most often the popular frame of NIMBY (Not In My BackYard) (Devine-Wright, 2011), which states that people are positive about something until it effects them directly after which they reject it for selfish reasons. Although there is some truth in it, almost every paper about SA and RE technology states that it is far more complicated than that (Wüstenhagen et al., 2007; Flacke & De Boer, 2017; Karytsas & Polyzou, 2021; Cohen et al.,

Figure 4.1: Triangle of social acceptance for RE innovation
Retrieved from (Wüstenhagen et al., 2007)

2014), and that this frame is even the reason for failing SA practices (Devine-Wright, 2011). Moving away from a NIMBY perspective towards a welfare balance perspective on SA is therefore of great importance for SA practices.

4.3.2. Three different levels of social acceptance

Social acceptance of RE can be subdivided into three parts, as can be also be seen in figure 4.1: Socio-political acceptance, Community acceptance, and Market acceptance. This model has been introduced by Wüstenhagen et al. and has since then been adopted by other studies (Flacke & De Boer, 2017; Karytsas & Polyzou, 2021; Cohen et al., 2014). The socio-political and community acceptance represent the macro and micro levels of SA that were mentioned in the exploratory interviews. They represent the regional general attitude towards a RE technology, and the specific acceptance of a RE technology project by the local residents. The third level, market acceptance, concerns the dynamics of consumers and RE companies. All three will be further explained in the following sections.

Socio-political acceptance

Socio-political acceptance, or macro acceptance, is the most general form of SA and forms the basis on which community and market acceptance is build. As shown in figure 4.1, this level concerns both the RE technologies themselves as the policy that shape their societal impact. It concerns to the general public, key stakeholders, and policy-makers. It is noticed that the socio-political acceptance of RE technology and policies is in general positive, but that the conversion of this acceptance rate to specific projects, the community acceptance, is difficult (Wüstenhagen et al., 2007; Cohen et al., 2014). For GE, the socio-political acceptance level is recognized to be somewhat lower than for other RE technologies (Popovski, 2003). Popovski states that this is due to the fact that for other RE technologies, like solar and wind, the consequences on nature and the local surroundings is easy to perceive. A wind farm or solar park will not influence the wind direction or solar radiation, and all local effects can be seen, measured and verified. For GE it is a lot harder to understand how subsurface water is really influenced, and most of it happens underground and out of view, thus outside of the easy comprehension of the public. Because of the greater amount of unknowns, socio-political acceptance of GE is more challenging. On top of that, socio-political acceptance of GE in the Netherlands has an additional challenge. The things that Dutch people do know about subsurface exploration does not have such a positive perception, because many people make the link between GE and the Groningen gasfield troubles (Jansma et al., 2020). This experience with subsurface exploration undermines both the technology and policies of GE. Both the perceived safety of GE is negatively affected, due to the many

earthquakes that are directly related to gas exploration, as well as the trustworthiness of GE policies, due to the generally perceived poor treatment of Groningen plaintiffs by the government. It is therefore important that the socio-political context of GE in the Netherlands is understood, realizing that in general GE projects start on the back-foot. Socio-political acceptance is however much more than just a first step towards community acceptance, moving from the public to local residents. Socio-political acceptance is a building block for both other levels, community and market acceptance, but besides being a context factor, it is also a level of acceptance that needs to accept GE itself. At the national or regional institutional level, a customary think- and work pattern concerning RE has developed over time, a RE policy regime, creating path dependencies that favor particular technologies, also named "institutional lock-ins". Studies have shown that these embedded institutional, political, and economical commitments can create inertia, allowing inferior technologies to persist despite their demonstrable inability to represent and enforce both long- and short-term values that are needed for the energy transition (Wolsink, 2019; Walker, 2000). These institutional lock-ins do therefore not only favor existing technology, but also implicitly resist new innovations, blocking SA for RE and GE at the socio-political level. SA at the general socio-political level concerns the acceptance by key stakeholders and policy actors, the policy subsystem, of effective policies for RE technologies. These policies *"require the institutionalization of frameworks that effectively foster and enhance market and community acceptance"* (Wüstenhagen et al., 2007).

Community acceptance

Community acceptance, or micro acceptance, is the level of SA that refers to the specific acceptance of siting decisions of RE projects by the local stakeholders, especially the residents and local authorities (Wüstenhagen et al., 2007). It is this level of acceptance that has received most attention in research, policy, and project development (Wolsink, 2019), and it is also in this area that the NIMBY model was introduced to explain the high acceptance rate at the macro level, but low acceptance rate at the micro level (Karytsas & Polyzou, 2021). This model has been discarded as accurate and deemed insufficient to explain this observed difference between macro and micro level acceptance for RE technology (Wüstenhagen et al., 2007; Karytsas & Polyzou, 2021; Cohen et al., 2014). This narrow SA perspective is even pointed out as one of the limiting factors for community acceptance (Devine-Wright, 2011). It is therefore one of the embedded institutional thinking patterns that need to change at the socio-political level in order to improve community acceptance practices.

There are two reasons why the NIMBY model falls short. First, in the NIMBY way of thinking, local resistance is blamed to selfish sentiments of local residents, implying that local residents are unreasonable and need to be brought back to reason. When looking at the definition of social acceptance for infrastructure projects from Cohen et al., the resistance of local residents towards aspects of RE projects that negatively impact their welfare is not unreasonable or selfish, but a fair and reasonable response that can be expected from every actor. This is also why community acceptance is shown to follow a time path in which there is high acceptance prior construction, a drop of acceptance during construction, and a rise of acceptance again during operation (Wolsink, 2007). Resistance because of decreasing welfare due to certain aspects (construction in this example) of RE projects is a logical results, and this needs to be overcome by appropriate compensation measures. Possible compensation measures are mentioned in appendix C. The second reason why NIMBY falls short is because it tends to focus purely on the substantive parts of RE development. In this line of thought, people reject a project for which they have a positive attitude in general, but refuse it due to the negative impacts of such a project that affects them locally. It his however much more the procedural side of RE development that leads to resistance, and in GE development it is most often the case that local residents reject the project developer and not the project itself (Olympia & Sofia, 2010).

A new frame on community acceptance should therefore leave the preconception of selfishness and instead strive for a balanced design for all negative and positive project aspects which maximizes increased welfare of all actors, including within these aspects both substantive and procedural factors. A more complete frame for community acceptance compared to NIMBY that is used in SA literature is the perspective of distributional and procedural justice, in which trust plays an important role (Wüstenhagen et al., 2007; Karytsas & Polyzou, 2021). This perspective states that the decreasing and increasing aspects of welfare should be distributed fairly, and that the decision-making process that leads to this distribution should be fair, inclusive, and transparent (Gross, 2007). The third dimension of trust represents the fact that the local community needs to trust the authorities (Huijts et al., 2007). Trust is

Figure 4.2: Community acceptance factors and context
Retrieved from (Karytsas & Polyzou, 2021)

a key issue in siting decisions. Siting decisions of RE projects always involves significant risks; environmental, economic, and social risks. The perceived fairness depends on how potential risks are defined, communicated, and by whom they are managed (Owens, 2004). Trust is needed both in the matters of distributional and procedural justice that cannot or should not be understood at a citizens level. Local residents cannot understand factors that either require extensive expert knowledge or are not fully understood by any expert at all because of inherent uncertainties. Secondly, local residents should not understand factors that would need hours, days, and weeks of study, resulting in an everlasting SA process. At a certain moment, a decision needs to be made to trust. This decision to trust when factors cannot and should not be understood by local residents can only be made based upon their relationship with the authorities. This highlights that SA is indeed about social acceptation, and not project acceptation. It is not the GE projects that often produce resistance, it are the GE developers (Karytsas & Polyzou, 2021). To provide an overview on the factors that are involved with community acceptance, as well as the context that influences these aspects, an overview was made by Karytsas and Polyzou and shown in figure 4.2.
What is important to note on this new model on community acceptance is that these three dimensions, distributional justice, procedural justice, and trust, and also the various factors that fall under these three dimensions as displayed in figure 4.2, all are heavily influenced by perception and subjectivity. There is no absolute measurement of justice and trust. Although the definition of SA by Cohen et al. introduces the quantifiable concept of welfare, it is only the perceived welfare neutrality or increase that will invoke social acceptance. However, this model does create a shared vocabulary on the perception of RE projects, which is a first step towards shared thinking and goals in the energy transition, and shared thinking and goals are key ingredients for building trust (Huijts et al., 2007).

Market acceptance

Social acceptance can also be expressed in the market adoption of a new technology. The willingness to adopt a new technology is based upon the perceived benefits offset to the required costs, i.e. the willingness to pay. The adoption of a technology is based upon the interplay between producers and consumers, the quality of a product and the willingness to pay for this product. For GE, the consumer side is part of the community acceptance, but for the producers side, two aspects are important to mention. First, multiple papers on SA mentioned that market acceptance also entails the intra-firm acceptance of innovations (Wüstenhagen et al., 2007; van Everdingen & Wierenga, 2002). The investment behaviour of energy firms is subject to path dependencies, favoring existing technologies over new energy innovations (Hirsh, 2003). Secondly, if an energy firm does decide to invest in new RE technology, the competitiveness of such technologies is often weak and requires niche market strategies to develop the technology till maturity (Parrish et al., 2006). It is in both these aspects of producer side market acceptance that the socio-political level of SA plays an important role. By stepping out of in-

stitutional path dependencies at the socio-political level, the breaking with old fossil energy paths in the market is promoted. Secondly, by creating new institutional frameworks that promote RE technology, the right conditions are created for fostering favourable niche market conditions.

4.3.3. Main takeaways social acceptance literature

To close this literature section, the main roles for local authorities in the SA process according to SA literature will be presented. SA literature highlighted that local authorities are important stakeholders for RE and GE development, due to their proximity to individual citizens and households (Flacke & De Boer, 2017). SA has been defined to occur when the welfare decreasing aspects of a project are balanced by welfare increasing aspects to make the net change neutral or positive. SA is broken down into three levels: socio-political, community, and market acceptance. The socio-political level creates legislation that promotes the acceptance of new technologies on the community and market levels. Community acceptance requires distributional and procedural justice underlined by trust, providing context to citizens to see the bigger picture in which a specific project plays a part. Market acceptance comes from legislation that drives energy market players out of lock-in on conventional (RE) technologies and promotes innovations by creating niche markets.

4.4. List of main dimensions

Based upon the literature of the previous chapter, and the exploratory interviews and literature of this chapter, a list of main dimension for urban GE is established and can be seen in table 4.1. This list will be used as a guideline for the first round of in-depth interviews. Although the literature research started before the in-depth interviews commenced, both activities had overlap. Because this overlap in activities was foreseen, an unstructured interview process was chosen, which provided the flexibility for possible adjustment and/or addition of dimensions. The initial list of main dimensions was formed in between in-depth interviews 2 & 3, and drafted together with the academic supervisors of this thesis and was refined with feedback from the guidance commission of the Mijnraad. The list has since been similar in scope but refined in its conceptions as the literature study and interviews progressed. All subjects have sources in the literature or exploratory interviews, except for three subjects which were added based on the first two in-depth interviews. These three subjects are explained in table 4.1.

Theme	Subject	Source
Spatial planning	Dynamic nature	4.2.3
	Public nature	4.2.3 4.1.1
	Co-existence and multifunctionality	4.2.3
	Development and protection	4.2.3
GE Technology	Well performance uncertainty	Source performance is only truly accurately known when first well is drilled.
	Dynamics in urban GE business case	4.1.4
	RE strategy	Municipalities are responsible for energy and heat transition in their city, but lack executive authority
	Knowledge and expertise required for urban GE	4.1.1
	Actor alignment and cooperation	Geothermal development involves many different parties: all levels of government, well development needs coordination with heat infrastructure development, heat suppliers that need to give purchase assurances, and more
Policy development	Policy subsystem	**??**
	Policy implementation space	**??**
	Substantive and procedural nature	**??** 4.2.3
Social acceptance	Socio-political legislation development	4.3.3 4.1.1
	Depicting bigger picture of energy transition	4.3.3 4.1.2
	Distributional and procedural justice	4.3.3
	Building trust	4.3.3 4.1.3
	Time path of communication	4.1.2 4.1.3
Uncertainty & risk	Simplifications and strategies for uncertainty	3.2.2
	Communication of uncertainty	3.2.2 4.1.3

Table 4.1: List of main dimensions urban GE for interview guidance

5

Key aspects urban GE development

The previous two chapters have identified and described a selection of relevant theory and background information that provides a context in which the case study of urban GE can be understood. In this chapter, the data retrieved from the first round of in-depth interviews will be presented. From this data the key aspects that need to be included in an AF for urban GE development will be identified, answering the third research question. This chapter is broken down into three parts: first the interviewing process and output structure will be described; then the main findings per code category will be presented; and lastly the list of elicited key aspects for urban GE development will be presented and described in more detail.

5.1. Interviewing process & output structure

The interviews have been conducted in an unstructured manner because this flexible and open style of interviewing suits the exploring nature of this study. However, a list of main dimensions for urban GE development has been used as a guideline to the interviewing process. The final version of this guideline is shown in table 4.1. Due to the limited time that could be requested from interviewees, not all main dimensions could be covered for each actor. This means that there is a bias in the data in which the coverage of the main dimensions of urban GE development differ over the interviews and the actors in the sector. This is compensated by interviewing multiple persons from a similar actor perspective, for instance 5 different municipality civil servants were interviewed.

The interview transcriptions have been summarized by breaking down the answers of the interviewees to each question in bullet-point form, whereby each bullet-point represented a different facet of the answer. After an interview was summarized, the answers were coded using the qualitative analysis tool Atlas.ti. The list of encoding included 7 code categories with each category having multiple subcodes. The overview of all codes used can be found in appendix A. It was decided to not use a pre-defined list of codes in order to prevent reading into the data. Although many codes can directly be related to the themes and subjects mentioned in table 4.1, also new topics emerged including two new code categories. The 7 code categories are Institutions, Social Acceptance, Technology, Uncertainty, Financing, Spatial Planning, and Assessment Frameworks. The categories are based upon the pre-defined themes with the addition of financing and assessment frameworks. The first one was added because it became an additional theme in the interviews, while the second was added because some interviewees made comments on a potential urban GE assessment framework or about AFs in general. From the enormous variety of data processing tools that Atlas.ti provides, the coding option and the corresponding data management tools were used in the following way. The encoding was applied on individual bullet-point level or on multiple bullet-points collectively, and multiple subcodes could be assigned to a single selection of source data, allowing overlap. The total bulk of data could then easily be represented in an overview per subcode with the code-document table and the concepts analysis which produced an overview of subcodes per interview and a word cloud for each subcode topic.

The overview of topics and their correlation provided by Atlas.ti resulted in an extensive archive of challenges, assessments, issues, concerns, recommendations, insights, and preferences expressed by the interviewees. To provide an overview of this data that would concisely formulate the main points of the interviews, this archive has been summarized per code category and from this summary four overarching key aspects were elicited. These key aspects are based upon the frequency of the topics

and relations in the interviews and are defined based not on a single subcode category but are drawn forth from a combination of several subcodes. However, the identification of these key aspects is not purely based upon numerical weights of topic or relations occurrence indicated by Atlas.ti. The analysis tools of atlas.ti served as a guidance, but the key aspects were defined by the researcher based upon the interviews and the literature.

5.2. Main findings per code category

his section presents the results of the interviews. First an overview will be given of the main findings for all 7 code categories. For each category a word cloud was created via atlas.ti to see which concepts stood out in the interviews belonging to this category. These concepts could then be traced back for all interviews using atlas.ti to see all comments on these concepts. After that, a number of interviews were selected to investigate the entire category in detail. To keep the overview condense the main takeaways per code category will be stated with the interviews on which these claims were based set within brackets. For all categories at least four interviews were selected of which two were municipalities and two were other organisations. The most relevant interviews per category were selected based on the code category occurrences per interview and on the sector position of each interviewee. For instance, SodM was selected for the technology sub-category since they set and control the technological parameters within which companies can operate.

Institutions

The institutions category was the most dominant of the encoding, about 40 % of all codes fell within this category. This is partly due to the research focus on the role of municipalities in the urban GE development, and partly because in the coding process several subjects from the list of main dimensions for the interviews were shifted to the institutional theme (policy development). Actor alignment and cooperation, Knowledge and expertise, and Socio-political legislation development for instance all mostly fell under institutional. Because this category has so many data, it was split into two parts for convenience of data interpretation. The two parts are: 'Multi-level governance' and 'Local decision-making'. The first mainly deals with inter-institutional activity while the second deals with local and municipal activity. The highlighted entries of the institutions column of table A.1 are the codes used for the 'multi-level governance' section and the non-highlighted vice versa.

In the multi-level governance coding of the interviews, the concepts "party, role, and communication" stood out (Partij, rol, communicatie). These words were mostly used in the context of dividing the roles between the different parties involved in the development and the necessary communication between them to make the division and cooperation of roles successful.
Communicating a clear role division is crucial in order for the public to understand which party is involved when (Eneco). By clarifying the institutional context it can be seen by the public that it are not just energy companies that want to make money, but that it fits within the context of the energy transition, both nationally and locally (Eneco). In order to collaborate with other parties on GE development, municipalities first need to develop a vision on how they want to develop GE in their city (Mu Delft). However, everyone is still learning in their role (Eneco) and there is much to improve in the current communication and understanding among the different parties (EZK), especially private and public sectors (Flevoland). Inter-governmental cooperation is usually good (Mu Delft) but due to different customs and work fields miscommunications do occur (Flevoland). In extreme case this lead to distrust between water authorities and ministry (Dunea), for which province can play binding role (Flevoland). When municipalities will learn their role, which according to Province is on the subjects of SP and SA, and focus their advice to the ministry on this role, their advice will be effective (Flevoland). There needs to be a better coordination between the national and local government on the development of heat networks and GE wells (Mu Almere).

Figure 5.1: Word cloud Multi-level governance

In the local decision-making coding of the interviews, the concepts ”knowledge, permit/zoning plan, and side” stood out (Kennis, vergunning/bestemingsplan, kant). An often bespoken topic was the knowledge of local civil servants on GE development, communication to the public, or heat transition in general. It was either deemed inadequate or in development and in need of refinement. The words ’permit/zoning plan’ indicate that municipalities and local decision-making is primarily focused on local permitting procedures, of which the zoning plan is a specific permit required for construction and operation on a specific location. The third word ’side’ or ’perspective’ showed that the municipality has many different perspective that it needs to take into account. It needs to direct the energy transition, balance heat supply and drinking water sources interests, consider spatial planning and social acceptance in promoting GE development, and provide public values whilst ensuring a profitable business case.
The municipality is primarily involved in the permitting procedures, having a clear transition vision will speed up this process (Mu Delft). Participating as municipality in the development of local GE projects in some form is either considered crucial for control (Mu Almere) or unnecessary and not their task (Mu Delft). Local perception due to local context needs to be understood to develop urban GE (Mu Almere). Knowledge needs to be shared in basic layman language both internally and to the public in order for people to grasp the concepts (Mu Almere). Due to the long leading times of urban GE projects, several local councils will pass requiring continuous knowledge provision (Mu Almere). Knowledge of municipalities can maybe be best gathered in provincial or inter-municipality organisations (Flevoland). The social acceptance communication process requires next to knowledge also lots of manpower for which the municipalities do not always have the resources (EZK).

Figure 5.2: Word cloud local decision-making

Figure 5.3: Word cloud social acceptance

Social acceptance

Social acceptance was the second most frequent code category over all interviews, all though be it at more or less the same level as technology (177 and 145). The concepts that stood out in this coding category of the interviews were ”People & resident, and communication, story & conversation” (Mens & bewoner, and communicatie, verhaal & gesprek). The use of these concepts was mainly in the context of involving and communicating with the right people at the right time. Especially the communication with local residents was described a lot in terms of telling the whole story, describing the full context. To bring people to a place where they support or accept a project, you need more than just facts about safety, sustainability, affordability, and so forth, people need to hear a story and the story needs to start at the beginning. Why do we need to transition, what are the sustainable heat options, which work best in our city, how do we want to develop these best options, who is responsible? Not only communication is needed in these stories, but also conversation. What does this specifically mean for you, your street, your neighbourhood? Each citizen or citizen group requires a tailored story.
In the story telling all relevant aspects of welfare need to be discussed, aspects like the context, alternatives, the expected prices and the subsurface (Mu Leeuwarden). In the communication and participation process the roles of government and citizens need to be made clear. When and about what can citizens give input, what can be expected from their input, who is responsible for processing their input (Mu Nieuwegein). Sincerity in communication is key, do not call something participation if it is just informing people, civilians will pick up on that (RES). Perceptions are huge drivers for SA and existing ones need to be taken into account or challenged. How does it differ from Groningen? This needs to be made clear (Flevoland). All sorts of misconceptions or ’totally irrelevant factors’ might influence the perceptions of civilians, these can only be dealt with when there is open dialogue and conversation (RES). Setting the right context will lower the need for extensive communication for the next project. Need for heat transition and usefulness of GE less of an issue in follow up projects in the same city (Mu The Hague).

Technology

In the part of the interviews that adressed GE technology, the concepts ”Heat network and time/year” were dominant (warmtenetwerk, tijd/jaar). Every interviewee highlighted the fact that GE wells are heavily connected to heat networks and that one cannot do without the other. When developing urban GE, it is crucial to see it as part of the entire ”heat chain”. Coordination among the different actors is crucial and during the time of interviewing the heat act was in alteration where the question was how much of the chain should be under public control versus a free market structure. This policy development made it a hot topic and the outcome resulted in a strong position for municipalities to set direction for the development of heat networks. Another well discussed topic on urban GE development is the required time for a project to develop, the late stage of project development in which project success can accurately be predicted, and the long horizon over which it creates revenue. The development is for now a process that takes a lot of years in which a decade is not uncommon. This long leading time creates problems for the business case and subsidy regulations. The difficulty in predicting project

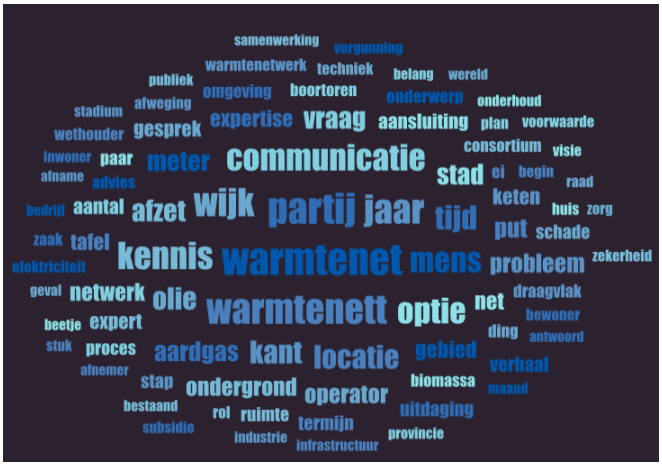

Figure 5.4: Word cloud Technology

success and the long horizon over which it creates profit also leads to uncertainties for the investment partners.
The long leading times can lead to loss of subsidy (Mu Delft), abandonment of the project (Mu Nieuwegein), create difficulty in co-planning with network development (Mu Leeuwarden, RES), and make it hard to keep actor focus and alignment (Mu Almere). The technology is still in an early stage of development and every project has had it's own teething troubles. Now GE is moving to the built environment it is important to take safety margins and prevent failures that can negatively impact the sector's reputation (SodM, Flevoland, EBN). GE technology requires expertise that is hardly accessible, finding experts that can verify permits is difficult (Mu Delft, The Hague).

Uncertainty

The concepts that stood out in the uncertainty coding category are "people and biomass" (Mens, Biomassa). People was interesting because it showed that the deepest uncertainty is not in technological or physical factors, but that the reaction of people and their perception of these factors are most important. Biomass was interesting because it was mentioned in two different contexts. Biomass was purposed by many as a secure and sustainable but temporary heat source for heat networks. Over time GE would replace it as a heat source, but it would enable heat networks to be developed independently from GE. However, because biomass has been canceled by the public opinion the only viable sustainable heat source for heat networks is either waste heat or GE. Because waste heat cannot or should not be developed at a new location, heat networks are very much reliant on GE. Because the potential of GE wells is not certain till very late in the development process, making a double investment in both GE and a network becomes very risky. The second context in which it is mentioned is the fear of GE following the same trend as biomass in the public opinion. One negative experience could possibly trigger the Groningen sentiment towards GE in the Netherlands and make it socially impossible to develop. This is part of a bigger uncertainty felt by the different actors: the public process. How will the people respond and how will their attitude be in 5 years when the project is halfway development?
The late stage of development in which the well performance and with it the business case is still uncertain makes it difficult to communicate and justify decisions to keep pursuing the project when so much is uncertain (Mu Delft). The attitude of the civilians might change over the long leading time of the project, and it is also very unpredictable how well connected or organised resisters to the project might be. Keeping updated on the local perceptions and maintaining dialogue is crucial for SA developments (Mu Almere). There are enough investors willing to invest in green energy projects, but the business case is just not good enough yet for wide scale investment and development (fHN). To improve the business case a part of the risk needs to be taken by the government (fHN) or could be dealt with by market structures as long as the legislation becomes clear and stable for a long period of time (GNL). Even when the well performance is less than hoped for, the business case of GE is most often still good (GNL).

Figure 5.5: Word cloud for uncertainty

Financing

Financing was added as a theme in the coding process, because it became a reoccurring theme in several interviews. Although it could be considered part of the institutional set-up and therefore of the institutional theme, it was decided to make it a separate one as it was recognized to be a crucial theme in the development of urban GE. The concepts on financing that stood out in the interviews were ”supply agreement, return, heat network/company” (afname, rendement, warmtenetwerk/-bedrijf). In the interviews it was highlighted several times that some form of sales assurance is needed for a GE project to succeed. This assurance is often formalised in a heat supply agreement (WLO), but this agreement needs to take place before drilling when well performance is uncertain. This step is a very riksy one for both the developer and heat company. On top of that a pre-existing or simultaneously developed heat network is crucial. It was also stated that the margins are very thin in urban GE and that when heat and gas prices are high the subsidy arrangement changes so that even in times of high prices projects have financial uncertainty.

Aligning the development of both a heat network and source is challenging and requires a party to take lead in coordination of both projects. The municipality can take lead in both processes now with the new heat act (Mu Delft). Having a secure base of sales is crucial for a project to succeed (Eneco), the market is more and more moving towards one party that develops both source and network (GNL). With the new responsibility for municipalities to coordinate heat network development it is important that they stick to their expertise. Developing a business case for heat networks in their neighbourhoods is something where they have slim expertise and they need to refrain from work that private companies can do better (fHN).

Figure 5.6: Word cloud financing

Spatial planning

From the 6 main code categories, excluding AF, spatial planning has the least amount of coding over all the interviews. This is because the questions that were prepared on this subject lead to the least amount of follow-up questions, indicating that spatial planning might not be the main issue in the current stage of urban GE development. The concepts that stood out in the interviews concerning SP were ”ground and derrick” (grond, boortoren). Ground was mainly referred to when indicating that the municipality has more authority and control when they own the ground of the prospected well. Derrick was mentioned in the context of picking a location in the built environment. It is important to take into account that during construction or severe maintenance a derrick or other heavy machinery will be operating day and night resulting in a temporary but significant decrease of living circumstances for local citizens.
The interviews that did speak about SP were the municipality of The Hague and Nieuwegein. This possibly explains why SP is not yet much of an issue. It is only in the city of The Hague that a multitude of urban GE projects is planned, while in all the other municipalities it only concerned a single or first well location. Finding one spot for urban GE might not be the hardest task, finding several might prove more difficult. In the interview of Nieuwegein the location decision was mentioned because it was one of the main causes for delays in the projects, and the long leading time was the final blow that stopped the project. Finding a theoretically suitable location was not the hardest part, selecting one while being able to bring the citizens along in the SA process was the challenge. It was also stated that the negative side effects of construction and operations should not be neglected (SodM). Lastly, it is important for municipalities to use their authority on the matter of spatial planning in order to prevent overruling from higher level governance like the ministry (Dunea).

Figure 5.7: Word cloud spatial planning

Assessment frameworks

This code category was created in order to collect direct wishes or statements on a potential assessment framework for the development of urban GE. It only contained 15 unique codings so they were all looked at directly without creating a word cloud. For the context of AFs it was mentioned that transparency is key (Mu Nieuwegein) and that it cannot be a simple list of trade-offs, but that each trade-offs has an implicit frame and that first a shared perspective is needed in order to deal collectively with important trade-offs (RES). Concerning wishes or desired purpose for an AF in urban GE, it was stated that for an AF they would like to see it structure the story telling process (Eneco, GNL) and streamline the public permitting process in order to reduce leading times (GNL), create clarity and guidance now the regulation has recently changed and more of it will change soon (EZK), and that it should clarify the participation process of local citizens (EBN). A concern about AFs for urban GE was raised on the fact that municipalities might develop AFs without proper knowledge on every aspect creating unnecessary blockades for GE development (EBN, EZK).

5.3. Key aspects for an urban GE assessment framework

Four overarching key aspects have been identified from the different code categories. All four of them have foundations within each code category. From the interviews these four key aspects are identified

as the most crucial for urban GE development in the Netherlands at this moment. The four key aspects are: Collective action; Effective citizens communication; Leading times; and Financing. In this section all four key aspects will be discussed. Each challenge will be described and their importance will be supported with quotations or paraphrases from the interviews.

Collective action

In the development of urban GE many different governmental agencies and institutions play a role: municipalities, provinces, the ministry, water authorities, SodM, Regional Energy Strategies, and next to them many private or public-private organisations have their influence: EBN, GE developers, network developers, GNL, fHN, and heat companies. Each of these organisations has their own specialities and interests and wants to contribute to the development of urban GE to their best interests. To coordinate the collective actions, the municipality has been assigned the director's role in the energy and heat transition (RVO, 2019), and with the upcoming adjustment of the heat act even more director's authority has been given to them (Brand, 2022). However, the direct control of municipalities on the development of sustainable heat sources and networks is limited. Because of the privatization of energy companies, municipalities require private parties to invest in energy projects, and the coordination of energy sources is difficult because the permits that allow developers to search for GE potential are not within their authority.

(1)"For municipalities it is difficult to decide what to do and they will always have to partner with a commercial company to develop heat networks. Even if they assign areas for heat network development, municipalities do not have the expertise to make a good business case" (fHN)
(2)"So then you have a GE heat source and a waste heat network that are both partly developed with public money that will compete with each other, because both are not yet needed. And the municipality does not have control over where sources will be used and where they supply their energy. That is up to the heat companies" (RES).

So next to a limited mandate or expertise for initiating sustainable heat sources or networks and therefore being dependent on private parties, municipalities also lack overall control on the coordination of energy transition projects. The only direct authority they have is on the specific location of urban GE or heat networks by either prohibiting or assigning locations.

"You don't have much control. You can revoke or refuse permits, but you can't just do that. Standing on stripes is not an option" (Mu Delft).

The director's role in the energy transition can therefore not be played using a 'command and control' style, but requires good communication among the different actors and clear division of roles based on each organisation's expertise and knowledge.

"We do take on the director's role, but it is difficult because you are talking to many different parties. Not only with the consortium, but also with the heat network manager and energy supplier. Then as a municipality you are a permit issuer and land manager, but part of the land then also belongs to the province with the water board as the permit issuer. Getting all those public and market parties on the same line is very difficult." (Mu Delft)

The director's role that has been given to the municipalities is a responsibility that municipalities struggle with. From the five municipalities that were interviewed, three of them explicitly stated that their authority is limited making it hard to align all the different parties involved (Mu Delft, Leeuwarden, and Almere), while the other two mentioned a shortage in knowledge and expertise to carry out this role effectively (Mu The Hague and Nieuwegein). In the mean time, the other actors in the sector requested municipalities to take more of a lead in for instance social acceptance and spatial planning, while not setting too much restrictions by too invasive policies, indicating the careful balance municipalities need to find.

Effective citizens communication

Effective communication is key in the process of inter-governmental and public-private collaboration in the development of GE, but a second crucial part of communication is the citizens communication. Despite all of the technical uncertainties that accompany GE development, the social uncertainty concerning the project perception of citizens was mentioned as one of the key aspects. The communicative

process was sometimes referred to as a black box with limited control, and although it was recognized that being too early or too late with communication can both be problematic, the right moment of communication was hard to define and mostly circled back to 'as early as possible'.

(1)"We have also researched similar projects in the Netherlands and we now know that communication is half the battle" (Mu Leeuwarden)
(2)"It is also difficult to predict or know how much influence each group has and what kind of communication is needed with that group. You can use all the right approaches and it can still go completely off the rails" (Mu Almere)
(3)"You have to communicate early, we have always been late. I still struggle with the question of whether you can be too early. But it has to be earlier than what we did. I am convinced that you can do damage if you are too late, but you can also do unnecessary damage if you are too early or do it wrong"(EBN)

A crucial aspect on the citizens communication is the context in which it is received. For people to understand and be willing to accept or support the project, the context of the project needs to be understood and it needs to be clear for citizens how it will impact them. However, the context is not a mere list of facts but is driven by the perspective that people have of the project. The challenge in communicating the project, it's context, and the effects that it will have on the local citizens, is that each person's or neighbourhood's perception, and thus the factors that matter to them, is different and unique. The value that they will assign to the project's welfare increasing and decreasing factors will therefore differ. Some of these different value allocation will be logical, while some will be based on false perceptions. Therefore, a unique communication process which discerns between different communication target groups is needed for every project.

(1)"Perception of the problem is the strongest motivation for people to form an opinion about geothermal energy. First it was the problem of Groningen, now that of dependence on Russian gas" (Mu Almere)
(2)"I've had cases where the objections to the project were based upon worries that stemmed from unexpected and false perceptions. Coping with these cases has to do with collecting information, knowing what is going on, and realizing that every neighborhood and individual is different" (RES)

To execute such an extensive communication process, a lot of human resources are required, who in turn need to be trained in GE knowledge in order to communicate effectively. The communication process needs to address the many different topics concerning GE and needs to be communicated in the most simplistic language as possible. And these communicators also need to be trained to be perceptive to all non GE-related worries people might have that effect their perception on the project. Secondly, to create a sense of nonpartisan information provision, the communication process should be executed in collaboration with the project developer and all the other public and private actors involved. Setting up these effective communication channels will thus require an increase in knowledge and take a lot of time and resources.

(1)"The communication process will take a lot of time and additional resources" (Mu Leeuwarden)
(2)"Who plays what role is very important for people to know. If you explain per phase in the project which authorities are involved, then people get the feeling of: 'this is being looked at carefully'" (Eneco)

Leading times

One of the frequently mentioned key aspects in the interviews was the long leading times of GE projects. These long leading times have serious repercussions in the form of lost subsidy, loss of focus among actors, and even cancellation of projects.

"A subsidy was also applied for and obtained here, but because it had not started within 8 years, that subsidy was withdrawn. No subsidy is no business case" (Mu Delft)

The reasons for these long leading times are diverse and cover all factors in GE development. These include the institutional setting and long decision times of the public process, the participation and information process that needs to create social acceptance among the local citizens, finding the right location for the project, and aligning the different investment partners for a final investment decision.

(1)"As a municipality, it is a huge challenge to align projects with their heat transition vision, policy frameworks, and municipal decision-making, and then also to make the right links with water boards and provinces in order to keep the alderman well informed and to let the municipal executive make a decision. All this within an advisory period of 8 weeks so that the ministry can provide an answer within the desired terms. That is very tight"(GNL)
(2)"So I do recommend projects like this to communicate directly with the council and the population at the moment an idea arises. It's just a very long track"(Mu Delft
(3)"But if urban GE is to succeed, we need to know quickly how much space is needed and what kind of buildings need to be built for it"(Mu Nieuwegein)
(4)"The final investment decision has still not been made and it could still cannot go through"(Mu Delft)

From all the reasons mentioned above, the long leading times are mostly attributed to the public process of decision-making, and this is stated by both private and public parties. The assembly of the public and private working methods is difficult because there is limited understanding between the parties. Private actors mention that it is difficult to get something on the public agenda or do so in time, often leading to numerous weeks of delay. Municipalities mention that gathering the required knowledge or finding the right expertise for assessing GE development plans is often difficult and takes time. Secondly, the different permits needed for GE development are poorly aligned, resulting in double work.

(1)"It is also interesting to see how the worlds of companies and the government are completely different. Communication between companies and the government is also very difficult and there is little mutual understanding"(Mu Almere)
(2)"What I see in the decision-making of projects is that putting something on the agenda of a municipality requires extremely good planning. It could be that you have to wait 3 council meetings, and for smaller municipalities that is just 5 months. That is disastrous for projects" (GNL)

Financing

For the successful financing of a GE project, it was mentioned several times that revenue guarantees in the form of a heat supply agreement is crucial. On top of that, a heat network is needed for distribution of the heat. However, due to the fact that certainty on well performance is only known late into the project, attaining this heat supply agreement and developing a heat network is difficult. The uncertainty of the well performance concerns both the amount of available supply as well as the reliability in continuity of supply. Both these factors heavily effect the heat supply agreement. Secondly, since this effects the total business case of the project, this also makes parallel investment in a heat network less attractive. The difficulty in securing these two crucial prerequisites makes the financing of urban GE projects a big challenge.

(1)"When it comes to geothermal energy, I always talk about heat projects, for which you not only need a source, but also a purchase and transport. So if you only talk about the source you miss 2/3rds"(Flevoland)
(2)"A GE party will only invest if it has a view of coverage, i.e. income from a supply agreement with a heat company. So before making major investments, such a party wants a heat supply agreement"(Eneco)
(3)"But we need a good solution for the chicken-and-egg problem where no source is installed without a heat network, and no heat network without a source. We are still working on that problem"(EZK)

The business case for urban GE projects remains tricky, making development difficult. SDE subsidy provided by the government creates a certainty in the price for heat that GE exploiters will receive, but due to the set up of the subsidy the margins remain low even in times of high heat prices. Next to this, the development of a well requires high capex expenditures before well performance is known. These expenditures, for which no fitting subsidies are present, include geological surveys, permitting procedures, and local communication.

"The problem is that developing both geothermal energy and heat networks is extremely complex. Both require a long-term investment where you have to spend a huge amount of capital and you have to look over 30 to 50 years. It is extremely difficult to invest with low margins over such a long period"(fHN)

Despite the low margins, high capex costs, and the possibility of lower well performance than expected, the business case for GE projects is most often still considered to be favourable compared to other sustainable heat solutions. It is recognized that when considering the advantages and disadvantages of urban GE, it is the drive towards sustainable energy that pushes these projects forward. The balance between a sustainable drive and the responsible judgment of the financial uncertainties creates discomfort for civil servants in justifying the commitment to GE projects.

(1)"Alternative sources for heat networks are not that numerous, so you quickly have to assess whether if urban GE does not work, what will? You might have liked and expected a higher potential for your business case, but then you have to calculate how geothermal energy compares to the alternatives. And in most cases geothermal energy is still the best option"(GNL)
(2)"Every municipality aspires to be greener than green and there are all kinds of new plans that often include geothermal energy. But there are risks involved and that can create tension"(SodM)

An important note on the four key aspects for urban GE development is that these are the four main issues at this moment in time. Which issues are most important might change over time. An example of an issue that might change in relevance over time is the issue of spatial planning. It might be that spatial planning is not the main issue right now, but this might change in the future when urban GE grows and multiple wells will be developed in a city or area. It is important to maintain informed about the developments in the urban GE sector so that the policy framework keeps up to date with the market reality. Now the key aspects for the development of urban GE in the Netherlands at this moment in time have been described, the next chapter will refine one of these four key aspects and discuss the best structure for an assessment framework.

6

Assessment framework structure

In the previous chapter, the four key issues for the development of urban GE at this moment in time were defined to identify what needs to be included in an assessment framework for urban GE. This chapter of analysis will answer the fourth research question, and work out which AF structure could work to address the key issues of urban GE. One of the key issues, financing, will be used as an the example to show how the draft design method for assessment frameworks can be applied to the case of urban GE. The chapter is broken down into three parts: first, the choice for applying the draft design method to the key issue of financing will be explained, as well as the second round of in-depth interviews that investigated the financing key issue further. Next, the four steps of the draft design method for AFs will be performed, designing a conceptual AF for the financing of urban GE. The third section will present the lessons learned from the application for refining the draft design method.

6.1. Financing assessment framework for urban GE

To give an example of how the draft design method for assessment frameworks may be applied, an example is given for the case of urban GE, specifically for the key aspect of financing. It was chosen to deepen the aspect of financing, because the interviews with the municipalities showed that it is this aspect that brings the most discomfort in the development process. Dealing with inter-governmental collective action problems, effective citizens communication/participation, or leading times for permitting procedures are all subjects that municipalities will have some experience with from other type of projects. Although municipalities do have experience with financing bigger infrastructure or energy projects in their city, the specific case of urban GE comes with some extra complexities, like the subsurface uncertainty and co-dependency of heat networks. Therefore, the challenge of financing seemed to be the one were the role of municipalities is the least apparent and would benefit most of a more detailed explanation. Although the interviews of the first round gave a good overview of the issues in play and the key issues that need to be addressed by an AF for urban GE, it was decided that more information was needed before real insights on the main trade-offs of a key issue could be given. To obtain the extra needed information on the financing issue, a second round of in-depth interviews was held focusing on the financing of urban GE projects, and also a meeting on financing organised by GNL was analysed. The four interviewees of the second round included an operator (Shell), the municipality Delft, GNL, and EBN. These four parties were chosen to have a perspective from an operator, municipality, the sector, and a governmental view. The interview set-up of the second round was similar to that of the first round. It also used a semi-structured approach, but instead of a list of main dimensions, a list of four leading questions was used as guidance for the interviews. These four questions were based upon the insights that the first round of interviews gave on the subject of financing and are presented in the list below. The interviews and financing meeting served as input for the four step draft for designing assessment frameworks.

1. Are the current policies that subsidise GE sufficient in providing financial security for investment?
2. If a project fails, what are the potential losses besides finances and how are they divided?
3. Are municipalities adequately aware of the financial risks and opportunities of urban GE?
4. Does the drive towards sustainability result in GE projects becoming 'too big too fail'?

6.2. Draft application

This section will show how the draft design method for assessment frameworks can be applied in practice. This is done for the urban GE key issue of financing as defined in the previous chapter. The application of this draft will not result in a fully worked out AF for financing, but will only be a first test in order to show its application and to refine it by practice. The are a number of limitations in this application compared to an actual AF for financing of urban GE. First, it is not context specific, meaning that it will not be designed with a specific municipality in mind. Since every municipality has different contextual circumstances, unique features will need to be designed for each municipality in order to be effective. In this application, no specific local context is assumed unless specified. The second limitation is that for the gathering of norms and deriving of values in step 1 & 2, only a limited portion of the public debate could be analysed, and stakeholder participation was not possible, both due to time restrictions. This means that the norms and values in this application are not considered to be complete. Therefore, also the final specifications that will be designed and justified in step 3 & 4 will be mere examples of how they can be designed and justified, and will not be considered the 'best solutions' for the challenges that are present in the financing of urban GE. However, despite the limitations due to its theoretical nature and the time restrictions limiting 'complete' analysis of the case, each step will be taken as extensive as possible in order to showcase and test the draft for clarification and refinement of the method.

6.2.1. Step 1: context and norms of urban GE financing

The first step of the draft investigates the context and the norms involved in the policy field. The context of financing of urban GE has been investigated by the first round of in-depth interviews. It was pointed out that the challenges for financing of urban GE projects are that investment and supply agreement is needed before certainty on well performance can be given, and that renewable heat projects involve not only a heat source, but also a heat supply network, and that they need to be developed simultaneously. The financing meeting organised by GNL included presentations from three different companies which addressed these points as well. The presentation of Aardyn addressed the heat chain development, thus both source and network, and the importance of agreements of heat supply and purchase (Aardyn, 2022). The presentation of Ennatuurlijk presented their plans as a heat network developer to enter the market as a heat source developer as well via a separate holding, enabling coordination of both source and network development (Ennatuurlijk, 2022). The presentation of ING addressed a preferred financing structure, non-recourse financing, that would stimulate urban GE development by using a risk allocation that would fit the uncertainties of urban GE development (ING, 2022). From the first round of interviews and the GNL financing meeting, two main challenges for the financing of urban GE projects can be identified: coordinated heat chain development, and financing in face of returns uncertainty.
The norms were gathered by analysing the second round of in-depth interviews as well as the financing meeting, and both were analysed using atlas.ti. The list of encoding that was used can be found in appendix A. The twelve identified norms are listed in table 6.1, and for each norm an explanation and a quote of one of the interviews or the financing meeting has been included. A thirteenth norm has been added based upon specification from values to norms in step 3. It must be noted that the interviews were only held with a small sample of urban GE actors, and all of them are either working within the sector, or are governmental actors who support GE projects. This resulted in a positive bias in the norms concerning urban GE. The discussion centered more around how urban GE could best be developed, instead of the question whether urban GE is or is not a good solution.

6.2.2. Step 2: deriving values for urban GE financing

In step 2, the values are derived from the norms in order to discover the deeper motives behind the norms, and to be able to make the value trade-offs explicit and debatable. This is proposed to be done by stakeholder participation in order to prevent misconceptions and form a broad support for the basis of the assessment framework. However, step 2 has in this test been performed differently than proposed in the draft. It has been performed in a limited version due to the extensive and non-available time required for stakeholder participation. Future research should therefore test and refine this step in more detail. Instead of a stakeholder participation process to define the values for urban GE development, a pre-defined list of values is used that was developed for the case of shale gas development in the Netherlands (Dignum et al., 2016) which can be seen in appendix B. The Dutch

	Norm	Explanation	Source
1	Closing clarity	Clarity has to be created concerning the closing (costs) of wells	*"We try to arrange the closing of wells as well as possible in the preliminary negotiations. However, clear agreements still need to be made about this, a kind of guarantee."*
2	Unforeseen vs foreseeable risk allocation	The newness of the sector and the uncertainties surrounding GE development lead to foreseeable and unforeseen risks. Foreseeable risks can be accounted for by market, unforeseen need to be taken by state. Clarity on what falls under foreseeable needs to be given	*"Foreseeable risks must be borne by the sector, but the government could step in in the event of unforeseen risks."*
3	Keeping momentum	A project should be continued even if the production is less than expected. If done right, this will ensure new investments in the sector and create positive social perceptions	*"You are in it for the long term and you want to show and prove that these kinds of projects are possible. Then you do retain perspective with the sector."*
4	Cut losses soon	If a project does not seem to work, it is best to quite as early as possible. Preferably before drilling	*"Projects preferably stop before drilling is started, because that is simply very expensive."*
5	Niche market creation	Public funding or additional subsidies are needed to create a niche market that overcomes current barriers for investment	*"At present, the risk profile is sometimes still too great to spend millions on subsurface research. It would take something like a grant to cover that kind of geological research."*
6	Short and trustworthy leading times	The reality of long and uncertain leading times because of permitting procedures frustrate investment and results in high personal costs. The leading times need to become shorter and more predictable	*"The lead times for permits are structurally exceeded. Those bureaucratic processes should be much more streamlined."*
7	Prospect of outgrowing niche market	Search for projects with potential to outgrow subsidy or public funding. Don't allocate subsidies to projects which target unrealistic ground layers or use far fetched tech	*"You have to spent the time and effort to hand out grants properly on a basis of probability to succeed and potential to grow as a market out of a subsidy based business case."*
8	Interaction of greenhouse and urban GE	Policy is mostly generic for both types of GE. However, separate approaches are needed to develop both optimally	*"Geothermal projects in the built environment may still succeed with an SDE that is disconnected from the gas price, but certainly not in horticulture. Strangely enough, the fossil alternative is cheaper for horticulturists the higher the gas price becomes."*
9	Fair play in sustainable energy markets	Subsidies are not equally divided over the different energy possibilities. Reveal the subsidised part of energy prices in order to give fair comparisons between the different sustainable (heat) energy solutions	*"What seems expensive is often due to government measures. Where geothermal energy receives a 1x subsidy, other forms of energy are subsidised much more. Provide more insight into the fair price, then GE will come out more favourably."*
10	Learning money	A major part that drives GE project developments is the green drive towards sustainability. This green drive often tips risk balances in favour of proceeding with the project. Make these trade-offs explicit and state that parts of the activities might end up being learning activities instead of immediate success	*"In the beginning, a project may not be profitable or it may be marginal. Then you don't have to constantly add money, but it doesn't yield much either. Continuing such a project is still good because then you look at the social and strategic value instead of the monetary value."*
11	Green market drive	Both the market and the government have legally required green targets. Make use and appeal to these motives to bring actors in (earlier)	*"Banks are therefore prepared to lose money in the short term in some of these areas or to make less profit than they would without an ESG objective. Showcasing as a company that you are working in innovative and sustainable fields is good for your name."*
12	Coordinated network and source development	GE will only work if the entire chain of heat supply is available. Coordination and assurance is needed for development of networks before financing of GE wells can be started	*"During the development of a geothermal source, provide a temporary alternative source for the heat network, such as a CHP. Such a package deal makes a geothermal project more interesting and less risky."*
13	Participation of local economy	By requiring urban GE projects to involve local businesses, social acceptance is improved and welfare promoted	*Inspired by energy participation AF of Renswoude. Added based upon 'specification' in step 3.*

Table 6.1: The 13 norms for financing urban GE projects

	Norm	Value connection
1	Closing clarity	Health & Safety Accountability
2	Unforeseen vs foreseeable risk allocation	Distributive Justice Health & Safety
3	Keeping momentum	Environmental Friendliness Resource Durability International Stability
4	Cut losses soon	Welfare
5	Niche market creation	Distributive Justice
6	Short and trustworthy leading times	Accountability Procedural Justice
7	Prospect of outgrowing niche market	Welfare Resource durability
8	Interaction of greenhouse and urban GE	Accountability
9	Fair play in sustainable energy markets	Procedural Justice Welfare
10	Learning money	Procedural Justice
11	Green market drive	Distributive Justice
12	Coordinated network and source development	Welfare
13	Participation of local economy	Distributive Justice Welfare

Table 6.2: Values connected to norms

shale gas debate has to deal with very similar issues as the development of urban GE, since both need to deal with: it being a 'novel' innovation, the Dutch perception of subsurface exploration, and the energy transition. Therefore, since this application is meant as a first test of the draft, it is assumed that the adoption of the list of shale gas values for the case of urban GE is valid for this first test. For this first draft application, the values has been connected to norms using the 'specification' relationship based upon the insight of the researcher, and the relations can be seen in table 6.2. The relations between values and norms in this draft test serve the purpose of being able to show all layers of the value hierarchy in this test, but should not be taken for accurate since they are based on incomplete sets of values and norms, and connected without stakeholder participation. When stakeholder participation is used, defining values and making the relation between norms and values could be done using the 'for the sake of' relationship and could be guided by the literature on applied ethics and ethics of technology (Dignum et al., 2016).

6.2.3. Step 3: designing final specifications

For designing adequate final specifications for an AF for financing on urban GE, the four principles for adequacy that were given in section 3.3 can be applied. However, since the list of norms and values is not considered to be complete, and more importantly because no stakeholder participation has been applied in the design process, the final specifications proposed in this first test of the draft cannot be considered adequate. The main purpose of the design of final specifications is to test the design methodology proposed in the draft. The final specifications that will be designed in this section will

cover the challenge of financing in the face of returns uncertainty.
The first specification stage that needs to be taken is from values to norms, and then secondly from norms to final specifications. The first stage from values to norms is based upon the intersubjective set of values that stakeholders in the sector have, and on a consensus of what these values entail. Specifying the values from step 2 into norms will most probably lead to additional norms. For example, the value of distributive justice might specify into an additional norm of participation of local economy, requiring urban GE projects to boost the local economy in the process. However, since the list of values is adopted from shale gas and not urban GE, and because the list of norms is not needed to be complete for the purpose of this first test, a detailed first level of specification is skipped in this example.
The second stage of specification is from norms into final specifications: objectives, goals, and constraints. The four principles for the final specifications are that they: should be locally specific and be based upon plural and conditional sources; use static or flexible strategies to deal with uncertainty; consist of policy instruments which are both procedural and substantive; and mind the discretion space.
The first principle requires specific local context, which is missing in this example. In general though, the solution space for the challenge needs to investigated by looking at semi-applicable standards, lessons learned from past or pilot urban GE projects and their legislation, and consultation with experts, stakeholders, and citizens. For example, one of the interviewees mentioned that grants with clawbacks worked well for other renewable energy projects. Risks in the business case can be covered by public money, and when the project worked out well and the dedicated public money was eventually not needed the grant can be returned. In this way, the barrier to start a project is lowered while (eventually) not needing to dedicate public money to every project.
Secondly, a choice for static or flexible uncertainty strategies has to be made, resulting in either flexible objectives or static goals and constraints. The challenges of financing in the face of uncertainty is influenced by fundamental uncertainties, effected by the social reality of creativity and non-predetermined structural change. However, parts of the challenge can be compartmented into different uncertainty aspects for which uncertainty becomes less complex. For instance, the challenge of financing in the face of uncertainties can be separated into future uncertainties of heat price fluctuations, which remain fundamentally uncertain, and uncertainty of subsurface characteristics, which can be simplified to ambiguity for which geological surveys can give credible predictions. By compartmenting the challenges in different uncertainty aspects, goals and constraints can deal with non fundamental uncertainties while what remains fundamentally uncertain can be dealt with by objectives.
The third and fourth principle require the chosen solutions are worked out in both procedural and substantive elements, while minding the discretion space. By creating both procedural and substantive rules, the AF aims for good results as well as a good and fair process. In designing the policy instruments, the discretion space for civil servants needs to be taken into account. An example of this discretion space is that for the energy participation AF of Renswoude (Gemeente Renswoude, n.d.). It stated that a minimal stake of 50 percent local ownership was required, but immediately after stated that this constraint is open for discussion if there are project specific reasons for deviating from this constraint. By leaving room for case specific adaptations, civil servants have room to create efficient implementation processes.

When these principles for adequate final specifications are taken into account, objectives, goals, and constraints can be designed. To give an example, all three kinds of final specifications are given for the challenge of financing in the face of returns uncertainty.
Since the future heat price fluctuation is a fundamental uncertainty that forms a barrier for urban GE development, an objective could be designed in order to use a flexible strategy to deal with this fundamental uncertainty. For instance, if a municipality wants to aid the development of urban GE projects, a policy solution for this uncertainty could be a pledge from the municipality to compensate future financial losses due to unforeseeable market changes. This pledge is not a standard solution and can be altered per project, based upon the reserves of a project developer. For instance, a municipality could be more motivated to pledge compensation to a new player in the energy market, while for existing energy conglomerates with huge portfolios they might not do so or in lesser extent. Using an objective, there is room for case specific alterations and also flexibility in the applications of such an objective. For instance, the interpretation of ”foreseeable changes” and ”compensation” can differ and lead to negotiations on the exact compensation based upon the market changes and losses that might actually occur. Though this uncertainty measure for financing might not be as concrete as a goal or constraint,

the backing of a municipality can help the project developer to get funding or better conditions for its funding.
Next to substantive objectives, also procedural objectives can be given. A procedural instrument could state that in the case of financial aid from the municipality for unforeseeable market changes, public disclosure concerning the project finances have to be given as far as possible in order to justify the spending of public money towards the citizens. This prevents hoarding of public money by companies and leads to social acceptance when compensation is needed.
A goal for the financing could be a policy solution for the ambiguity in the subsurface characteristics. A barrier for project financing is the required and expensive geological surveys needed to attain credible certainty on the prospected well performance. A policy solution could be a subsidy for specific geological surveys. The difference with the objective example is that this goal is specific (for instance 30% of survey costs) and static. Again, procedural instruments are needed to indicate under which conditions this subsidy would be aloud.
A constraint for the financing could be a local ownership constraint like the one of Renswoude. By demanding local ownership, social acceptance can be boosted by involving local parties, and the local economy can be boosted as well. The difference with the goal is that although the minimum admissible standard is specific, there is still room in how much the local ownership is, while the subsidy is fixed.

6.2.4. Step 4: clarifying and justifying final specifications

The last step of the draft for designing an assessment framework, is the clarification and justification chapter. This part works out each final specification out in detail, to prevent any confusion, and explains and justifies the value-based decisions that have been made. A value hierarchy is presented to show the relations between values, norms, and final specifications in one overview. The value hierarchy for the challenge of financing in the face of returns uncertainty is shown in figure 6.1. The overview presents all values and norms which are involved in the final specifications.
Next to presenting a value hierarchy, an explanation and justification is needed for each final specification. To be able to explain the value-based decisions, the definition and relation between values and norms is also required. Therefore, for sake of transparency, an appendix is needed which defines all values, norms, and describes the process of value and norm definition. The focus point of the third chapter is the clarification and justification of all final specifications. How this is exactly structured could differ per AF and is open to the discretion space. A shorter AF might define all final specifications already completely in the intervention chapter, only justifying the value trade-offs in the justification chapter. A longer AF might choose to describe all final specifications only in outlines in the intervention chapter for sake of conciseness, explaining the nuances in the clarification and justification chapter. Also, depending on the extensiveness of the AF, all final specifications might be fully discussed and justified based upon the values that were traded off, or only a sample of 'most impacting' or 'possible controversial' final specifications might be covered in detail. For all AFs, a general discussion on the balance between long and short term values is needed, ensuring that the policy intervention benefits both the long and short term ambitions of the municipality. As an example, the goal of the subsurface research grant is justified by explaining the value trade-offs.
The norms that underlay the goal are niche market creation and the prospect of outgrowing the niche market. The subsurface research grant makes subsidies available for surveys that explore a target reservoir in detail to get greater certainty on the expected well characteristics like temperature and permeability. Because these surveys are expensive and require investment at a time in which much is still uncertain, this creates a barrier for project development. To overcome this barrier, a municipality might choose to subsidize this development step. However, although you might want to aid potential development by creating a niche market, there is no desire to waste money either. Therefore, the second norm in consideration is the prospect of outgrowing subsidies. You don't want to subsidize geological research into target reservoirs which will require innovative first of a kind project development which has a significant likelihood to never be executed. For instance, if the target reservoir is in a type of groundlayer which has never been used for GE before or would require sloped drilling, the chance of the project being followed through upon is small. Therefore, the grant is only given when there is a business case with significant chance of proceeding and with a prospect for similar projects in the future not even requiring subsidy anymore. In this manner, both long and short term development of urban GE are taken into account. It promotes projects that could be realised on the short term while considering long term factors like outgrowing subsidy in the future, with the overall long term ambition in mind of

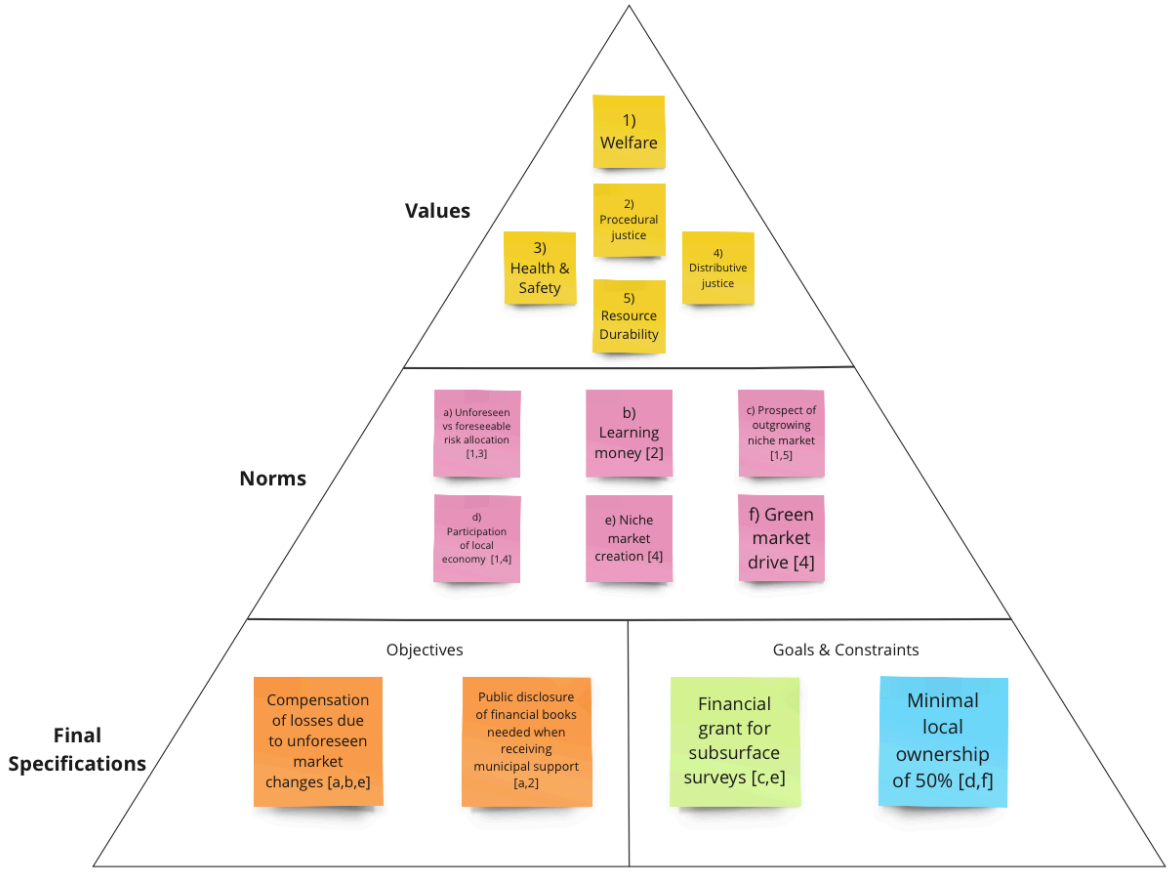

Figure 6.1: Value hierarchy financing challenge

renewing the heat supply and making it sustainable. Also on the value level, the long and short term ambitions are balanced. The long term ambitions are promoted with the value of resource durability of both energy (renewing heat supply) and finances (aiming to outgrow subsidies), while at the same time minding the short term value of welfare in both energy (selecting short term achievable projects) and finances (not wasting money). In it all, distributive justice makes sure that the policy intervention is accepted (short term) and remains trusted in its application (long term). Also here, in the justification style of the final specification, discretion is possible in how it is justifies. The justification could be done either on the level of norms, or on the level of values, or both. Important is that the logic is easy to follow and transparent, so that the choices that were made can be debated constructively.

6.3. Draft refinement

The application of the draft lead to three refinements in the value hierarchy structure. First, the objectives were moved down to the final specifications layer in the value hierarchy, as opposed to the norms layer. It made more sense to put all outputs on the same level, and from practice it was also seen that the objectives are based in norms, not in values. However, one of the objectives was based in both a norm and a value. This was because none of the 13 norms covered this aspect of procedural justice. This seems to be because the norms gathering and the specification from values to norms were both not considered to be complete. If a full stakeholder participation process would have been executed, this would have resulted in more norms and therewith also a norm that satisfied the value of procedural justice.

As a second refinement, whether or not a procedural instrument is needed, seems best to be decided on the general application of this procedural instrument. In this example, the objective was separated in both a substantive and procedural part, requiring disclosure of financial books. The goal of subsurface subsidy however, was not worked out in a separate substantive and procedural part, but also

mentioned conditions for attaining this subsidy. A reason for working out procedural instruments is if it can be applied in general to other substantive instruments as well. In this example, it could be said that disclosure of financial books is required for every financial aid of the municipality, including the subsidy for geological research. The condition of outgrowing subsidies however is applied only to one specific substantive instrument. It could just as well be argued that outgrowing subsidies should be applied in general as well or that giving disclosure of financial books should be only considered for compensation, but the principle still holds. Work out a specific procedural instrument if it can be applied in general, and in case of a specific procedural requirement for a single final specification, incorporate it within that substantive instrument.
A third refinement is that in the case of stakeholder participation for deriving values and specifying norms, it would make more sense to place the first specification stage in step 2 instead of step 3. Although this does not make a lot of structural difference, it would clarify better which actors are involved when in the process. In step 1, research of the public debate gathers a list of norms, and this step could best be executed by independent researchers in order to have a base from which to start the stakeholder participation. Step 2 requires stakeholder participation for deriving values, and for determining the adequacy of the norms in representing these values. In evaluating the adequacy of the norms, additional norms are formulated to make sure all values are represented in the final specification design. For both these steps, the stakeholders are involved, and in the participation already some possible policy solutions can be suggested by the stakeholders. In step 3, the policy solutions are chosen by the decision-makers, the authoritative public officials who are elected. At the end of the day, they are responsible for the design choices of the assessment framework, and also they are responsible for a justification chapter, explaining their choices and trade-offs. By separating the two specification stages and placing them in step 2 and 3, a clearer role division in the design process is created. When looking at these role division in the 4 steps, it can also be seen that four distinct actor groups are involved. The first step involves political scientists and researchers for an objective analysis of the public debate. The second involves direct stakeholders for the participation process. The third step involves only the authoritative elected decision-makers who are at the end responsible for the policies. The fourth step allows for a meaningful involvement of any person or actor group who are effected by the policies whom have not yet been involved in the direct design of the assessment framework.
All these refinements, just like the draft in itself, require further research and are not to be considered definite best practices yet.

Now the draft has been refined, and a direction of AF development is indicated for each key aspect of urban GE, all four research questions have been investigated and answered. The following chapter will present a discussion of the research outputs.

7

Discussion and future research

Now the analysis is done and all the research questions have been answered, this chapter will discuss the outcomes of the study. The discussion will both reflect on the outcomes' validity and discuss their applicability. Next to a discussion, also recommendations for future research will be discussed in this chapter. Because this research is an exploratory one, the outcomes are not yet final and mainly contribute by indicating areas of future research. Because the discussion of the outcomes is therefore very much connected to future research recommendations, both will be mentioned in this chapter. The chapter discusses the research outcomes in three parts: first the findings for the specific assessment framework for urban GE will be discussed, next the findings for assessment frameworks in general, and lastly the methodology and research evolution will be discussed.

7.1. Urban GE assessment framework discussion

This research used the developments within the urban geothermal energy sector as a case study to investigate the typology and characteristics of assessment frameworks, and the usefulness of assessment frameworks for bridging the implementation gap of renewable energy policies. The main purpose of this research was therefore not to create a fully worked out assessment framework for urban GE, but to create a draft design method for local decision-makers to use to develop local AFs. In doing so, the key issues that need to be taken into account for the design of an AF for urban GE development have been defined. First, two general notes on the development of urban GE assessment frameworks will be given. Secondly, an advise is presented on the next steps required for the development of urban GE assessment frameworks.

Defining the key issues that need to be covered by an AF for urban GE was an important step for identifying the subjects that need to be addressed in the assessment framework. Four key issues were defined, including a potential fifth for in the future. However, next to identifying what is important to cover in the AF, just as relevant is which topics should not be covered by assessment frameworks. The guide for urban GE development of metropolis region Amsterdam for instance indicated that *"caution is advised with agreements for which the municipality is not the competent authority"*. As the key issue of collective action indicated, clear role division is needed and actors need to stick to their expertise and role. Factors like subsurface safety or technological conditions should be left to responsible agents like SodM, and not be covered by additional AF policies. However, as long as national standards are not up to date, local AFs have to deal with certain factors that are not yet incorporated into national legislation. A factor that was mentioned several times in the interviews was a damage handling protocol. All actors agreed that this had to be arranged nation wide, but since no standard has been fixed yet, local solutions have to be constructed which is not ideal. However, in general the principle applies that an AF for urban GE should cover the key issues, and not more than those (unless further research indicates new or updated key issues). Especially for the key issue of social acceptance this is important. If there are concerns about safety or subsidence hazards, the solution for the AF is not to create additional subsurface safety policies, but to improve communication and trust between the citizens and the actors responsible for this safety issue like SodM or the Mijnraad. This communication process might lead to additional national legislation, but this is not the responsibility of a municipality. Their role is one of communication and linkage between citizens' concerns and national legislative bodies.

In chapter 6 the key issue of financing was worked out in more detail in order to refine the draft design method for assessment frameworks. The list of values and norms that were presented are both not without its flaws. The list of 13 norms that were identified from the second round of interviews needs more research before it can be deemed sufficient. Only four market players were interviewed and they all had a positive bias towards urban GE development. A wider and more diverse base of references is needed, and an extensive specification process from values to norms is required to identify a sufficient list of norms that are relevant for urban GE. Next, assuming that a similar list of values can be used for urban GE as for shale gas development worked for the purpose of explaining the draft design method, but for a fully worked out AF design the adequacy of the list must be looked at. Although many factors of urban GE and shale gas development in the Netherlands are similar, there are also significant differences. Shale gas for instance is not necessarily close to or within the built environment and neither does it require the development of an extensive distribution network. Therefore, future research should develop a set of intersubjective values relevant for urban GE in specific, using stakeholder interaction and literature on applied ethics and ethics of technology.

7.1.1. Practical application of the draft

The approach to design an AF for urban GE that has been described in chapter 6 is an extensive process of gathering values and norms, from which then final specifications should be designed, after which a justification chapter is needed. It cannot be expected from each and every municipality to go through this entire process. Therefore, it is suggested that preliminary work is done so that the design process of a local AF for urban GE development becomes more accessible.

What can already be done, is to determine a list of norms and public values for urban GE development, making a list that is specific for urban GE. The norms should be gathered from an extensive analysis of the public debate, and the values and additional specified norms could be generated by a general stakeholder participation process with the sector. This participation process could be done along the lines of the key issues for urban GE development. Next to creating a list of public values and norms for urban GE development, also possible final specifications can be suggested based upon sector insights, well working policies from other sustainable energy sectors, and from experience in GE development in the Netherlands and abroad. For instance, one of the interviewees suggested a drilling subsidy with 'clawback' structure which worked well for an innovative sustainable project development in Scandinavia. Next to preliminary work for the intervention design, preliminary work can also be done for the context chapter, by detailing the national policy context and how urban GE projects fit within this societal context.

By doing this preliminary work, the design of a local AF for urban GE development becomes a simplified four step process. Municipalities only have to: 1) connect the context chapter of an AF to their local energy transition policies, like the heat transition plan; 2) evaluate with their citizens if the list of values and norms is adequate; 3) design intervention requirements based upon these values, norms, and the suggested interventions; and then 4) consult again with their citizens if the political choices made are clear and just. If pioneering municipalities have gone through this process, examples of how to do this will make the process simpler for municipalities that follow. The preliminary work could for example be organized by a collaboration between the ministry and sector representatives like GNL and fHN.

7.2. General assessment framework discussion

This research set out to investigate how assessment frameworks can support local policy making in dealing with the complexity of urban geothermal energy development in the Netherlands. It did this, by investigating what defines a good assessment framework and using urban GE development as a case study. Because of the double focus of the research, both assessment frameworks and urban GE development, research time had to be divided among the two subjects. Therefore, only five AFs of related fields and one guideline for urban GE development were analysed. This means that the draft design method for AFs, which was based on these six papers and the public decisions-making literature, only has a small basis of AF data. A second remark is that although the financing issue of urban GE was worked out in broad strokes, no fully worked out AF has been designed using the draft design method. An important next step would therefore be to investigate a larger base of diverse AFs and to design a fully worked out AF using the developed draft to verify the validity of the framework. Four concrete suggestions for future research are identified for the development of a design method for assessment

frameworks:
First, the extent to which generalisation of the research is possible is still unclear. The research focused on local assessment frameworks in the Netherlands in relation to the energy transition. This very specific research interest leads to the question of how this might have effected the draft for AF design in general. Perhaps different principles are needed if it covers a renewable energy source that is more appropriately managed on a national level, like nuclear power. Which differences in design are needed when the topic does not concern the energy transition at all? How are AFs used in other countries? In a brief search for finding comparative international examples, nothing similar to assessment frameworks could be found in a municipal database of Manchester for example, perhaps it is typically Dutch. All these questions address the broader question of how do these insights reflect on policy implementation tools in general?
A second note for further research, is the choice for choosing either an objective, goal, or constraint. In this research, a principle of uncertainty compartmenting was applied to choose between either objectives, or goals and constraints, as they represent a flexible or static uncertainty strategy. However, some final specifications do not address a specific uncertainty in particular. For instance the constraint of 50% local ownership does not address a specific uncertainty, or at least not one that is directly apparent. Further research is required to investigate on what grounds objectives, goals, or constraints are the best kind of final specification.
A third aspect which requires more research. is the matter of adequacy of norms and final specifications. The adequacy of final specifications in satisfying the norms is guided by five principles, but what about the adequacy of norms satisfying the values? Both questions will always be subjective and thus require consensus, not objective measures, but principles for adequacy could be given for values and norms, and a stakeholder participation guideline could be generated that would guide this process and help built toward a consensus. Also the process of value derivation and how the literature of ethics could aid this process requires further research that investigates the adequacy of values. When do you know that all the 'for the sake of' relations have been found and described sufficiently?
A fourth note for further research is the matter of discretion space. Which amount of discretion space is enough and how exactly should this be formalized in an AF could be refined. The discretion space might also lead to a different policy practice than envisioned. How should this discretion space be monitored?
In general there are still many aspects of the draft that still need refinement or more detail, which is a logical conclusion for an exploratory research. Each one of the four steps of the draft design method for assessment framework could still be investigated further.

7.3. Methodology discussion

This research used a double exploratory research path, in which both a framework and a case study example for this framework were explored. This specific research approach was chosen because of the double research focus on both assessment frameworks, which required a draft development methodology, and urban GE development, which required a broad investigation to define key issues of GE development. This combination of research paths worked well but also had its disadvantages. Because exploratory research is flexible in nature and requires a willingness to adapt the research direction based upon new data and insights (Saunders et al., 2009), the link between draft development and case study was also dynamic and changing throughout the study. Aligning these two research paths while their nature or research focus continuously changed was difficult and sometimes frustrating. However, the double research path also resulted in a double dimension of research insights and recommendations for future research. Also for the methodology of future research, a number of suggestions might lead to improved understanding of assessment frameworks.
It was mentioned in chapter 2 that the coding process is ideally done without any prepositions towards the data and without predefined code categories. However, because the interviews were guided by a list of main dimensions, the coding categories were quite similar to these main dimensions. It makes sense that the categories overlap with the line of questioning of the interviews, but is also a possible indication of a researcher's bias. It is therefore advised for future research to take measures to prevent a bias in the interpretation of the data. This could be done by ensuring that the interviewer and the encoder are different persons, with an encoder not yet invested in the subject. Other solutions are that the coding is done by a group of researchers, preventing a personal bias, like the study to shale gas

(Dignum et al., 2016).
The interviews were analysed using atlas.ti, a text analysis program. In this research, it was mainly used to keep an overview of the coding, but the program provides many more useful applications. One of these options are the wordclouds which were also used to present an overview of the most important topics per code category. Future research could look into using text analysis via atlas.ti or other programs like the R programming language. Especially for step 1 of the draft design method, were the norms are gathered from the public debate, does text analysis provide potential.
In the literature on uncertainty, the information flow from science to decision-makers was discussed, including the note that a two-way dialogue needs to be maintained during the research between politicians and scientists. Since this research is a request from the Mijnraad, a governmental advisory agency to the ministry of Economic and Climate Affairs, these principals were also important for this research. The two-way dialogue was maintained via a three person committee from the Mijnraad who were consulted in the early stages of the research in order to tune the research direction. During the analyses process, provisional conclusions were presented to the entire Mijnraad for feedback on the results thus far. Based on their feedback, the interpretive framework for the structure of assessment frameworks was changed to improve the insightfulness of the research outputs. It is suggested for future research to pro-actively shape this communication and feedback process. By doing so, the political choices are left at the politicians and science can give their plural and conditional insights as good as possible.

8

Conclusion & future research suggestions

This chapter will present the conclusions of the research. It must be noted that since this study used an exploratory research approach, the conclusions are not intended as final or conclusive. All the conclusions presented in this chapter require further research and reflection based upon data and insights that could not be covered in this study time frame. The conclusions of this study are not meant to present completely new insights or to create completely different assessment frameworks. Rather, it creates a structured way of looking at assessment frameworks in order to define and design them accurately. First, the conclusions on assessment frameworks will be stated, answering the first two research questions by giving both a typology and design principles for assessment frameworks. Secondly, the conclusions on the case study for urban GE development will be stated, answering the third and fourth research question by listing the key issues of urban GE development and how an AF should be structured to cover these issues. Lastly, the conclusions for the main research question will be stated on how assessment frameworks can support local policy making in dealing with the complexity of urban geothermal energy development in the Netherlands.

8.1. Assessment framework design method

The first two research questions aimed at understanding the nature of current assessment frameworks and what constitutes a good assessment framework. The end result was a draft design method for assessment frameworks, with the goal of ensuring that newly designed assessment frameworks follow principles of good AF design.

8.1.1. Assessment framework typology

From the assessment frameworks that were investigated, three conclusions can be presented on the nature of assessment frameworks. The structure of AFs follow a triple chapter format: context, intervention, and clarification. The main chapter is the policy intervention chapter, which aims at structuring or adding to the current policy regulations of the policy subsystem in question. The context chapter connects the intervention to the policy agenda and explains the motive for the intervention. The clarification chapter explains the structure and added legislation in detail and justifies the political choices made in structuring or adding legislation.

Next, three sources were identified that are used in the design of assessment frameworks. These sources are semi-applicable standards, past or pilot projects, and consultation with experts, stakeholders, and citizens. Semi-applicable standards are for example goals or previous frameworks. For a spatial planning AF for instance, principles were used from the global sustainability goals and the existing procedure for environmental impact assessments (VNG, 2020). Past or pilot projects provide insights from the practical reality, while consultation is a process of participation that ensures completeness and applicability.

A last conclusion from the analysis of existing AFs is that although the general aim of policy intervention is shared among all AFs, the specific goal of the intervention is diverse. It can be subdivided into structuring and adding legislation. The general aim of AFs it to intervene in the policy implementation

by creating a more efficient implementation practice. In some cases, this is done by only structuring the existing policy legislation. For instance, structure could be given by listing a set of principles or creating a road map that could or must be followed, creating uniformity in the policy implementation. In other cases, next to structuring the existing legislation, additional process rules or legislation is introduced as well. These added policies are either process rules that require a certain way of operation from actors to improve efficiency, or create additional policy regulations for areas that are left unclear by national legislation.
To summarize, a definition for assessment frameworks is proposed. Assessment frameworks are policy implementation tools that create greater efficiency in the implementation (assessment) process of policies by structuring and adding to the existing policy regulations.

8.1.2. Draft design method for assessment frameworks

Next to understanding the nature of existing assessment frameworks, the next question was on what defines a good assessment framework and therewith the question how an AF should be designed. To find a basis for good design, literature on public decision-making was investigated with a special focus on values-based and robust decision-making. The main conclusions from this literature research is that structuring and adding of legislation by assessment frameworks should always be an explicit, traceable, and debatable process for which politicians are ultimately responsible (Stirling, 2008b), and that the specific intervention requirements can adhere to these principles by using a design approach that specifies intervention requirements from values and norms (I. v. d. Poel, 2013).
The proposed design approach is to design AFs by the guideline of value hierarchies (I. v. d. Poel, 2013), which has been used before to design public institutions in the domain of the energy transition (Dignum et al., 2016). This study introduced a four step process to design an AF along the lines of a value hierarchy. The first step is to gather a list of norms by analysing the public debate. The public debate can be investigated by for instance taking interviews, or desk research into news paper articles and reports. This data can then be analysed using text analysis. The second step is to organize a stakeholder participation process in which a list of values is derived from these norms, and additional norms are formulated in order to adequately cover each value. This second step should result in a shared list of values with all stakeholders and an agreed list of norms that when followed, each value should be represented in the intervention requirements. The third step is the step in which the final specifications, or intervention requirements, are constructed. This step is done by the authoritative decision-makers, which in the case of local assessment frameworks is the municipal council. Each norm is specified into either objectives, goals, or constraints. The fourth and last step is to clarify and justify each final specification, thus each objective, goal, and constraint. A general overview is given on the traceability of values, norms, and specifications by a value hierarchy, like figure 6.1. Next, a clarification and justification is given for each, or the most important, specifications, and a final reflection is given on the balance of the AF, ensuring that both the short and long term values and ambitions of the municipality are carefully balanced. This four step process ensures that the AF is value-based, robust, traceable, and debatable.
The adequacy of the norms and final specifications is a subjective matter and ultimately requires consensus, no objective measure can be given that defines any value or norm to be adequately represented. However, four principles have been given that help in designing final specifications consistently and efficiently. The four principles for the final specifications are that they: should be locally specific and based upon plural and conditional sources; use static or flexible strategies to deal with uncertainty; consist of policy instruments which are both procedural and substantive; and mind the discretion space.
The first principle of making specifications locally specific will ensure that specifications will not just be copied from other policy fields or locations, but that they are adapted to fit the local context, making use of possible synergies and preventing misfits. This can be done by using sources for specifications that explicitly are plural and conditional. The second principle states that is best to use a combination of both static and flexible strategies to deal with uncertainty to come to a robust assessment framework. For fundamental uncertainties, flexible strategies could be used like objectives, while for uncertainties that can be simplified to either ambiguity, procedural, or weak uncertainty, static strategies like goals and constraints could be used. The third principle states that the final specifications should consider both the procedural and substantive side of policies, ensuring both a good end result and a fair process. It is advised to work out general procedural final specifications if they can be generalised for multiple substantive specifications, or otherwise fit both the procedural and substantive side in one specification

if the process rule only applies to that one specification. The last principle states that in the design of final specifications, the implementation needs to be considered so that civil servants have discretion space to adjust the style of implementation to create efficiency. This discretion space should empower them to treat every project uniquely, and to alter the general policy implementation style by either being more strict or lenient based upon the actions of the sector.
A first test of this design process has been performed in this study for one of the key issues of urban geothermal energy. The conclusions on the case study of urban GE are summarized in the following section.

8.2. Urban GE development

For the case of urban GE development, the key issues for development have been investigated by studying literature and conducting interviews with the sector. Four key issues and one potential key issue for the future have been identified. These are: collective action, effective citizens communication, lead times, and financing, with a future potential key issue of spatial planning. This section will present a short overview of the problem and the potential direction of AF intervention for each key issue. The main responsibilities of the municipality will be highlighted for each key issue of urban GE development, and for each issue, an intervention purpose is suggested based upon the identified intervention types of table 3.2.

8.2.1. Collective action

This issue is mostly represented by the scope of intervention requirements in the AF. The municipality has received the director's role in the energy transition, which is a difficult role due to the limited authority or control a municipality has on the development process. The mandate for approving urban GE projects is at the ministry, and the expertise on subsurface exploration is most of time also lacking at the municipal level. The collective action issue asks from each actor to remain in their lane of expertise and to do the task that falls under their responsibility. This includes the municipality and how the AF should cover topics that fall under their expertise and responsibility. For instance, intervention requirements on the safety of well operation are unwanted, since this is the task of the SodM, while matters of social acceptance do need to be covered by the municipality. Creating clarity on distributed responsibilities would seem the most fitting intervention purpose for this issue.

8.2.2. Effective citizens communication

This issue is mostly effected by the moment of communication: when is the right time to inform and/or involve citizens? It is recognized in the industry that both too late or too early communication is problematic. A crucial factor for how communication is received by citizens, is the clarity of the context in which the project takes place. The societal context, within which a project for sustainable heat is desirable, as well as the social context, about which actors are involved and what each of their role is. To do this, coordination of communication is required in which the municipality plays a crucial role. Every actor in the sector recognises that the municipality is the one with the best connection to the local citizens and that they should therefore take lead in this issue. However, it is recognised that in order to create a trustworthy information provision, the story needs to be communicated by the entire collective of agents involved. Therefore, uniformity is needed in the story telling, in both what is being told as how it is being told. To take lead in this coordination of communication, the municipality should create process rules for other actors to follow that ensure this uniformity. Creating uniformity and new process rules would seem to be the most fitting intervention purposes for this issue.

8.2.3. Lead times

The issue of long lead times is due to several factors, like the time required for citizens communication or finding a project location, but are mostly contributed to the public process of decision making. Because several institutions have a right of consultation, and because multiple required permits will need the approval of several governmental bodies, the public process is a point of much frustration for GE developers. To create a more effective permitting procedure, better alignment is needed between the different branches of government. This alignment cannot be dealt with by the AF, but needs to be dealt with by national policies. What can be improved by the AF, is the private & public collaboration and the gathering of expertise to judge the permit requests. Next to inter-governmental policy alignment, these

two factors were indicated as significant contributors to long and uncertain lead times. The AF should create clear expectations for companies to know when and how (they are required) to contact the municipalities, and when and how they will receive answers or permits. Secondly, the AF should provide civil servants with the needed knowledge for judging the permit requests or indicate where this expertise can be found outside the municipality. Overview of expertise and a road-map for public-private communication would seem the most fitting intervention purposes for this issue.

8.2.4. Financing

For the issue of financing, two main factors have been identified in chapter 6: simultaneous development of both the well and distribution network, and financing in the face of uncertain returns. This issue will be the one with the greatest diversity over the different municipalities. Although urban GE has in potential a good business case, the requirement of high capex investments in the face of high uncertainties make it a difficult market to invest in. Municipalities could therefore choose to co-invest or subsidise local development. The eagerness to do so depends on several factors and include the potential for heat networks in their city, their financial strength, and the perception of GE by the public and local politicians. Since the intervention requirements of this issue will divert greatly over the different municipalities, the intervention requirements for financing will need clear explanation and justification. Clear process rules and additional legislation that describe which types of financial aid under which conditions are possible would seem the most fitting intervention type for this issue.

8.2.5. Spatial planning

Although spatial planning is not marked as one of the key issues for urban GE development at this moment in time, it might very well become one in the future when a greater number of projects will be developed in the same area. Therefore, it would be wise to already start thinking ahead. Within the boundaries set by the provinces, municipalities have the main responsibility in coordinating the spatial planning of energy projects in their city. Spatial planning literature and interviews indicated the usefulness of multi-functionality of space and portfolio development of GE projects. For now, creating clarity on the vision of the municipality for GE spatial planning seems the most fitting intervention purpose for this issue. Later, new process rules might be introduced when experience with multiple well developments in pioneering cities indicate effective spatial planning procedures.

8.2.6. Issues out of scope for municipalities

Besides the key issues and the accompanying insights for future urban GE development, another important lesson is about which subjects are not covered by the key issues, i.e. are out of scope. Certain important topics like subsurface stability are not covered by these key issues. The reason is that these are the key issues for the municipality, and not for urban GE in general. As the key issue of collective action stated, it is important that each actor, including the municipality, sticks to their role and expertise. Although during an information and participation process with citizens questions might arise on subsurface stability, this does not mean that the AF should directly address this. The responsible agency for assessment of subsurface stability are organizations like the Mijnraad, TNO, and SodM. The issue of citizens communication requires municipalities to communicate with citizens about concerns and to refer to the correct institutions if questions are left unanswered, but not to intervene on subsurface stability themselves. However, this requires that the other institutions do sufficiently cover these issues that are out of scope for the municipality. If issues are left open or are unclear, like for instance the damage handling protocol, municipalities will have to create additional legislation to ensure a fair process or good outcome. But the general advise is to remain focused on the key issues that fall under the direct authority of the municipality.

8.3. Bridging the urban GE implementation gap

Lastly, the main research question can be answered: how can assessment frameworks support local policy making in dealing with the complexity of urban geothermal energy development in the Netherlands? The previous section already explained how each of the key issues of urban GE development at this moment in time in the Netherlands can be covered by an AF. However, because of the exploratory nature of this study, no fully worked out assessment framework has been designed. What is presented,

is a draft design method for assessment frameworks that can be used to construct such a fully worked out AF for urban GE. This draft still needs refinement as well, and the next suggested step to do so is to test it for a fully worked out AF, and the case of urban GE presents an excellent case. Therefore, to bridge the implementation gap for urban GE in the Netherlands, the envisioned next steps for the development of an AF for urban GE will be presented here.
The draft presents a four step process to come to a fully worked out AF design. However, going through the entire process of gathering norms, deriving values and specifying additional norms, designing final specifications, and clarifying each specification and justifying the balance between long and short term values and ambitions, is a very lengthy process. Therefore, standardisation of AF development needs to aid municipalities in creating them. It is suggested to do this by doing preliminary work for the municipalities with representatives of all involved actors in the urban GE sector. The preliminary work can cover the gathering of norms, the derivation of values and specification into additional norms, and the collection of several final specifications that could be adopted by municipalities. Also, a context chapter outline can be drafted that municipalities can use as a basis for their context chapter. By doing this preliminary work, designing a local AF for urban GE development becomes a much simpler and shorter process for which municipalities only have to: 1) connect the context chapter of the AF to their local energy transition policies; 2) evaluate with their citizens if the list of values and norms is adequate; 3) design final specifications based upon these values, norms, and the suggested specifications; and then 4) consult again with their citizens if the political choices made are clear and just. If several pioneering municipalities have gone through this process, examples of how to do this will make the process even simpler for municipalities that follow. The preliminary work could for example be organized by a collaboration between the ministry and sector representatives like GNL and fHN. By doing this preliminary work, the suggested approach, the draft, for the development of urban GE assessment frameworks will not only be a nice idea in theory, but could also become a well working reality, supporting the local policy makers in dealing with the complexity of urban GE development in the Netherlands.

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A

List of encoding

Institutions (330)	**Social Acceptance (177)**	**Technology (145)**	**Uncertainty (79)**	**Financing (58)**	**Spatial Planning (35)**	**AF (15)**
Actor's own role (32)	Acceptance vs support (5)	Construction (5)	Business case (20)	Abandoning (10)	Crowdedness (10)	Assessment Frameworks (10)
Context factors (25)	Affordability (7)	Expertise (29)	Communication (21)	Business case (34)	Existing planning (7)	Trade-offs (5)
Cooperation (52)	Awareness (5)	Geo & petroleum (11)	Public process (12)	Investment partners (13)	Location (16)	
Knowledge & capability (54)	Communication (67)	Heat infra (42)	Risk taking (24)	Sales agreement (4)	Long horizon (6)	
Multi-level government (56)	Groningen (9)	Heat sources (26)	Well performance (10)		Synergy (6)	
Permits (21)	Participation (23)	Innovation (9)				
Policy development (16)	Perception (27)	Leading times (10)				
Policy gap (17)	Story telling (20)	Risks (20)				
Public vs private (28)	Subsurface (17)	Time path project (26)				
Role developer (21)	Trust (18)					
Role mu director transition (64)	Welfare balance (16)					
Role mu investor (17)						
Role mu local process (37)						
Role mu out of scope (10)						
Role mu public interplay (24)						

Table A.1: List of codes used in atlas.ti. Numbers indicate the number of unique occurrences of a code (category) in all the interviews

Norms financing (101)
Abandoning (6)
DevEx (8)
Financing policies (18)
Green drive (11)
Heat chain development (5)
Investment partners (6)
Investment structure (17)
Investment uncertainty (4)
Market reality (19)
Price guarantee (5)
Profit margins (3)
Risk allocation (8)
Role government (15)

Table A.2: Encoding second round interviews

B

List of values for urban GE development

Substantive Values	*Definitions*
International Stability (IS)	National and international stability in relation to energy supply, including concerns about import dependence, geopolitical tensions due to changes in energy reserves, and concerns of energy exporting countries regarding demand insecurity.
Resource Durability (RD)	Availability of resources for future generations. This may include the conservation of existing finite resources, as well as the development of alternative resources to compensate for depletion of resources.
Environmental Friendliness (EF)	'Preserving the status of nature leaving it no worse than we found it' (Taebi & Kadak, 2010). This value is presented here in the non-anthropocentric mode, which assigns an inherent value to the environment.
Aesthetics (Ae)	The intrinsic value of the beauty of nature. Changes in the landscape can impact the experienced beauty of the landscape.
Health and Safety (HS)	'[A] state of complete physical, mental and social well-being and not merely the absence of disease or infirmity' (WHO, 1948). An argument relates to the value of health when it compromises, or refers to, the state of well-being as defined by the World Health Organisation or when it inhibits people from reaching this state.
Welfare (W)	Affordability and economic viability of the decision (not) to pursue urban GE exploration and exploitation.
Procedural Values	
Accountability (Ac)	'[S]ound political and legal basis with a corresponding institutional framework' (Flüeler & Blowers, 2007).
Distributive Justice (DJ)	The fair distribution of costs, benefits, and other positive and negative external effects, including both spatial and temporal distributive justice. The spatial part refers to distribution of negative and positive consequences in a physical spatial sense. The temporal aspect includes intergenerational issues and includes exploitation of resources for future generations, as well as the environment we leave behind.
Procedural Justice (PJ)	Transparency, honesty as well as timely, full, and unbiased information in the procedure of planning, exploratory drilling, and exploitation (adapted from (Hall, Ashworth, & Devine-Wright, 2013)).

Table B.1: Values of the Dutch shale gas debate, adopted for the urban GE debate. Adapted from (Dignum et al., 2016)

C

Potential for improving social acceptance

Social acceptance is defined to occur when RE projects either positively or at the minimum neutrally effect the welfare of an actor, and that these effects are either substantive or procedural. Therefore, to improve the likeness of SA for new RE technologies like GE, design characteristics can be embedded in the GE policies and projects to improve the likeliness of social acceptance of GE. Karytsas and Polyzou states that activities that relate to the social acceptance of GE can be categorized into three pillars, as can be seen in figure C.1: 1) avoidance and reduction of unfavorable impacts, 2) generation of added benefits for surrounding communities, and 3) community engagement. The first two refer to distributional justice of GE project development, whilst the third refers to the procedural justice and the trust dimensions.

Avoidance and reduction

The first pillar, avoidance and reduction of unfavorable impacts, can improve SA on all three levels. At the socio-political level, GE legislation can be enforced, preventing the occurrence of unfavorable GE impacts. For instance, in the Netherlands legislation was accepted that prohibited the penetration of drinking water reservoirs by GE wells to prevent loss or degeneration of drinking water resources ("Kamerdebat", 2022). At the market level, product development and increasing industry knowledge can lead to decreasing negative side effects. The GE sector in the Netherlands set an industry standard for well design to decrease negative effects like corrosion and leakage (Geothermie Nederland, 2022). Also at the community level avoidance and reduction is possible. By understanding the local context, wishes, and values, product customization can avoid unneeded negative effects. This could for instance be an alternative design of the power plant location or outer appearance in order to avoid loss

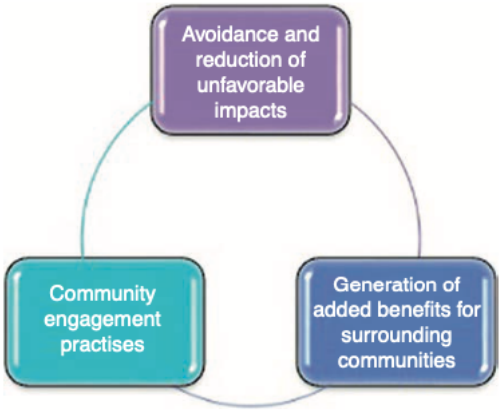

Figure C.1: The tree pillars of GE social acceptance retrieved from (Karytsas & Polyzou, 2021)

of aesthetic value of the surroundings. The most common negative effects surrounding RE projects accordingly to Karytsas and Polyzou are:

- Visual impacts
- Noise
- Unpleasant smells
- Landscape impacts
- Potential displacement
- Heritage and culture impacts

Generation of added benefits

Although many negative effects can possibly be avoided or reduced, each and every energy infrastructure project will have unavoidable negative effects like construction disturbance. It is therefore important that these negative effects are compensated by positive ones, which is the subject of the second pillar: generation of added benefits for surrounding communities. RE projects have been mainly driven by the need to transition to sustainable energy and reducing greenhouse gas emissions, highlighting the very important long-term gain of these technologies, but there are many more potential socioeconomic benefits that can improve the SA of GE projects (Del Río & Burguillo, 2008). These benefits are grouped into four categories: public perception, employment, safety & health, and improvement of local infrastructure (Gale et al., 2013). Karytsas and Polyzou summarized the key benefits that RES projects might bring on both the national and the local scale. At the national scale, the main benefits are:

- Environmental protection
- Energy security protection
- Diversification of risks
- Trade balance improvement
- Export opportunities

and at the local scale these benefits potentially are:

- Employment creation (direct, indirect, and induced job positions)
- Improvement of income and new sources of revenue for local communities (e.g., increase in the tax base, income for landowners, and land-based activities).
- Cheap energy (reliable and low-cost energy generation can trigger economic development).
- Increased self-reliance.
- Customers having a choice concerning their energy source.
- Supply of power to regions lacking electricity grid access.
- Technological advancements/development of local infrastructure.
- Enhancement of local population skills and education.
- Better health and life quality.

Community engagement

This third pillar focuses on the procedural justice and trust dimensions of community acceptance. Public engagement is defined by the National (UK) Coordinating Centre for Public Engagement (NCCPE) as *"a two-way process, involving interaction and listening, with the goal of generating mutual benefit"* (NCCPE, 2019). Three different degrees of engagement are defined in public engagement literature: communication, consultation, and participation (Rowe & Frewer, 2005; Hügel & Davies, 2020), see figure C.2.

Figure C.2: Degrees of community engagement.
Modified from (Karytsas & Polyzou, 2021)

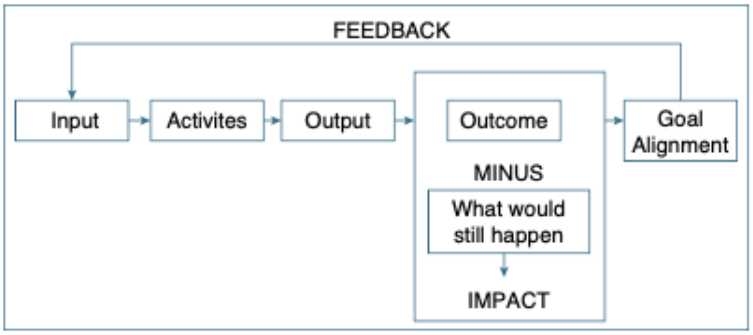

Figure C.3: Impact value chain
Retrieved from (Karytsas & Polyzou, 2021)

The first two degrees, communication and consultation, both represent one-way engagement in which communication represents the uni-directional information flow from the GE developer to the community, and consultation the opposite information flow from the community to the GE developer. Both these forms of public engagement lack interaction, whilst participation represents a two-way information flow involving dialogue, being true public engagement according to the NCCPE definition. Active participation of local communities in international GE projects have not been common place yet (Karytsas & Polyzou, 2021), but the Dutch GE sector has created a community engagement protocol in order to better incorporate the wishes and interests of the local residents (Geothermie Nederland, 2019). However, in the exploratory interviews the GE developers did indicate that communication and/or participation still remains a big challenge. In order to understand which project aspects require most participation efforts, an accurate assessment is needed of which aspects have the most impact. To make this impact assessment of project aspects, evaluation of past and projected impacts can help. By evaluating their social impacts, companies and institutions can increase local support, safe costs by early detection of problems, strengthen their reputation, and promote their product, service, or policy (Karytsas & Polyzou, 2021). One model available is the impact value chain which can be seen in figure C.3.
This model evaluates the impact of certain inputs, distinguishing between outcome and impact by subtracting the part of the outcome that would have happened without the specific input under evaluation. The purpose of this model is to achieve goal alignment with all stakeholders, a key ingredient in building trust (Huijts et al., 2007). It is important to keep all stakeholder in mind during this evaluation process, since certain impacts might have diverse effect on different stakeholders (Karytsas & Polyzou, 2021). GE developers can use impact evaluation of past projects, research on local context of project, and an evaluation of projected impacts of the project to gain insight on which aspects require most effort in community engagement. Using this impact value chain for building trust is especially important when a GE developer wants to operate in an area where pre-existing connections with the local community are slim or nonexistent. When GE developers and their investors are from outside the local community, trust in their goals, attitude, and proficiency is contested. Then the openness of the process concerning public engagement, and the flexibility and open mindedness of the 'outsider' (GE stakeholders) is crucial Wüstenhagen et al.. One way of reducing this factor, is by attracting local (financial) support from local investors or potential big consumers of the sustainable heat.