Analysing the implementation of geothermal energy in urban areas in the Netherlands: A comparative case study


Nicki Jansen

Master Student Complex Systems Engineering and Management

Delft University of Technology

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ANALYSING THE IMPLEMENTATION OF GEOTHERMAL ENERGY IN THE NETHERLANDS: A COMPARATIVE CASE STUDY

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NICKI JANSEN

STUDENT NUMBER: 4551338

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Graduation committee

Chairperson	: Dr. ir. I. Bouwmans, Department of Engineering Systems and Services
First Supervisor	: Dr. N. Goyal, Department of Multi-Actor Systems
Second Supervisor	: Dr. A. Ghorbani, Department Engineering Systems and Services

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EXECUTIVE SUMMARY

The Dutch government has set an ambitious goal: by 2030, greenhouse gas emissions in the Netherlands should be 49% lower than they were in 1990. The built environment accounts for 15% of CO_2-emissions in the Netherlands, because fossil fuels account for a sizable amount of the energy produced for heating. The Dutch government therefore invests in sustainable produced energy, such as geothermal energy to reach these goals. But even though geothermal energy is gaining recognition given the high heating demand in the Netherlands and its subsurface potential, **implementation** of this technology, especially in urban areas, is **stagnating**.

Thus, there seems to be a gap as implementation of geothermal energy is falling behind even though there is sufficient knowledge and technical capacity present. A **threefold-knowledge gap** was identified in literature. First, it was identified that the viability of geothermal energy is case-specific. Therefore, the lack of knowledge about geothermal energy implementation in metropolitan setting results in uncertainty about the possible trade-offs of stakeholders and makes stakeholders wary of entering the market. Second, it is unclear how and to what extend regional norms, rules and regulations influence development of geothermal systems in urban areas after policy has been adopted. Third, significance of social acceptance is being discussed in a growing number of studies, however it is unclear how social acceptance may be operationalized in policy implementation research. Therefore, this thesis addresses the **question** how and to what extent institutions influence the success of the geothermal energy policy implementation process in urban areas in the Netherlands. The **aim** of this research is to consistently track institutions in geothermal energy policy implementation in urban areas in the Netherlands for two reasons. On the one hand to develop policy considerations for governmental parties and geothermal operators based on insights of the identified influences of institutions. On the other hand to show that identification of institutions in the policy implementation process can be done in a systematic process with a framework and adds value to the insights.

For this purpose, a **comparative case study** has been designed to contrast the geothermal policy implementation process of two municipalities, The Hague and Nieuwegein, that share similarities in urban development, external context and type of geothermal technology, but differ in policy outcome. To structure the individual case analysis, a theoretical framework is developed that utilizes elements from the Multiple Streams Framework (MSF) by Kingdon and the Institutional Analysis and Development (IAD) Framework by Ostrom. The strength of the MSF lies in the ability to not just describe the interaction between policy concerns and their environments, but also to investigate causal relationships between variables that lead to adoption of a policy. The IAD framework offers a structured approach to study existing institutional structures and procedures, as well as the dynamics of relationships between different stakeholders. Semi-structured interviews and academic and grey literature have been used to gather data for this study. The information has been consistently organised in the analysis using both qualitative data coding and causal process tracing methods in order to discover emerging themes and case differences and similarities.

The comparison analysis led to the following **findings**. First, it is conceptually simple to assume that implementation is unsuccessful when difficulties are not solved by the suggested payoff structure. The case of municipality Nieuwegein demonstrated that the political stream did not support a connection of the policy and problem stream, which resulted in a failure of the policy implementation process. Despite the fact that legal decision-making was centralised in both municipalities in accordance with the Dutch law, consensus-oriented interactions created a decentralized environment. Negotiations, which required approval from a large number of participants were prioritized and the process took longer than was practical from an economic standpoint. Consequently, there was no connection between the problem and the policy stream in the absence of a favourable political context. Second, participant interactions affected how decision-making power was actually distributed among participants and what kind of solution was most likely to be workable, but the leadership of a public party was crucial. These participant interactions moderated the impact of general policy variables on the implementation process and outcome. Moreover, the existing systems for implementing geothermal energy are considerably more focussed on cost recovery from both public and private sides, which resulted in a long implementation process as no set guidelines were available. From these findings it can be **concluded** that taking institutions into consideration influences the political and policy flow directly. The primary issues raised by the comparative analysis relate to social, ethical, and politically significant transactions. The lengthy policy implementation process was tainted by a general (mis)trust of the decisionmakers, and concerns were focussed about the equitable allocation of risks and rewards and the willingness to work together for a sustainable system.

In light of the study's conclusions, the following geothermal **policy recommendations** can be formulated. The focus on damage management was a crucial factor that influenced the interactions. Accordingly, more precise and explicit instructions on damage control and liability should be pre-defined in Dutch geothermal legislation. Additionally, the significance of strong governmental leadership in the implementation initiation and progress was highlighted. It stands to reason that local government should oversee its sustainable management of (sub)surface usage since it is tied to public interest. Lastly, it is suggested to predefine an assessment procedure up front so that local governmental have a means to swiftly qualify and quantify the results of geothermal implementation.

The **scientific value** of the research is based on two additional insights in contrast to earlier empirical studies of geothermal energy policy implementation in urban areas in the Netherlands and institutions and policy implementation. For urban areas it was identified that more precise structure and local guidance is necessary for designing the implementation process, and that geothermal energy implementation is specifically affected by the costs and benefits of stakeholders. Additionally, the study offers a theoretically solid way to combine analysis of policy implementation processes with institutions. And the study offers a way to define and examine geothermal energy policy in a way that takes into account various levels of institutions and actions. This has not been previously done in a theoretically systematic way. This research is however still **limited** in its explanation of the exact efficiency and influence of policy instruments in light of investment decisions and the amount of external factors that may have influenced the policy implementation process. Therefore **future research** should address the heat governance of collective heating in the Netherlands and the potential feedback loop this design has on the geothermal energy policy implementation.

ACKNOWLEDGEMENTS

Numquam poneda est pluralitas sine necessitate, or translated ‘Plurality should never be used without necessity’. In my first year of the bachelor I came across these wise words from William van Ockham where he states that no additional statements should be added if not necessary. And as you may have guessed, while finishing up my Master Thesis five years later, this was a frequently returning comment on my work. Nevertheless, I've learned a great deal from working on this thesis. The completion of this research represents the end of a beautiful experience as a master student studying Complex Systems Engineering and Management, perhaps after a few tears here and there. I would like to take this chance to express my sincere gratitude to everyone who helped me finish this graduation project and helped me during my studies in Delft.

First, I would like to thank my first supervisor, Nihit Goyal. While working together you always asked critical questions not just about the analysis, but also about the applicability of my work for the geothermal sector and academic literature in general. This pushed me to take sometimes a step back and reflect on my work not as a student, but as a researcher. Thank you for the time and attention that you put into helping me improve my theoretical framework and for keeping my confidence up during the feedback sessions. Thank you, Amineh Ghorbani, for helping me scope down my topic in the beginning of the thesis and help me reflect critically on my work. The information in your slack-channel was incredible helpful, and your methodologically-driven comments were really valuable to me. Furthermore, I would like to thank Ivo Bouwmans, whom I practically started my Master career with as his Teaching Assistant and who stepped in when we found out my committee was not complete yet. It was inspiring to work closely for two years with someone who is so dedicated and passionate to help students with research and is always open for a nice conversation. I would also like to thank all the interviewees for their enthusiastic attitude and their willingness to share their experiences with me. Geothermal energy was a field I knew little about when I started my thesis. However, they very were all very helpful and their insights were all of great value to my work. It was a pleasure and motivating to have the interviews and notice that there was mutual enthusiasm for the topic.

My time as a TU Delft student concludes with the submission of this thesis. I can confidently say that the relationships I have built while pursuing my master's, which started in Corona times, are the ones that will remain forever. Maleen, Jil, Jonas, Jakob, Ben and Tormo, I could not have asked for better friends. I appreciate you being there when I needed you, for the critical powerpoints full of honest feedback and making these two years as a CoSEM student, even in partial lockdown, rememberable. Lastly, I would like to thank my family for their support and their tolerance when I was stressed during this research. I know I can be quite stubborn, but you always found the time to comment on my work and the willingness to discuss the obstacles I was facing.

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The Dutch government has set a goal: by 2030, greenhouse gas emissions in the Netherlands should be 49% lower than they were in 1990 (Gooijer & Mennen, 2021). The **built environment** accounts for **15%** of **CO_2 emissions** in the Netherlands (CBS, 2018). One of the key causes of this is that fossil fuels have a considerable portion of the energy generated for the built environment (TNO, 2022). According to the Climate Agreement, the built environment even needs to be totally climate neutral by 2050. The Dutch government therefore invests in sustainably produced energy, such **geothermal energy** in the Netherlands, to reach these goals. The Dutch government has addressed geothermal energy as one of the potential renewable energy sources that could be used to speed up the energy transition in this sector (Provoost et al., 2019).

But even though geothermal energy is gaining recognition given the high demand for heat in the Netherlands and its subsurface potential (van Mersbergen, 2020), **implementation** of this technology, especially in urban areas, is **stagnating** (Schoof et al., 2018). An energy transition is defined as a significant change in an energy system that can be caused by one or more of the following factors: resource consumption, system structure, size, economics, and energy policy (Nava-Guerrero et al., 2022). Moreover, CO_2 emission reductions, a rise in energy savings, and the energy system becoming more sustainable by employing more renewable sources while replacing fossil fuel sources are all goals of the sustainable energy transition (Kemp et al., 1998). However, contrastingly to the formulated ambition, the Netherlands is **falling behind** on its energy transition ambitions (PBL, 2020).

1.1. TOWARDS SUSTAINABLE HEATING

In recent years, the profile of geothermal energy in the Netherlands has risen. The falling production and consumption of gas, along with rising gas costs and the growing need for **sustainable heat** and energy sources, necessitates the development of sustainable natural gas alternatives (Geothermie Nederland & EBN, 2021). Geothermal energy is a **potential** and **long-term alternative** for heating buildings, greenhouses, and industrial applications. Furthermore, the Minister of Economic Affairs and Climate has stated that 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 CO_2 energy sources*" (Schoof et al., 2018:p.4). Depending on the depth and technology used, there are a variety of ways to use heat from the subsurface.

The hot water is pumped up at depths ranging from 500 meters to over 4,000 meters and used for heating in greenhouse horticulture, the built environment, and light industry via a heat exchanger (EGEC Geothermal, 2019). Depending on the depth and techniques employed, the heat from the subsurface can be exploited in a variety of ways. In the Netherlands, the following **techniques** are used:

- ATES (Heat Cold Storage) is a technology for storing heat or cold (i.e. not to produce it). An excess of energy is stored in the ground (up to 500 metres) for usage when there is a high demand for heat, in the winter, or cold, in the summer (Kiruja, 2013; Schoof et al., 2018).
- Geothermal energy, which is mined at depths of **500 to 4,000 metres**. Temperatures (30-40℃) are not usually high enough for direct use with present procedures at smaller depths, necessitating a heat pump to elevate the temperature to the appropriate values.

Temperatures of 70 to 100℃ can be won at altitudes of 2,000 metres (Johnston et al., 2011; Schoof et al., 2018).

- Ultra Deep Geothermal Energy (UDG) is a type of geothermal energy that can be extracted at depths of over 4,000 metres. UDG is a method of creating heat at temperatures higher than 130℃. The heat could be utilised to create power or to heat industrial activities (EBN, n.d.; Schoof et al., 2018).

In this research, only the second term is meant when referring to *geothermal energy*. In general to extract heat from the earth, aquifers need to be **drilled** (Johnston et al., 2011). Warm salt water is then pumped up from these aquifers and transported to the **heat network** using a heat exchanger. The cooled water is then pushed (injected) back into the aquifer, where it is reheated by the earth's continual heat. A geothermal installation thus consists of at least two **wells** ("doublet"): one well for pumping hot water (the producer) and one well for injecting cooled water (the injector). These wells are several metres apart above ground, but the end of this well is around 1 to 2 kilometres apart from the first well to prevent too rapid cooled water breach (Johnston et al., 2011). A doublet's technical life is predicted to be around 35 years (Jharap & Trienekens, 2022). After the heat extraction in the vicinity of the well has been stopped, the aquifer is predicted to restore to temperature in a few decades.

Geothermal energy initiatives require a **thorough understanding** of the subsurface (Geothermie Nederland & EBN, 2021). An aquifer's capacity is highly influenced by the properties and position of the rock layer, which include: The temperature of the water rises by 30℃ each kilometre of depth; the depth of the earth layer controls the amount of available water in the aquifer; the aquifer's minimum thickness is 20-50 metres; and porosity and permeability mainly govern the amount of water that can be produced (Johnston et al., 2011). Aquifers can be found in sand and limestone layers, which have adequate porosity and permeability. The subsurface is unknown to some extent before a geothermal energy project is started. Because of the **unknown nature** of the subsurface, a variety of situations must be considered (Schoof et al., 2018).

1.2. KNOWLEDGE GAP AND RELEVANCE

Even though the need for geothermal energy usage is present, the ambition of both the sector and the government has been presented (Kloosterman et al., 2021; Schoof et al., 2018; Wiebes, 2018), there still seems to be a **gap** as development of geothermal energy projects in urban environments has been stagnating considering the newly started projects in the past years (Schoof et al., 2018). Given the population density of the urban environment, it is suspected that institutions influence the policy implementation process. Therefore, before the start of this research, a literature review has been conducted in order understand the theoretical knowledge gap in geothermal energy usage and the potential role of institutions with the policy implementation in the Netherlands. The definitions that were defined upfront, the methodology of the literature review, the results and a reflection of the results can be found in Appendix I: Literature Review. The findings from the selected papers are discussed in three main aspects: resource allocation, technology development in metropolitan areas and the lack of discussion on social acceptance.

- **Resource allocation** - Geothermal systems should be considered a suitable available technology for generating huge volumes of heat when environmental risks and advantages are taken into account (Pan et al., 2019). However, Norouzi et al. (2021)

adds that besides the suitability of the technology itself, in order to make geothermal energy commercially viable, most single cases employ the technology in a hybrid combination with another form of energy for economic feasibility (Bujakowski et al., 2020; Pellegrini et al., 2019). As a result, the viability of geothermal energy may be regarded case-specific, and the lack of knowledge about geothermal energy implementation in metropolitan settings makes stakeholders wary of entering the market (Washim Akram et al., 2021). Therefore, it can be stated that there is a lack of experience in implementing geothermal energy in urban setting, considering local factors such as stakeholder decisions, norms and trade-offs with different technologies (Washim Akram et al., 2021).

- **Technological development in metropolitan areas** - It is apparent that transitions cannot be realized just through technological innovation (Blum et al., 2021; García-Gil et al., 2020; Raza et al., 2020). Additionally, the second argument adds to the first that it is unclear how and to what extent regional norms, rules and regulations influence development of geothermal systems within urban areas after policy has been adopted (Xiang et al., 2021).
- **The absence of social acceptance in literature** – Many articles support Zeng et al.'s (2021) assertion that an integrated methodology, which includes social and technical variables, is an effective way for identifying, defining, and mapping the knowledge base of geothermal energy usage. And in practise, the importance of social acceptance has been addressed by geothermal developers (Jansma et al., 2020; Karytsas & Polyzou, 2021). However, none of the publications discuss the specific role or potential operationalization of end-user acceptance that affects the implementation of geothermal energy, which could potentially play an important role in the outcome (Flacke & De Boer, 2017). This is an intriguing tendency, especially given the social status of drilling technologies in current Dutch newspapers.

Policy alternatives that are anticipated to result in unique solutions are the main focus of policy analysis (Cairney & Jones, 2016). However, looking at the three-folded knowledge gap, it is the conversion from policy into action, which is the area that is defined as problematic. Consequently, the knowledge gap hints indeed that institutions influence geothermal energy implementation. However, the precise influence of institutions is unclear. It is therefore of **scientific and societal relevance** to further analyse the role of institutions and involvement of different stakeholders in the implementation process of, in this case, geothermal energy, as it is clear that an energy transition cannot be realized just through technological innovation alone (Xiang et al., 2021). This will be later elaborated on.

1.3. RESEARCH APPROACH AND RESEARCH QUESTIONS

The **aim** of this research is to consistently track institutions in geothermal energy policy implementation in urban areas in the Netherlands for two reasons. On one hand to develop policy considerations for governmental parties and geothermal operators based on insights of the identified influences of institutions. On the other hand to show that identification of institutions in policy implementation process can be done in a systematic process with a framework and adds value to the insights. This section will elaborate shortly on the research questions formulated from the knowledge gap and the designed research approach that will be followed in this master thesis.

1.3.1. RESEARCH QUESTIONS

Based on the identification of the problem and the background information the main research question is formulated as follows:

Research Question: *How and to what extent do **institutions** influence the success of geothermal energy **policy implementation process** in urban areas in the Netherlands?*

First, it is necessary to define what is meant by *policy implementation process* and *institutions* in this research to understand the ways that both of these can be analysed together. Furthermore, given the fact that policy implementation research focusses on how governments put policies into effect (PEPD, 2021) and institutional analysis is the part of social sciences which studies how institutions behave and function according to empirical and theoretical rules (Ostrom, 2010), their application in this research needs to be adjusted in order to give a comprehensive analysis. Therefore sub-question 1 will address this.

Sub-question 1: *How can **institutions** in the **policy implementation process** be conceptualized?*

Policy implementation is a process that takes place within a given institutional setting (Fowler, 2019). Therefore, it is necessary to see how this *setting* looks like in the Netherlands and which elements and stakeholders play a role in the geothermal energy sector. This will be answered by sub-question 2:

Sub-question 2: *What does the **geothermal energy implementation process** in the Netherlands entail?*

The output of sub-question 1 and 2 is used as input for sub-question 3. Following the initial objective of this research, the question of which essential features characterise a successful geothermal energy implementation process against those that characterise a failing one arises. From the perspective of interaction patterns, the analysis will look at the possible dynamics between problems, politics, and policy entrepreneurs:

Sub-question 3: *How do **institutions** influence the outcome of the geothermal energy policy implementation process?*

In order to grasp to identify key indicators and verify the outcomes, it is necessary to compare two cases and describe key similarities and differences. Therefore this leads to the following question:

Sub-question 4: *What are key **institutions** that contribute to the success of geothermal energy **policy implementation process**?*

1.3.2. RESEARCH APPROACH

Two **aspects** of the nature of this research are highlighted by the questions that were created. First of all, because the concepts being treated are intrinsically complex and multifaceted, simplifying quantitative measures would result in the loss of important meaningful components. Second, the questions don't really try to figure out what happened, but rather *why* certain things happened. Thus, the utilisation of **comparative case studies** is one of the most intuitive ways to take both of these factors into consideration. This approach allows *"in-depth, multi-faceted exploration of a complex issue in their real-life setting"* (Yin, 2009) within the time span of a Master Thesis. In brief, the aim is to identify institutional influences in the policy implementation process of geothermal energy. Therefore, a 'most-similar' research design is appropriate for this research as it can entail comparison across two or more cases that are as comparable as possible on situational factors, but have variation in terms of success. Many institutional analysis and policy analysis studies have successfully employed this type of approach and shown that it fits the aim of this research (Leeson, 2007, 2010; Walt et al., 2008; Yin, 2009). For determining if the causal assertions claimed in comparative case studies are plausible, academic literature offers a number of criteria (Skarbek, 2020). Comparability of the individual cases and plausibility of causal assertions by recognising the source of variation in specific variables are the two most crucial requirements for a valid research design (Skarbek, 2020). As a result, this study will address these two issues by 1) establishing the case selection criteria and 2) developing a theoretical framework that incorporates components of the aforementioned theories and acts as a guide for the examination of each unique case (Yin, 2009; Yin, 2018). For this research it was decided to have one case that shows successful geothermal energy policy implementation in an urban area, and one case that shows the opposite.

There will be **four main steps** in this research: (1) design of the study and development of a theoretical framework on which to base subsequent case analysis; (2) case selection and data collection (3) an analysis of the individual cases; and (4) cross-case comparison. Figure 1 visualises the approach briefly. The advantage of comparative case study approach is that it offers an organized and focussed approach that provides guidance to analyse the implementation process of geothermal energy in urban areas (Yin, 2009; Yin, 2018). At the same time it offers the possibility to gather empirical data. However, a challenge will be to validate the outcomes of this research as specific focus will be on institutional factors and therefore leaving out other influences, such as techno-economic trade-offs by stakeholders and cross-cultural factors.

The **theoretical framework** that will be used in this case-comparison will be based on the **Multiple Stream Framework** (MSF) by Kingdon (Fowler et al., 2019; Howlett et al., 2009) and the **Institutional analysis and Development** (IAD) **framework** developed by Ostrom (Ostrom, 2009, 2011). The MSF is suitable for this as it allows for integration of situational factors in the policy process in a flexible, but structured manner (Ackrill et al., 2013; Béland, 2016; Kingdon & Stano, 1984). The IAD-framework is suitable for this as it can structure the identification of the conditions and variables within collective an operational action situations that happen within the policy process for the geothermal energy implementation, as demonstrated by Künneke & Finger (2009). These theories and their role in this research will be more explained in Chapter 2 and Appendix II: Theoretical Framework.

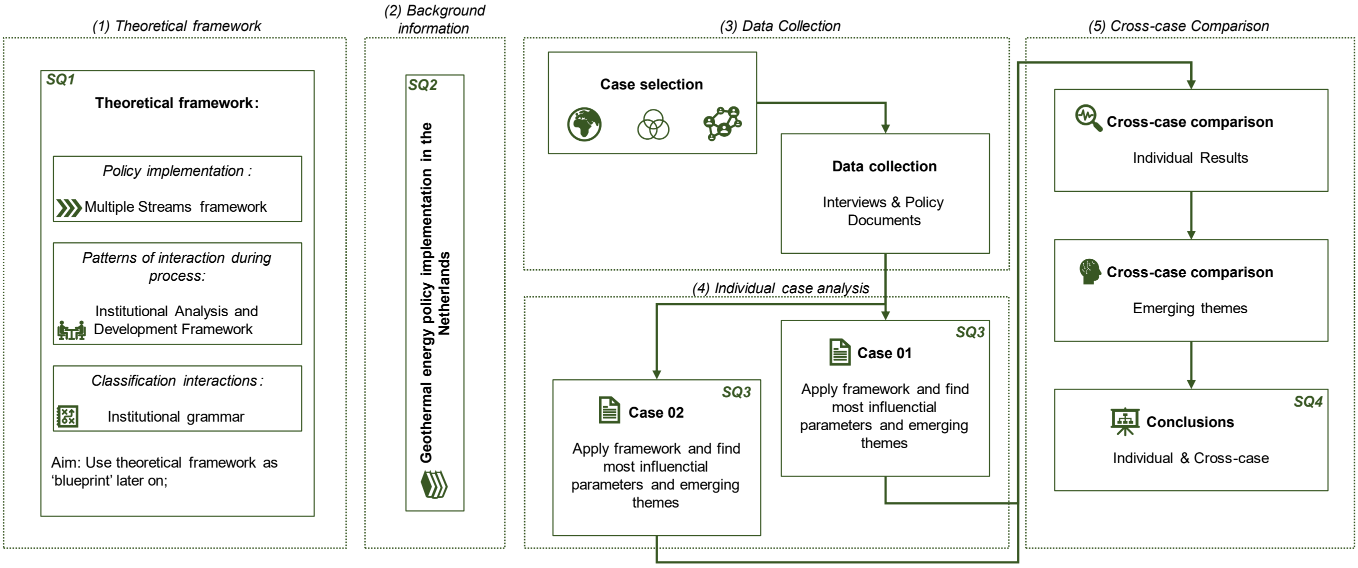

Figure 1: Research design based on Yin (2009; 2018)

1.4. SCIENTIFIC RELEVANCE OF RESEARCH

In order for renewable energy policies to have a significant and long-lasting distributional impact, academic literature that combines a perspective of policy implementation analysis and institutional analysis has stated that they must be inclusive, context-based, and equitable in addition to being efficient (Sandhu & Fatima, 2014). Scholars have utilised institutional analysis in a broader context to better understand the interaction between science and human values in decision-making and to spot bottlenecks (Imperial, 1999; Radaelli et al., 2012; Shah et al., 2020; Shah & Niles, 2016). The idea that the **implementation and governance** of a relatively new resource in an environment can only evolve, provided researchers pay great attention to the issues surrounding institutional design and performance, was therefore confirmed at the beginning of this study. Two features, however, could not be supported by academic literature. First, it has not yet been determined how much the game's rules, different stakeholder positions, and community attitudes may have influenced a particular policy decision. Second, transactions do not operate in isolation, and it has never been carefully examined how stakeholders become locked in path dependence dynamics.

By shifting the analytical focus to the dynamic implementation processes and including a bigger network of adjacent acts whose outputs mutually impact the contextual conditions, this research will therefore expand the academic findings. Additionally, processes do not operate on an individual level, so this factor will also be considered. Therefore, the **scientific relevance** of this research will be threefold. First, by illuminating the role of institutions in the success of geothermal energy diffusion, this research will advance the field of energy studies. Second, by emphasising the function of institutions within the MSF, this research will add to the body of knowledge in the field of policy studies. Third, by placing institutional analysis within broader policy implementation processes, this study will add to the body of knowledge on institutional analysis.

1.5. POLICY RELEVANCE OF RESEARCH

It was observed that the majority of the literature that mention the implementation of geothermal energy technology focusses on the technical aspects and do not consider the institutional aspects. Respectively, how public and private actors both use their influence and take individual and action to achieve successful implementation, is also not elaborated upon. Research in the implementation of geothermal energy is of high **societal relevance** as including context-dependent variables highlights accepted geothermal energy-policy input (Blake et al., 2020). According to Basurto et al. (2010) governments engage in energy transition governance to coordinate strategy and actions in order to accomplish sustainable energy transition goals in society. The geothermal sector in the Netherlands is a perfect example of this: a relatively young sector that has made immense technological advancment steps the past few years and is working its way towards the heating regime of the Netherlands. Interestingly, the lessons that are learned in this sector emerge from practise and have yet to find their connection towards theory. Thus, upon combining the policy implementation process of geothermal energy with an institutional perspective that sheds light on the interactions within that process, could provide guidance to **policymakers** for more effective strategies.

1.6. LINK TO STUDY PROGRAM

The implementation of geothermal energy is part of the general section of (local) implementation of renewable energy sources, which present a challenging case of a **socio-technical system** to explore and construct recommendations as a **CoSEM-student**. Analysing normative systems, legislative processes and subjective interests presents a complex task given the multi-actor context, existing legislation and the combination of existing and upcoming infrastructure (Nilsson et al., 2011). Moreover, the heterogeneity and interaction of public and private actors in the implementation process, emphasizes the need for development strategies (Whaley & Weatherhead, 2014). Furthermore, the combination of geothermal-technology being mature but the allocation of this technology in a different sector requires the inclusion of different levels of governance. As a result, the proposed study aligns with a CoSEM student's multidisciplinary toolkit.

1.7. STRUCTURE OF THESIS

The research flow diagram for this study is shown in Figure 2, along with the sub-questions 1-4 to which the chapters will give an answer. The second chapter will focus on establishing a theoretical foundation for policy implementation, institutions, and probable relationships, as well as a framework for the study. The third chapter will elaborate on how the geothermal implementation process currently looks like in the Netherlands. The technique and methods used in this study will be discussed in further detail in Chapter 4. In Chapter 5, we'll look at a successful geothermal implementation process in the built environment in the Netherlands. Following that, Chapter 6 will look at a geothermal implementation process in the Netherlands that has been deemed as unsuccessful in the built environment. The results of both situations will be compared in Chapter 7. Chapter 8 responds to research issues and summarises the study's scientific contributions. Finally, Chapter 9 answers the research questions, offers policy considerations and makes recommendations for future research based on this study's findings.

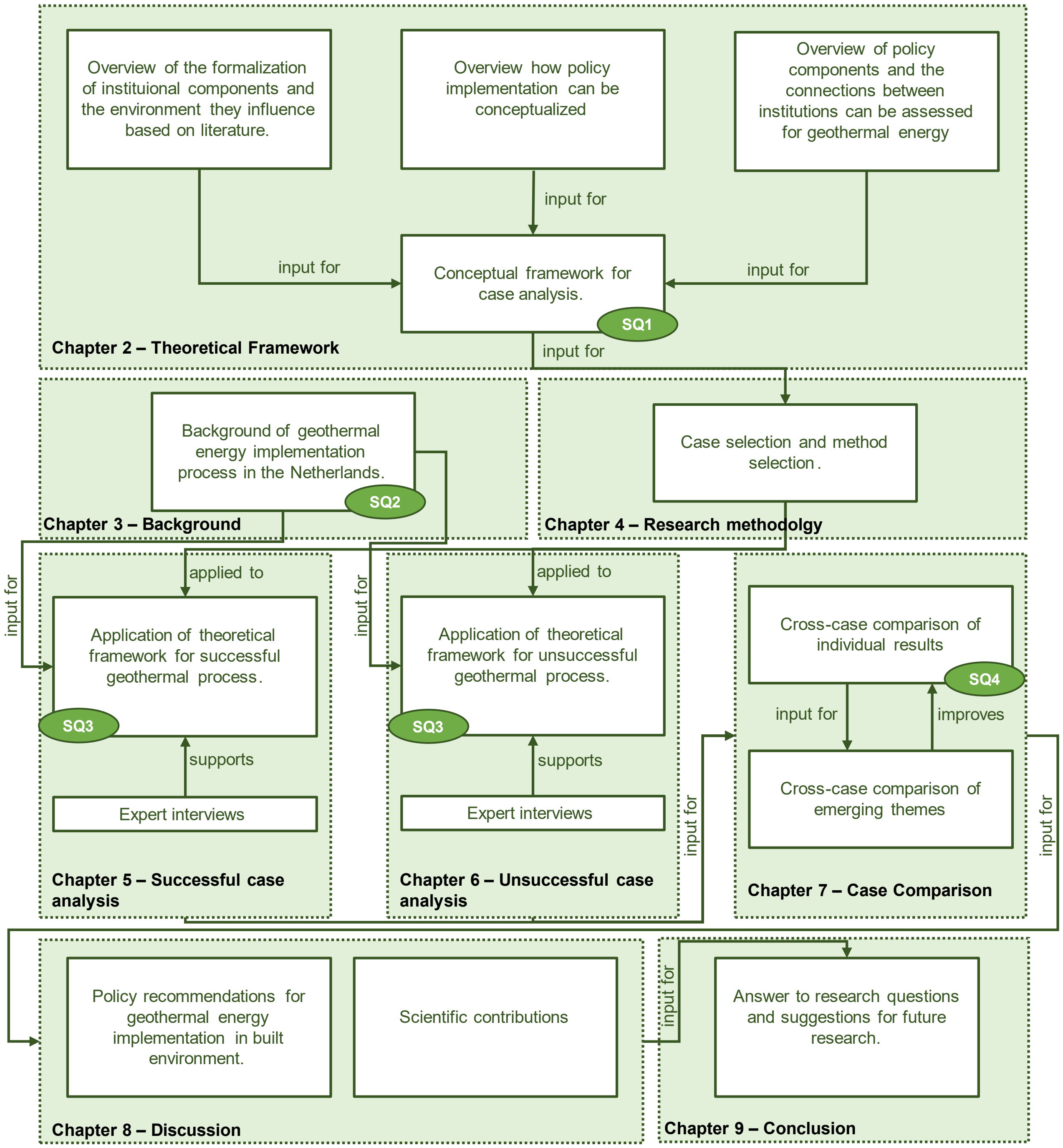

Figure 2: Research flow-diagram

2. THEORETICAL FRAMEWORK

The first part of this research is to conceptualize institutions within the policy implementation process. Two bodies of theory are used for this: the Multiple Streams Framework (MSF) and the Institutional Analysis and Development (IAD) framework. The chapter is organized as follows: both theories and their position and relevance will be explained briefly. Then, the integration of the frameworks will be discussed. More information can be found in Appendix II: Theoretical Framework.

2.1. THE MULTIPLE STREAMS FRAMEWORK (MSF)

The **MSF** is a Kingdon-developed theoretical framework that assumes three distinct and independent streams to explain how public policy agendas are established (Kingdon & Stano, 1984). The conditions that are thought to urge action are placed in the **problem stream** (Béland, 2016). The **policy stream** is a collection of suggestions, options, and ideas for policies developed in policy communities that may or may not be able to address the current issue (Béland, 2016). The **political stream** includes the institutional context, cultural context, and political processes (such as legislative politics) that motivate policymakers to concentrate on particular issues and potential solutions for the agenda (Ackrill et al., 2013; Zohlnhöfer et al., 2016). Prominent individuals known as **policy entrepreneurs** invest their time and energy into influencing the course of a certain policy stream (Béland, 2016). The **policy window** is finally described as a brief window of time when there is a higher possibility of beginning policy change than usual as a result of focusing events in the problem stream or activities of policy entrepreneurs.

The predominant focus on agenda-setting and policy adoption, and the lack of attention to what happens after policy is accepted, are **key criticisms** of the framework, despite its widespread use (Fowler, 2019). Three crucial theoretical foundations are provided by earlier researchers for using MSF to achieve policy: Policy entrepreneurs use political manipulation to influence implementation processes, which is similar to how policymakers influence policymaking processes (Aberbach & Christensen, 2014); implementer behaviour is driven by threats to the status quo, with problems and politics streams affecting commitment to policies (Herweg et al., 2018); and policy systems and processes are nested (Howlett et al., 2015). Based on the research of earlier academics (Boswell & Rodrigues, 2016; Fowler, 2019), we assume in this study that the fundamental structure of MSF is still present throughout the **implementation of policies**, while it has been somewhat reformed for this setting. First, there is a complicated relationship between the results of policymaking, the results of implementation, and the results of policy (Fowler, 2019). A steady policy output over time that is in line with socially stated goals established throughout the policymaking procedures is the consequence of successful implementation. Second, the main decision-makers in the implementation procedures are the implementers (Fowler, 2019). Because of this, policy entrepreneurs turn their attention away from legislators and toward implementers, who exercise discretion in deciding how policies are executed. Third, the non-ideal socioeconomic or environmental circumstances that policymakers wish to solve are represented by problem streams (Fowler, 2019). As a result, implementers' decisions regarding how to balance conflicting interests while directing their efforts are influenced by the policy and politics stream as well as policy entrepreneurs. Fourth, even while there are already policies in place, implementers must choose between different ways to employ administrative discretion (Meier

& O'Toole, 2006). As a result, policies are composed of tools for guiding implementers' actions, which add up to implementation results. Fifth, political streams mirror those of policymaking, where politics encourages focus on certain topics. As a result, similar to policymakers, implementers might modify their conduct when they perceive that the political climate favours or opposes specific policies (Herweg et al., 2018). Finally, implementation behaviour varies when streams pair during crucial occasions (Howlett et al., 2015). Implementers may be able to endure challenges to the status quo from any one stream (such as a change in public opinion or a focus of events), but when those streams are coupled, implementers are forced to act. Problems, politics, and policy streams all have separate effects on implementation processes, but when they combine, they also have conditional consequences that lead to divergences from the status quo.

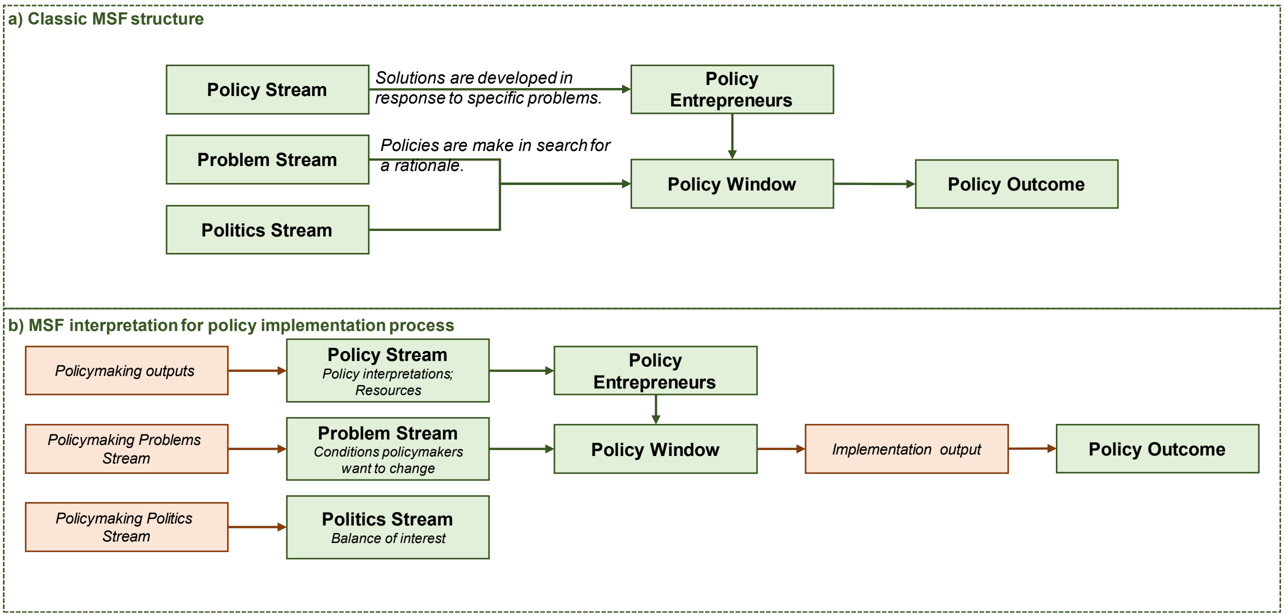

Figure 3: The classic MSF structure and the MSF interpretation for policy implementation (based on Fowler (2019))

The MSF's ability to contribute to theoretically sound and empirically testable policy literature has received criticism (Cairney & Jones, 2016; Zohlnhöfer et al., 2016). Given its current emphasis on elements that may open policy windows, MSF is particularly well-suited for theoretical development through the identification of causal mechanisms that result in specific outcomes. Another common criticism of the MSF is that it does not explicitly address the function of political institutions, which are generally understood to be the formal and informal rules that govern how agendas are set, decisions are made, and other aspects of the policy-making process in a particular setting (Polski & Ostrom, 1999). Although the MSF literature acknowledges the influence of institutions on how issues are perceived, what communities form around them, and who has authority over policy changes (Herweg et al., 2018), the framework's **inability** to explicitly state the role of **institutions** restricts its capacity to adequately explain or forecast policymaking and subsequent implementation performance (Zahariadis & Exadaktylos, 2016). This will be addressed by synthesizing the IAD with the MSF for this study.

2.2. THE INSTITUTIONAL ANALYSIS AND DEVELOPMENT (IAD) FRAMEWORK

The **IAD framework** as created by Ostrom (Ostrom, 2009, 2010) formalises the structures, roles, and regulations involved in managing common-pool resources as a methodical approach to understanding and forecasting outcomes (Lammers & Heldeweg, 2019). The IAD framework offers instructions for highlighting important perceptions on institutional, technological, and participative components of collective action challenges and their effects (Mcginnis, 2017; McGinnis, 2011). An **action situation** is affected by a set of external variables in the framework, which leads to patterns of interactions and results that provide feedback on both the external variables and results (Ostrom, 2010). The social area where people interact, exchange goods and services, solve problems, dominate one another, or engage in conflict is referred to as the action arena, which is made up of the providers and beneficiaries of a collective good (McGinnis, 2011). The biophysical conditions, community characteristics, and current rules are considered external variables. The **biophysical conditions** in this study pertain to the properties of the geothermal (sub)surface and the viability of the business case financially. The **community attributes** include trust, internal resources, prior interactions, and social capital of stakeholders involved or impacted by participants. The context in which an action situation takes place is framed by the **rules-in-use**, which include both informal and formal rules. The following factors are taken into consideration when defining the internal action situation: the range of actions that actors may take, their traits, and their positions; the amount of information available, the costs and benefits, the degrees of actor control, and patterns of interaction and results (Ostrom, 2010). It is crucial to comprehend the problem in light of the unique geothermal energy setting. Chapter 3 will elaborate more on this aspect.

The understanding of policy adoption and implementation has lagged behind **policy implementation research** (O'toole Jr, 2000). Because the conventional implementation procedure is unclear – on other words *'what does it include'*, literature has relegated the policy implementation phase to the 'black box' (Fallin et al., 2014). In past research, the IAD framework has showed promise as a model to direct the investigation of policy adoption and the success of some legislation during implementation (Fallin et al., 2014; Fleischman, 2016; Gain et al., 2019; Omori & Tesorero, 2020). According to studies, paying attention to governance techniques at the level of collective decision-making should result in more coherent management outputs at the operational decision-making level (Hardy & Koontz, 2009). Furthermore, it was demonstrated that diverse biophysical, social-economic, and institutional configurations result in qualitatively different outcomes for the application of technologies using common-pool resources (Gain et al., 2019). The constitutional, collective choice, and operational levels of action are all included in the IAD framework. The **constitutional level** provides the framework for institutional policymaking. The constitutional levels in this study involve Dutch national policymaking. Local policymaking is part of the level of **collective choice**, and the municipal council and aldermen are responsible for action at this level. **Operational activities** required to implement a policy are included at the operational level. The attributes at each level (f.e. community attributes) have an impact on action arenas, which can occur at any of the three levels (constitutional, collective choice, and operational) (Mcginnis, 2017). Institutions can be further classified in these three levels to better understand how they influence the behaviours and consequences of the participants (Ostrom, 2010). Constitutional pronouncements have a direct impact on day-to-day management, enforcement, appropriation, and provision acts on a practical level. The operational assertions refer to actual choices made by actors who have received permission (or are permitted) to do so as a result of collective-choice processes (Mcginnis, 2017; McGinnis, 2011). On a collective-choice level, statements establish who is entitled to change operational institutions and how that can be accomplished (Basurto et al., 2010). On this level, the institutions are in charge of prescribing, monitoring, implementing, and enforcing the statements organizing operational activities (Clement, 2010). Institutions define the suitability of participants to make and amend collective-choice institutions on a constitutional level. In essence, constitutional decision-making and institutional pronouncements have an impact on collective choice, which in turn has an impact on operational level. The lower levels, in turn, can have an impact on the higher levels. Because the constitutional level is consistent and not the focus of this comparison study, this research focuses on action areas at the collective choice and operational levels. The adoption of geothermal energy as part of the energy mix was the action area at the collective decision level. At the operational level, the installation of geothermal energy in metropolitan an area was the main arena. These action zones have a direct impact on the outcome. More information on the specifications of these levels can be found in Appendix II: Theoretical Framework. However, for the research it is important to understand the structure of the IAD framework and the factors that bound the actions situation (see Figure 4).

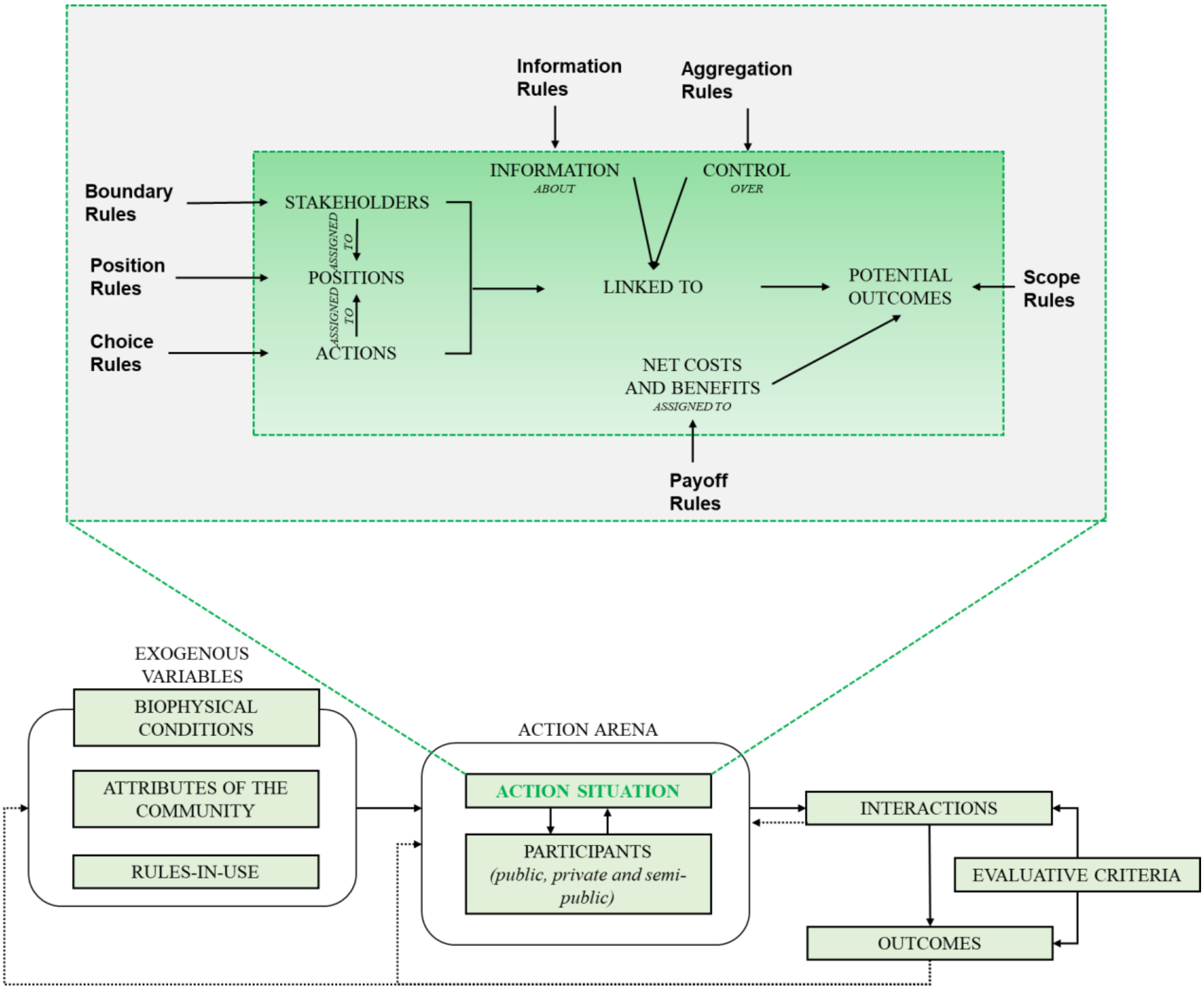

Figure 4: Structure IAD framework and elaborate overview action situation (based on Ostrom (2009;2010) and McGinnis (2011))

The IAD framework's effectiveness comes from the fact that it acknowledges the **complexity** of the world while giving academics a means to deal with it and combine findings from many studies (Ostrom, 2009; Polski & Ostrom, 1999). However, Ostrom did not intend for this framework to be understood in the way it is represented in Figure 4 because **no** action situation exists entirely in **isolation** (Ostrom, 2010). Instead, it conveys the idea of a static action situation. In general, without carefully considering the context in which it resides, no single action situation can be properly understood. An implicit implication that suggests the necessity of at least one action in addition to the one being represented can be found by carefully examining the original IAD representation (Ostrom, 2010, 2011). As a result, **adding causality** and increasing the number of contextual factors that influence the action situation will enhance a study that uses the IAD framework. This will be addressed by synthesizing the MSF with the IAD for this study.

2.3. INTEGRATING POLICY IMPLEMENTATION AND INSTITUTIONS

Where the strength of policy implementation studies lie in the ability to not just describe the interaction between policy concerns and their environments, but also to investigate causal relationships between variables that lead to adoption of a certain policy (Kagan, 2019), it is often so hypothetical that its insights extend far away from the original focus of a study (Cairney & Jones, 2016). Therefore, institutional analysis elements will be used to study the existing institutional structures and procedures, as well as the dynamics of relationships between different stakeholders. An institutional analysis lacks the option to take into account the in-depth examination on a specific chronology of events, yet its strength comes from its systematic theoretical focus on the impact of rules and norms on individual incentives in complex systems (McGinnis, 2011). Therefore policy implementation has the added value to keep a manageable set of key variables over time. With this knowledge in mind the **theoretical framework** of Figure 5 was designed for the purpose of **consistently tracking institutions in policy implementation process**. The aforementioned theories of the MSF and IAD framework have been integrated.

First, the framework is designed to **capture the processes** and events that occurred during the process from agenda setting to policy implementation. After thorough research, it was concluded that elements from the IAD framework already play an important role in the earlier stages of the process, and that they were often referred to in arguments in the decision-making process. The problem stream entails the process of interpreting situations as problems using indicators, focused events, and feedback (Kingdon & Stano, 1984). These sub-elements aid in the processing and interpretation of how current situations fail to match public expectations, resulting in issues. The policy stream is made up of policy communities that come up with policy solutions to challenges (Kingdon & Stano, 1984). The national mood, organized political forces, and changes in the government and legislature are all part of the political stream (Kingdon & Stano, 1984). In this stream, prominent political actors decide which issues should be on the agenda and how much consensus building is required among various groupings. A policy window is defined as *“a pivotal point in the policy process that created the prospect of influence over the process’s direction and outcome”* (Kingdon & Stano, 1984) and will be the last variable to be identified according to the framework.

Second, within the identified policy window multiple **transactions** happen. A transaction is defined as *“the transfer of ‘right to use’ goods or services across technologically separate interfaces”* (Menard, 2005; Williamson, 1985). The concept of transaction as stated here has two important components. First, the ability for activities to be separated from a technology standpoint is required by the very presence of transactions (Künneke et al., 2010). There is no other option for the geothermal system's structure if this isn't technically achievable. If separability is possible, however, the problem of how to organise transactions arises, and alternate solutions must be taken into account. Second, from an economic perspective, separability opens up the potential of creating *‘rights’* on necessary assets and of transferring these rights (Künneke et al., 2010). Accordingly, a significant transaction is one that has to do with protecting crucial infrastructure functions during the implementation process (Menard, 2005), and it's crucial for this research to identify and analyse the transactions within the policy window. Moreover, the elements of the IAD framework that have been weaved into the theoretical framework, giving the possibility to understand these transactions in more detail in order to find the influential variables.

Lastly, the **policy's performance** in terms of implementation quality should be assessed by looking at the difference between actual and projected policy outcomes. The viability, integrity, capability, and extent of the operations and activities that were supposed to be influenced by the policy, as well as the general absence of unintended (bad) consequences on other agencies (Sabatier, 1986) are all aspects that need to be addressed at the end of the analysis. It's vital to note that implementation success is determined regardless of whether the activities and tasks reach the future-oriented results or outcomes indicated in the implementing party's initial plan (Howlett et al., 2009; Saetren, 2005). However, due to the time constraints of this research, those part of the analysis will not be executed in this thesis. Consequently, the results from the analysis is limited in the sense it will miss the reflection of the policy process in general.

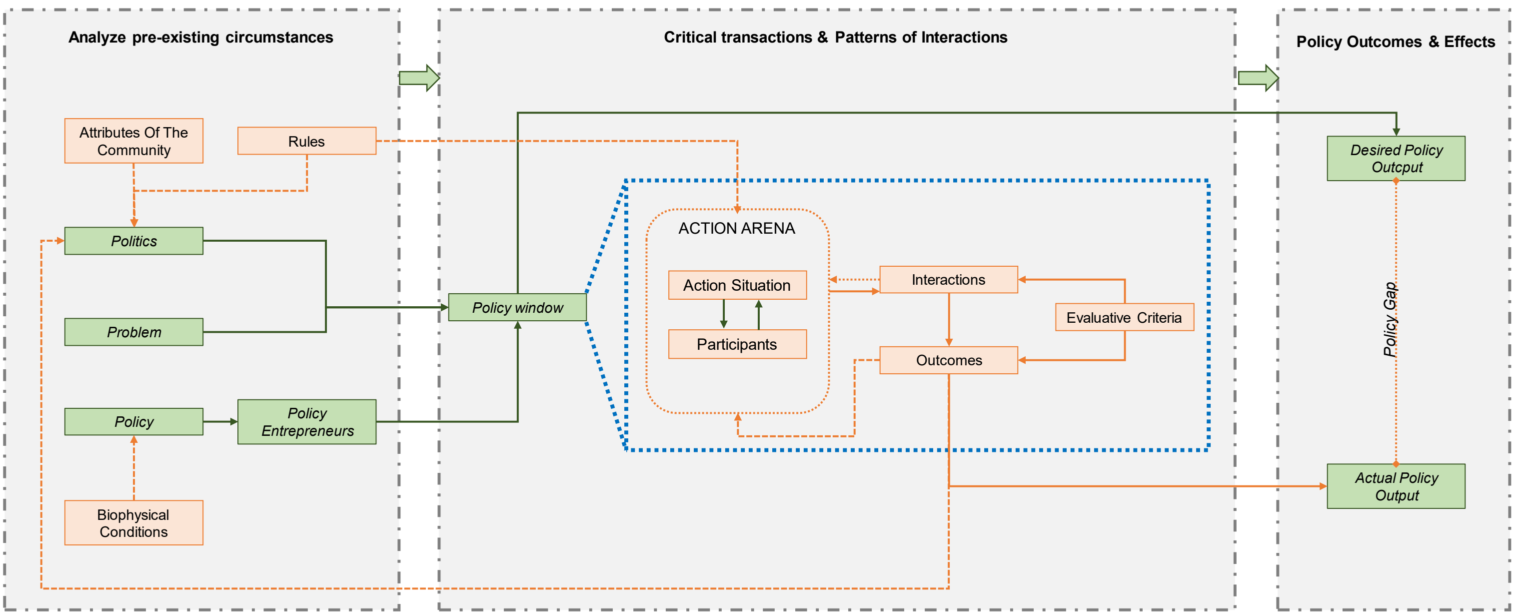

Figure 5: Integrated framework for Analysis

3. GEOTHERMAL ENERGY IMPLEMENTATION IN THE NETHERLANDS

Based on the knowledge gap this research hypothesized that institutions influence the policy implementation process of geothermal energy in the Netherlands. Existing policy research is ambiguous regarding who is the driving force behind it and how is policymaking affected beyond creating agendas (Béland, 2016; Milchram et al., 2019; Sovacool et al., 2017). Academic literature has conflated different actors, activities, and strategies, and often even a combination thereof, as contributing to policy entrepreneurship and innovation (Goyal et al., 2020). Therefore, this chapter will give a short overview of the participants involved in the geothermal sector in the Netherlands and their main responsibilities. This chapter will identify the main regulation in the Dutch geothermal sector and visualize the relationships in urban areas.

3.1. PLAYERS IN THE GEOTHERMAL SECTOR

Geothermal energy production in the Netherlands is a multifaceted operation. Here, the key players in the industry will be briefly explained. Permits are issued by the Ministry of Economic Affairs and Climate Policy (WN et al., 2022). Coordination on Dutch building, agriculture, and nature policies is handled by the Ministries of the Interior and Kingdom Relations, Infrastructure and Water Management, Agriculture, Nature, and Food Quality. In addition, State Supervision of Mines (SSM) oversees environmental protection when utilising the subsurface, human safety when using the subsurface, and conformity with the Mining Act. In accordance with Article 16 of the Mining Act, provinces offer assistance in integrating projects into the environment, promptly reserve the necessary space in spatial plans, designate areas for the protection of drinking water, and provide advice to the Ministry of Economic Affairs and Climate Policy on the issuance of exploration and production licences. In accordance with the General Provisions Environmental Law Act, municipalities coordinate spatial and environmental policies and licencing with the Ministry of Economic Affairs and Climate. Municipalities are also solicited by the Ministry of Economic Affairs and Climate for advise on environmental permits as well as by the provinces for input on local requirements for exploration and production licences. By the end of 2021, municipalities should have developed their heat transition vision as part of the regional energy strategy. The role of the municipalities in relation to heat governance may alter as a result of the modification to the Heat Act in 2022.

In addition, the water boards carry out water and environmental law enforcement. Energie Beheer Nederland (EBN) actively promotes the development of geothermal energy and takes part (financially) as a partner in geothermal energy production (Schoof et al., 2018). EBN is dedicated to utilising the Dutch subsurface to its fullest capacity (SCAN). The knowledge Centrum Warmte (ECW) offers towns technical and financial support for the (sustainable) transition of heat in homes and buildings. Through the SDE+, the Netherlands Enterprise Agency (RVO), among other things, distributes expertise, encourages innovation, and offers subsidies. The Netherlands' TNO provides guidance to the Ministry of Economic Affairs and Climate for the issuance of geothermal heat licences. A national organisation called the Netherlands Environmental Assessment Agency (PBL) focuses on policy analyses, offering guidance on the Sustainable Energy Subsidy Scheme (SDE) and examining potential directions for sustainable energy in the future (WN et al., 2022).

Lastly, interest organisations like Geothermie Nederland and the Information and Consultation Body for Geothermal Heat are also available (ICO). The sector association for geothermal energy is called Geothermie Nederland. They encourage the use of geothermal energy and represent all businesses and groups with a stake in the industry (WN et al., 2022). ICO provides unbiased knowledge concerning geothermal energy extraction in the Utrecht region, participates in local discussions, and provides guidance to stakeholders and residents. Then there are other stakeholders who have a business interest. This comprises financial service providers, heat firms that run heat networks, and geothermal energy developers and operators who plan, create, and manage geothermal energy projects. An overview can be found in Figure 6.

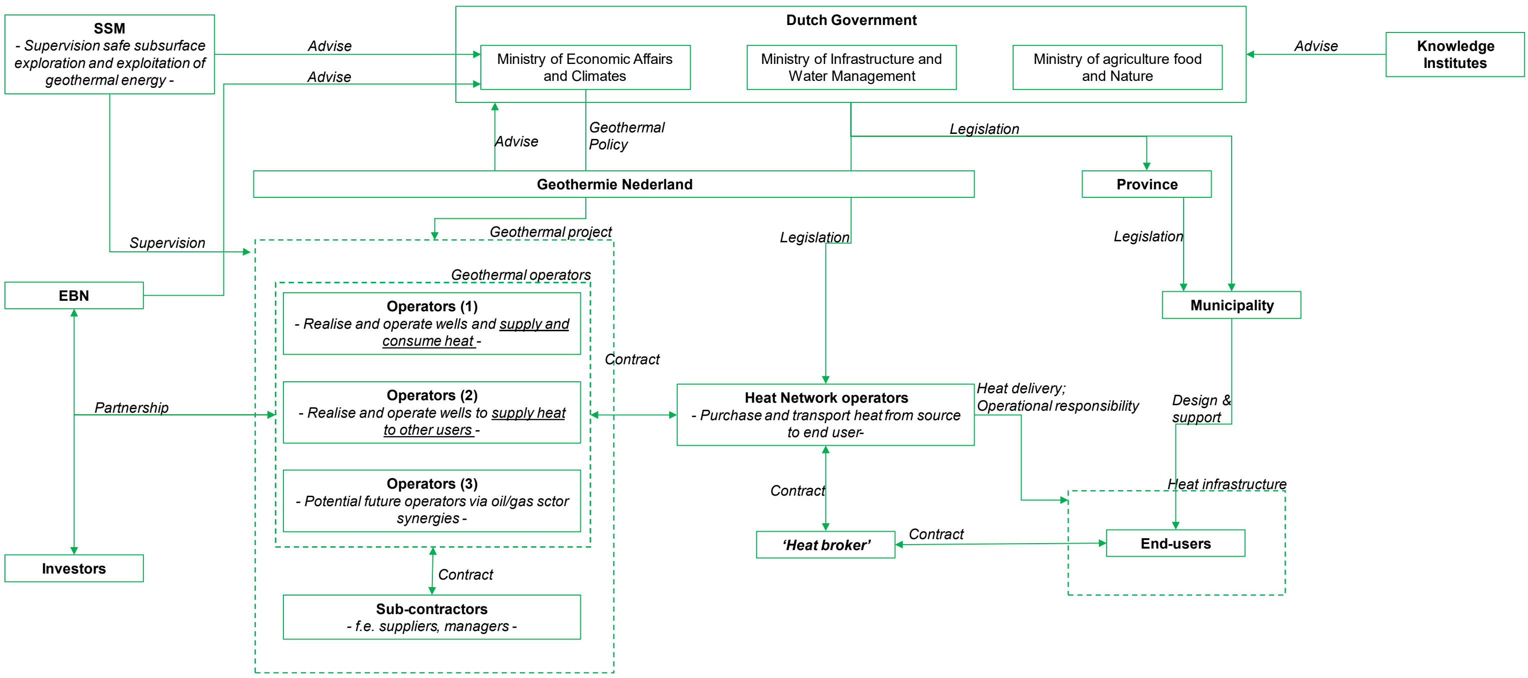

Figure 6: Stakeholder overview Geothermal Energy in the Netherlands (based on Schoof et al. (2018) and WN et al. (2022))

3.2. GEOTHERMAL LEGISLATION IN URBAN AREAS

Institutions are human-made norms that shape social, political, and economic relationships, or, to put it another way, rules that control a system, which is in this research the local urban heating system (Fouladvand et al., 2022). Institutions can be divided into formal and informal rules. As changes to the heating system will be implemented by a range of stakeholders including individuals, communities, governments and geothermal developers and thus such measures involve a combination of institutional and behavioural aspects, the deployment of technologies and the design of robust infrastructure (Parry et al., 2007), both formal and informal rules will be analysed in this research though formal rules have the focus. Energy policy (e.g., regulations) and incentive mechanisms are among the themes investigated in formal rules influencing urban energy systems research (e.g. subsidy schemes). In general geothermal energy implementation consists of five global phases in which different institutions are embedded: initiation, exploration, construction, winning and closing (Steffens et al., 2018).

1| Initiation. It is often a geothermal developer who wants to investigate the opportunities for geothermal energy in a certain area (Provoost, 2022). In addition, an energy company or a municipality can start an initiative based on the desire to make energy sources more sustainable. Several years pass from the idea to the start of geothermal heat extraction. Every geothermal energy initiative starts with determining whether there is a heat demand. The developer asks future customers (such as the heating company and companies) to sign a declaration of intent for heat consumption. In addition, there must be a prospect of connection to a heat network that can transport the heat to the users. At an early stage, the developer, together with municipalities, investigates where there is a suitable site for geothermal heat extraction in the area. The developer is looking for financiers for the geothermal energy project. This can be different interested organisations.

2| Exploration. The starting point for a geothermal project is the question: is it possible at the desired location? The developer is having geological calculations performed that provide more details about the exact location for the extraction (Schoof et al., 2018). The developer makes agreements about future heat supply with government authorities, the energy company and heat consumers. After that, permits are applied for. There is water everywhere in the ground, but not everywhere are the layers of the earth permeable enough to lift the heat from the soil. That is why seismic research is necessary: Earth layers are visualized by sending out sound waves. When there is more certainty about the location, heat customers, the presence of geothermal heat, financing and a heat network, the developer can apply for the necessary permits (Sayginer, 2022):

- The developer applies to the Ministry of Economic Affairs and Climate for an exploration permit as stated in the Mining Law. This allows the developer to further investigate the presence of geothermal energy in an area of usually a few km^2.
- for the construction and use of a Mining Work for the extraction of geothermal energy, as an initiator you will have to deal with the General Provisions Environmental Law Act (in Dutch: wabo) and the permits that fall under it. The environmental permit relates to the above-ground spatial impact of the extraction, such as the above-ground buildings and the extraction site.
- The Ministry asks experts and the regional and local authorities for advice on whether the permit can be granted.
- Within four weeks of the granting of the exploration permit, the operator must submit a work plan for the exploration.

When the plans are finalized and permits have been issued, drilling of the first well can start, followed by testing of the geothermal heat recovery.

3| Building. The preparation of the work site, the construction of the drilling rig and auxiliary installations can cause nuisance to local residents. The municipality has an important role in informing and involving local residents (Jharap & Trienekens, 2022). Geothermal energy operators have committed themselves through the code of conduct for environmental involvement to involve local residents as early as possible in the geothermal energy initiative or project. The derrick will operate 24 hours a day for a period of 3 to 6 months to drill the well. During drilling, the borehole is flushed. The drilling fluid ensures that loosened drill cuttings are removed, so that the well remains open during drilling. After construction, the first test takes place: is hot water also found in the subsoil? The operator must test the production well to determine whether sufficient heat can be recovered. The tests must show how much water can be pumped, at what pressure and at what temperature. This information is included in the extraction plan. Once the Minister of Economic Affairs and Climate Policy has approved the extraction plan, the second well can be drilled and the installation completed. The geothermal heat extraction can then actually start. Geothermal heat is supplied to the users via the heat network. If a heat network is not yet available, this must be installed.

4| Winning. If the geothermal energy company wants to start extracting geothermal energy after the installation and testing, it will apply for a production permit. In addition, the geothermal energy company must submit a work plan and an extraction plan. If this has been approved, the extraction can officially start. Underground pumps ensure that the warm (geothermal) water is raised from the underground. The geothermal water is in a closed circuit with a heat exchanger. The heat is transferred to the tap water in the heat network via a heat exchanger. The cooled geothermal water goes back into the underground. A distribution station ensures that the heated tap water is transported to homes and buildings. The heat comes in via a receiving station (or heat unit) in the greenhouse, home or building. After use, the cooled tap water is returned to the geothermal system via the heat network and is heated again.

5| Closing (end-of-life). After 30 to 40 years, geothermal energy production will be phased out and discontinued. There can be several reasons. The temperature in the subsoil may have dropped or the quality of the installation may need to be replaced, for example due to corrosion or new technological standards. If a location is no longer in use, the geothermal energy company (operator) must dismantle and clean it up. The operator is obliged to draw up a closure plan and a closure work program. The original temperature of the substrate will naturally recover over time. It is possible to drill a new production well nearby to continue extracting geothermal energy.

Thus, the following bodies of law have a prominent position during the implementation of geothermal energy:

- **Mining law**: Oil and gas drilling below 100 meters, as well as geothermal drillings below 500 meters are covered under the Mining law (Overheid.nl, 2017). According to this part of legislation, an exploratory license and production license are required for exploring respectively producing geothermal energy.
- **Environmental law**: This law applies to the surface-aspects of the geothermal energy installation (Akerboom et al., 2016). According to this part of the legislation an environmental permit is required for all aspects of construction and test drilling.
- **Heat act (2)**: This law contains rules about the supply of heat (Tempelman & van den Berg, 2019). The Heat Act protects heat consumers against for example high prices for heat supply and covers part of the heat governance in urban areas.

The legislation and other important bodies are more detailed explained in Appendix I: Literature Review. Figure 7 shows the overview of how the different phases and institutions can be connected to the urban environment. The visualisation shows that the urban environment brings two additional characteristics into the picture identified (EGEC Geothermal, 2019):

- Challenges are land suitability and availability in urban areas given the population density and divided property rights (Geothermie Nederland & EBN, 2021);
- Governmental organizations lack sufficient human resources dedicated to regulation and promotion of geothermal energy. As a result, getting clearance for concessions takes longer (Peijster, 2022; Provoost, 2022).

Literature has also identified that the majority of geothermal resources are found in or close to protected zones where geothermal energy exploration and production are forbidden. As a result, an environmental impact assessment (EIA) is required (Monteiro & Partidário, 2017). Thus, the regulator(s) must initiate any potential land use policy and/or regulation modifications, which takes more time and increases the complexity of implementation.

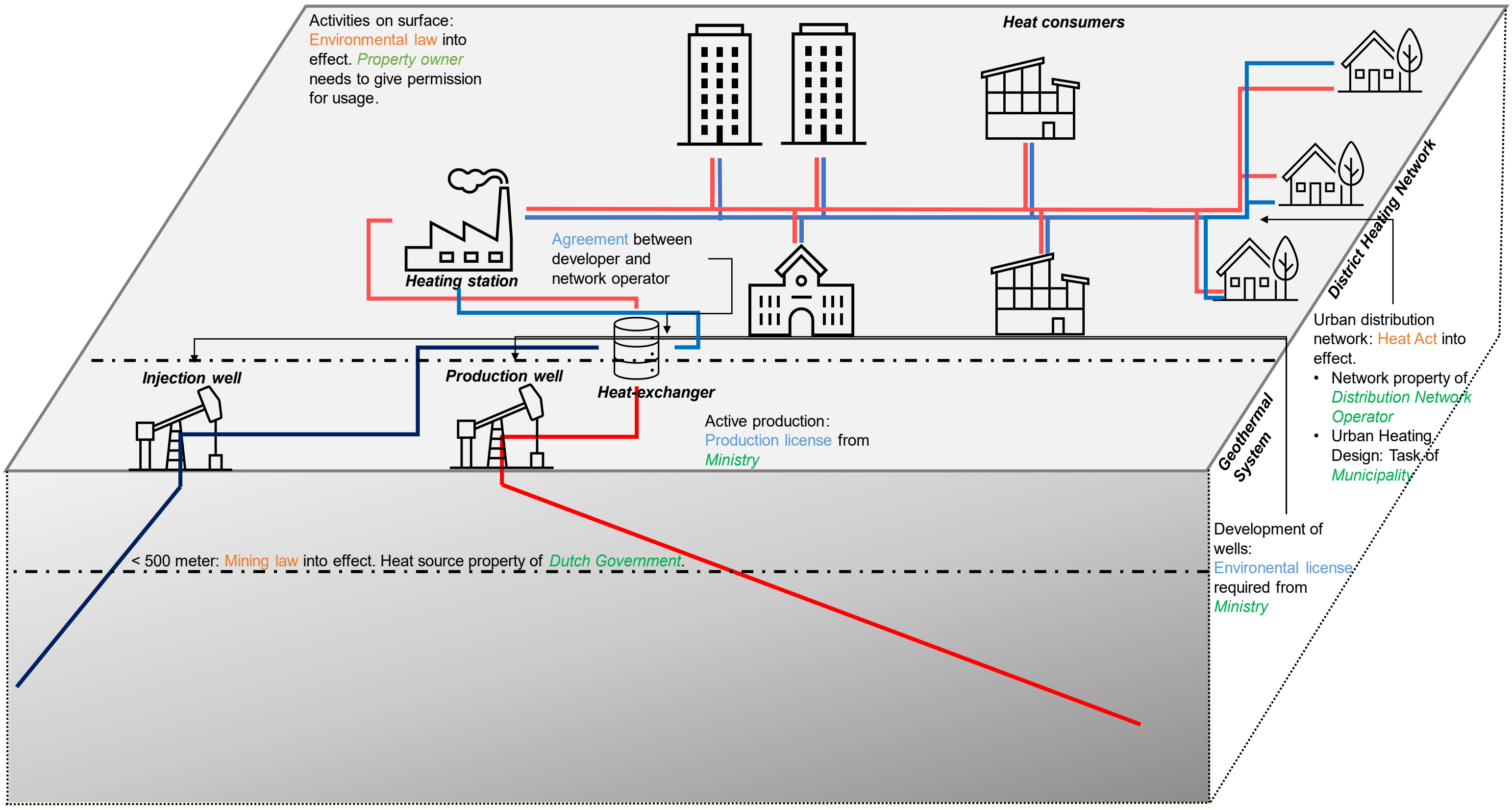

Figure 7: Brief overview stakeholders and transactions for geothermal project in an urban area (Steffens et al., 2018; SodM, 2021)

4. RESEARCH METHODS

This chapter explains the steps for conducting this analysis. The analysis follows the research approach as depicted in Figure 1. Each section explains the steps that have been taken, the methods and tools that were employed and how data was obtained and stored. Additional information on the coding can be found in the Appendix III: Codebook.

4.1. CASE SELECTION

The theoretical framework has been explained in Chapter 2. Therefore, the first next step entails the case selection. It is necessary to gain a better understanding of the potential cases that are present in the Netherlands. Therefore whether a case is suitable for this research is determined by the following selection criteria:

- **Urban development** – The research questions focusses specifically on the implementation of geothermal energy within urban context. Therefore, cases need to take place in an urban area development and aim to supply solely to the urban area. Therefore, projects that supply (partly) to horticulture and/or industry are excluded from this research.
- **Context** – Because the external context (e.g. the policy and regulatory system) is also studied in the analysis, the choice was made to select cases that are under a similar system of governance. For this reason, the researcher has chosen to select cases in the Netherlands.
- **Type of geothermal energy** – As mentioned in the introduction of this thesis. The type of geothermal energy that is of interest for this study is *geothermal energy* that is collected between 1,800 – 3,000 metres deep approximately.
- **Outcome clarity** – Following up on the last criterium, the cases should have an outcome that has been published in the news. This could either mean the project has been put on indefinite hold or that the project has been successfully implemented. Projects should not be *'under construction*'.
- **Cases (constraint)** – Due to the time constraints of the Master thesis, only two cases will be analysed and compared. Based on the research objective, both cases should have different outcomes.

All geothermal projects in the Netherlands are published on the website of Geothermie Nederland (2020). Based on the first criterium for the case selection, 11 projects can be used for this research. In Table 1 the other criteria are visualized. Based on the criterium the cases *Haagse Aardwarmte Leyweg* (project Leyweg) en *Warmtebron Utrecht (project LEAN)* will be analysed in this research.

Table 1: Case selection overview (based on Geothermie Nederland (2020))

Project name	Urban Development	Context	Type of GE	Outcome clarity	Check: cases
Aardwarmte in Vallei	•	•			
Aardwarmte voor Almere	•	•	•		
Geothermie Delft	•	•	•		
Geothermie Zwolle	•	•	•		
Haagse Aardwarmte Leyweg	•	•	•	•	•
Haarlem – Schalkwijk	•	•	•		
Mijnwaterproject Heerlen	•	•			
Rotterdamse Haven	•	•	•		
Warmte van Leeuwarden	•	•	•		
Warmtebron Utrecht	•	•	•	•	•
Wayland Leiden	•	•			

4.2. DATA COLLECTION

First, theoretical knowledge on the connection between policy implementation and institutions should be done. The essential data has been acquired through a **literature study** of academic documents. These documents have been used to build the theoretical framework of chapter 2. To avoid limiting the data collection too much, the focus was not only on urban implementation. Scholarly databases have been searched for peer-reviewed academic material. Secondly, the goal was to establish a context from the two selected cases to investigate its characteristics according to the framework-variables. A part of the essential data was acquired through a literature study of **academic** and **grey literature**, which allowed for the collection of existing sources from a wide range of fields (Lawrence et al., 2014). The researcher was confined to available material, which could be incomplete, while conducting a systematic review. However, the analysis was combined with interviews, thus this limitation was accepted (Queirós et al., 2017). More general variables have been deduced from existing records, therefore desk research has been undertaken as well. Institutions have been formalized by using **institutional grammar** and they will be extracted mostly from formal documents. For this research eight in-depth **interviews** have been conducted and four brief discussions have been held with experts from the field as stated in Table 2.

Table 2: List of interviewees

	Stakeholders
Governmental agencies	Ministery of Economic Affairs and Climate, State Supervision of the Mines, Municipality of The Hague (cancelled), Municipality Utrecht (cancelled)
Experts	Geothermie Nederland
Private Sector	Well Engineering Partners, Haagse Aardwarmte Leyweg, ENGIE, Hydreco Geomec, Huisman

The interviews that have been conducted were **semi-structured**, which had the advantage of being adaptive (Rabionet, 2011). Other advantages of this type of interviewing were that it allowed the interviewees to discuss more sensitive topics while maintaining a clear structure (Stuckey, 2013). The interview-transcripts and potential recordings have been stored during the research on the TU Delft One Drive conform the approved *Data Management Plan.* The questions were tailored to each interviewee individually. Because each expert represents a separate party with a comprehensive set of expertise based on previous experiences, the goal is to gather as much information as possible. The method has downsides due to the minimal time effort required to create an interview protocol, afterwards transcription, and analysis of the data (Rabionet, 2011). An overview of example questions can be seen in Table 3.

Table 3: Example questions interviews

Topic	Example Questions
Stakeholder positions	• What were the direct responsibilities of the party during the project? • What was the vision for participating in the project? • Which actions have been taken over time to finalize the project? And which actions were considered challenging?
Uniformity in sector	• How did you decide which knowledge base to give prevalence to, given that different parties conduct research for the same project? • How do you decide which measures needed to be taken during the project? • Who is responsible for what part in the project? • What aspects do you focus on the most during the preparation and excecution of the project?
Regulatory boundaries	• Which rules and regulations did you have to comply to in spatial design of the geothermal project? And this clear upfront, or where there certain regulations that limited the project process? • What type of local policy was present in the project? • Which governmental party had, according to your perspective, a critical position during the process?

All collected data was collected and added to **Atlas.ti**. Atlas.ti is a qualitative research tool that was used to code and analyse the data. This will be further explained in the following paragraph 4.3. Thirdly, the theoretical and empirical insights discovered in the first two parts provide the required data for the **case comparison**, allowing the data requirements to be considered met. As a result, this part reflects the phase of integrating the new information. The comparison consist of two parts: comparing the individual results and comparing the emerging themes of the cases. Both parts are again the data input for the policy recommendations, hence the data requirements are again met. An complete overview can be found in Table 4.

Table 4: Subquestions, methods and data overview

Subquestion	Selected Method	Data analysis tool
1) How can institutions in the policy implementation process be conceptualized?	Desk research: Literature review	Spreadsheet tool: Microsoft Excel
2) What does the geothermal energy implementation process in the Netherlands entail?	Desk research: Literature review	Text Analysis tool: Atlas.ti Spreadsheet tool: Microsoft Excel Visual representation: MIRO
3) How do institutions influence the outcome of the geothermal energy policy implementation process?	Desk research: Literature review of policy documents Emperical research: semi-structured interviews Qualitative data anlysis: stakeholder analysis Case study method: Process tracing	Text Analysis tool: Atlas.ti Spreadsheet tool: Microsoft Excel Stakeholder analysis tools: formal chart Analysis tools: theoretical framework
4) What are key institutions that contribute to the success of geothermal energy policy implementation process?	Case study method: Method of differences	Visual representation: MIRO Spreadsheet tool: Microsoft Excel Case analysis tool: Pattern-matching logic Case analysis tool: Explanation building technique

4.3. DATA CODING

The process of categorizing and organizing qualitative data in order to find unique themes and their links is known as coding in qualitative research (Fereday & Muir-Cochrane, 2006). Atlas.ti was used to help with the coding and qualitative content analysis. In this research, deductive coding was used. **Deductive coding** starts with a collection of pre-defined codes (Fereday & Muir-Cochrane, 2006). The codes were based on the operationalization of the theoretical framework of Chapter 2 and defined in the codebook as explained in Appendix III: Codebook. The coding approach is based on the work of Scott et al. (2019), which will be explained briefly here. The qualitative data is first split into smaller samples of text: *General information, Case 01: Leyweg (The Hague)* and *Case 02: LEAN (Utrecht)*. The Document Groups option in Atlas.ti is used to finish this part. After the documents had been organized, they were coded. Coding in this research means that (parts) of sentences were **labelled** with predefined codes. These codes are based on the operationalisation of elements in the theoretical framework. Furthermore, all codes were given a month and year indication. This will make potential reconstructing and process tracing easier later in the research. The data coding is more elaborated on in the Appendix. An example is stated in Figure 8:

Vervolg uitlijnen

Zorgvuldigheid in het proces is volgens Joris enorm belangrijk. "De gemeente is aan zet met een eigen afwegingskader om zo voorbereid te zijn op een eventueel voorstel voor een locatie. [ProRanFE | 04-2021]. Dat kost iets meer tijd dan wij van tevoren hadden ingeschat. [ProRanIND | 04-2021]. Dat betekent dat wij onze eigen planning ook opnieuw moeten maken. Daarom maken we nu afspraken met de gemeente om van beide kanten duidelijk te hebben waar we aan toe zijn."

Figure 8: Example coding (reconstruction) - text taken from document

4.4. CASE ANALYSIS

To reconstruct policy implementation through time, a causal process tracing technique will be used: process tracing was used to determine whether and how a specific change or set of changes was influenced by a potential cause or reasons (Collier & Brady, 2010). This is accomplished by employing a series of rigorous tests to assess the quality of evidence linking project or programme activities to change(s). The formulation and testing of alternative ideas about how and why change occurred is an important component of process tracing (Collier & Brady, 2010). The following steps were undertaken for **process tracing**. The first step was to identify a critical factor that was mentioned in literature and/or interviews. The second step is to answer the question *'why was this considered critical?'*. This puts the emphasis on a certain chain of variables and by asking this question *until the variable is traced back to a pre-defined circumstance*, the whole process will be documented. After a chain is established, the last step is to assess the evidence for alternative explanations. Figure 9 gives an example of the process tracing that was originated from the analysis in this research.

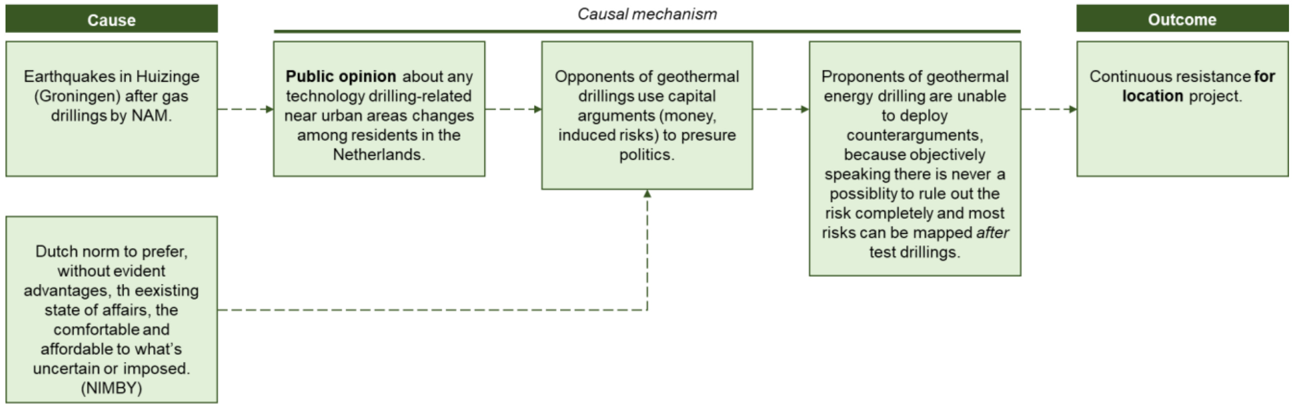

Figure 9: Example process tracing - Social acceptance for geothermal drilling

4.5. VALIDATION

It is critical to ensure the validity of qualitative research in order to ensure the accuracy of the findings and persuade readers of their accuracy (Abbaszadeh & Abbaszadeh, 2012). The **clarity**, **authenticity**, and **replicability** of the qualitative work in this study are all important factors in determining its validity (Brink, 1993). There are several reasons why various types of validity are appropriate for this research. The information used in this study was selected from a large and diverse collection of policy, legislative and news publications. In addition, interviews with former involved parties were conducted to confirm key aspects of the cases as well as to highlight the more important variables. The inclusion of a specified scope for this study permits other researchers to apply what has been concluded to future studies. The study's replicability should be highlighted by a thorough description of the methodology, tools, and procedures, as well as a comprehensive codebook and data analysis.

5. LEYWEG PROJECT – THE HAGUE

The goal of project Leyweg, *Haagse Aardwarmte Leyweg*, in The Hague was to generate geothermal heat in order to create a more sustainable inner-city environment for the Hague Soutwest Neighbourhood. Aardwarmte Den Haag (ADH) originally started the initiative in 2007. They successfully drilled the geothermal wells in 2010 and even though the company went bankrupt in 2013, the project found its restart and was revived in 2016. How the policy process proceeded, which institutions were involved with the critical transaction that led to the hold of the project will be explained in this chapter. First there will be an overview that explains the project development with important events and the key stakeholders will be elaborated on. Secondly, the pre-existing policy circumstances will be analysed for the Leyweg Project. Thirdly, the patterns of interactions within the critical transaction and how these led to the outcome will explained. Lastly, the chapter will conclude with a brief result section that holds an overview of the important variables and how they relate to the outcome of the Leyweg project.

5.1. CASE OVERVIEW

According to Segers et al. (2019), The Hague was the third city to decide to build a district heating network in 1975 as a result of the oil crisis. **Aardwarmte Den Haag** (ADH) was the organisation that started the initiative in 2007 before the Haagse Aardwarmte Leyweg (HAL) was formed (Rösingh, 2022). The Hague municipality, the housing organisations Vestia, Haagwonen, and Staedion, as well as the energy firms Eneco and Uniper Benelux, formed ADH (Schoof, 2022). On October 22, 2007, the Municipality of The Hague submitted an application for the **exploration license** for geothermal energy for a period of 4 years in the area of The Hague with a size of 36 km^2, which was granted in April 2009 (Peters, 2009). The ADH organisation planned to build 3.812 homes and 20.000 m^2 of office space in The Hague's Zuidwest region, which is a city within a city (Schoof, 2022). The sustainability goals of the municipality of The Hague led to a heat plan in which the district would be connected to a geothermal energy-based heating network (Peters, 2009). According to Hoes (2010), the geothermal wells were drilled in 2010 by ADH and developing partners and the organization reported these activities to the Ministry of Economic Affairs in March. After the geothermal wells were successfully drilled, ADH declared **bankruptcy** in 2013 due to obstacles in heat sales due to unfinished residential development induced by the credit crisis (Schoof, 2022).

After the bankruptcy Eneco purchased the distribution network to distribute heat to the already connected households (Rösingh, 2022). At that time, Eneco bought heat from Uniper, which was generated by a Combined-Cycle Gas Turbine (Rösingh, 2022). The geothermal wells were taken over by Haagse Aardwarmte Leyweg in 2016, with Hydreco Geomec as the operator in charge of the geothermal well's planning, construction, and operation (van Dun, 2022). This is laid down in the transfer of the exploration license to HAL B.V. and Hydreco Geomec B.V. (Brouwer, 2016). In November 2019, the Ministry of Economic Affairs and Climate granted HAL an **environmental permit** to update its current environmental permit and to set up installations for the exploitation of a geothermal source (Minister van Economische Zaken en Klimaat, 2021). An opinion (in Dutch: *'zienswijze'*) for the license was submitted by a resident on the basis of acoustic and environmental grounds. The opinion was later judged to be unfounded by the court, but it did lead to minor adjustments in the granted permit

(*Uitspraak omgevingsrecht* , 2022). The last work has been completed in 2021 and HAL started extracting geothermal energy in December 2021 as part of the test phase. For these activities HAL and Hydreco Geomec were granted permission through obtaining the production license in April 2020 (Rosch, 2020). As the last part of this test phase, HAL will continue to expand the supply of the heat to maximum capacity in 2022.

By means of coding the aforementioned information, a timeline was visualised in Figure 10 and a closer look will be taken on the **key stakeholders** that were involved in the process of the Leyweg Project. A more elaborate description of the stakeholders can be found in Appendix V: Case 01 – Background Information.

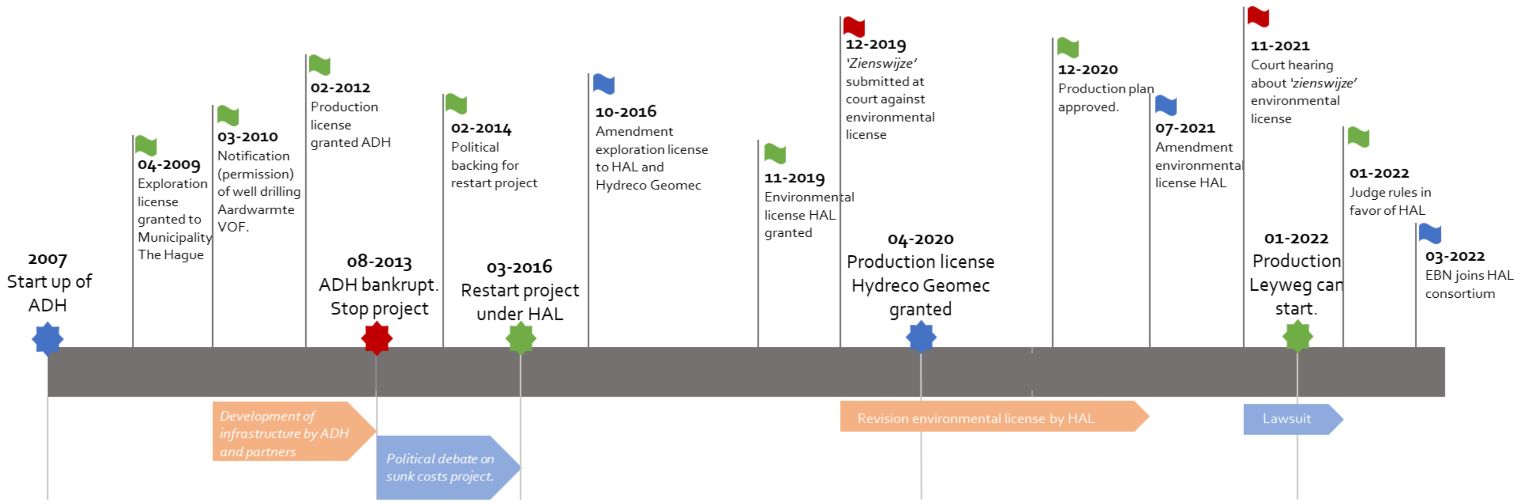

Figure 10: Visualisation timeline Project Leyweg (The Hague)

Haagse Aardwarmte Leyweg (HAL) is a collaboration between three companies: Hydreco Geomec (which is now known as Aardyn B.V.), Perpetuum Energy Partners (PEP), and Energiefonds Den Haag (ED), which has taken over the former organization's existing geothermal well (Rösingh, 2022). The goal of HAL was to generate geothermal heat in order to create a more sustainable inner-city environment for region the Hague (Werker et al., 2017). EBN has been a shareholder since 2022 with the goal to assist the portfolio development of the company through its knowledge, expertise and extensive experience with doing research in the Dutch underground (Rösingh, 2022).

The installation was not finished when HAL took over the organisation from the curator. ADH obtained certain licences for the geothermal well, however they were reliant on the Municipality and Province's decisions on construction plans at the time (Schoof, 2022). In addition, Rösingh (2022) stated that these licences were not complete and that they needed to be obtained anew. An extraction licence was obtained directly from the Ministry of Economic Affairs, who is advised by the States Supervision of the Mines. Development works for the geothermal well are carried out by the HAL organisation. The **Province of South Holland** and the **Municipality of The Hague** are in charge of not only publishing plans for heating networks that affect HAL that may be found in literature, but also of assessing environmental licences (Jongerius, 2022).

Aardyn B.V. provided managerial and organisational services for the Leyweg Project (van Dun, 2022). They are in charge of obtaining the necessary licences, planning, construction, and operation of the geothermal well on behalf of HAL. In addition to its role as shareholder,

PEP acts as process manager for the redevelopment and commissioning of the wells and PEP manages the company Haagse Aardwarmte BV. To put it another way, PEP handles management, while Aardyn B.V. handles operational tasks and provides the project manager.

The **Municipality of The Hague** pursued the restart of the project firmly as heat distribution from the geothermal well would aid their Energy Transition plan (Rösingh, 2022). The Municipality established ED revolving energy fund in 2013, which uses European Funds for Regional Development to deploy financial instruments (EFRO). According to Rösingh (2022), ED fills the gap in capital demand that the project lacked owing to market failure. As a shareholder, ED played a significant capital-raising or capital-providing role in HAL. The means of ED are supplying capital for development and is funded by HAL's future cashflows.

The inclusion of **RVO** subsidies ensures additional income that boost project feasibility (Jongerius, 2022). The SDE++ subsidy on geothermal energy appears to be essential in geothermal projects since it encourages the generation of energy from sustainable sources (Rösingh, 2022). **Eneco** is in charge of heat transmission and distribution. The transmission of heat was business to business, according to (van Dun, 2022), with the risk of claims by end-users being shifted to the DSO, Eneco. All four shareholders have contributed a holder's agreement and share premium (share premium is what an entrepreneur pays on top of the nominal value of a share). ED and Aardyn B.V. have also contributed additional financing, of which the ED fund has by far the largest share.

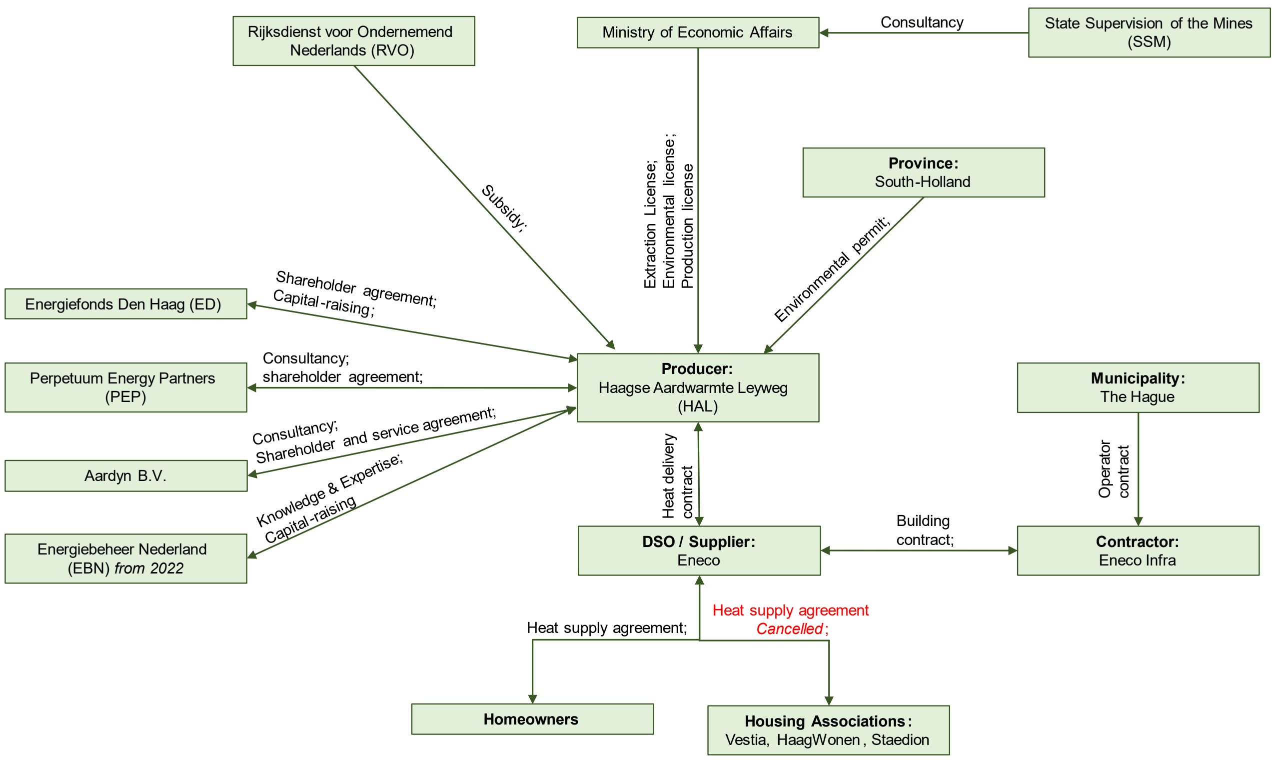

Figure 11: Stakeholder analysis - project Leyweg

5.2. PRE-EXISTING CIRCUMSTANCES

Looking at the implementation **process** and the specific **ambitions** set, the geothermal implementation of project Leyweg was **successful** in both: the project reflected innovation that resulted from a public-private cooperation. Moreover, even though there were not always agreements among decision makers, the initiative was mostly successful as it met the Municipal and Provincial sustainability objectives and proved to be useful for the private investors to gain experience in urban areas. Looking at the elements of the theoretical framework it can be stated what developments led to project Leyweg to be called *successful*.

The **policy stream** shows multiple developments shortly after the bankruptcy of the project in 2013. In 2014, the objective was reconfirmed in the coalition agreement *'Haagse Kracht'* that the municipality of The Hague aimed to be climate neutral by 2030 (de Snoo & van Aartsen, 2016). In addition, the Energy Vision The Hague policy memorandum (RIS 180175), the backcasting study (RIS 258292) and the Energy Vision 2040 Progress Memorandum (RIS 279785) indicated that this required maximum effort on the heat transition (Baldewsingh, 2011; Bertram & van Aartsen, 2013; Wijsmuller, 2014). The municipal coalition had indicated in their policy that they did not see themselves as a producer and/or supplier of heat, but rather as an important facilitator in the local energy transition (Wijsmuller, 2014). Additionally, whenever there would be a risk of market failure in the heat market, the municipality aimed to encourage and support citizens and business activities based on this responsibility (Wijsmuller, 2014).

The legislative re-election and reinforcement of existing policy along with the shifting awareness of the importance of the energy transition opened a **window of opportunity** in the **politics stream** (Omroep West, 2014). In Kingdon's words, the Labour Party (in Dutch: PvdA) was acting as a **policy entrepreneur**, seizing on politically favourable changes by moving Project Leyweg back up the agenda (Omroep West, 2014). They took advantage of the public outcry over the project's sunk expenses and raised public awareness to bring the project to the top of the discussion. Despite increased public and political awareness, the right-wing parties VVD and PVV had refused to continue the initiative due to the substantial financial commitment (Omroep West, 2015). Left-wing parties have demonstrated persistence throughout the negotiation process and have been heard as a result of their political clout. In other words, the success of Project Leyweg was affected partly by the national strategy for geothermal energy usage.

The commitment shown by the labour party, along with the positive attitude of residents towards the realisation of a sustainable form of living, led to the creation of a broad coalition in support of the geothermal policy (Wijsmuller, 2014). Therefore, the focussing events in the **problem stream** were actually not explicitly present in occurrence of the window of opportunity. However, the problem stream does contain one focus event and an indicated issue that must be addressed. Minister Kamp published the Energy report, *Transition to Sustainability*, which indicated that heating with gas must be reduced and that geothermal energy was one of the main alternative heat sources (Wiebes, 2018). Many arguments later in the process refer back to this national document that was published. While the policy moved swiftly to the implementation stage, one issue surfaced in the process. More than two years after the bankruptcy, the bankruptcy trustee had no longer a optimistic outlook about the geothermal project. This was due to the required investments for a swift restart.

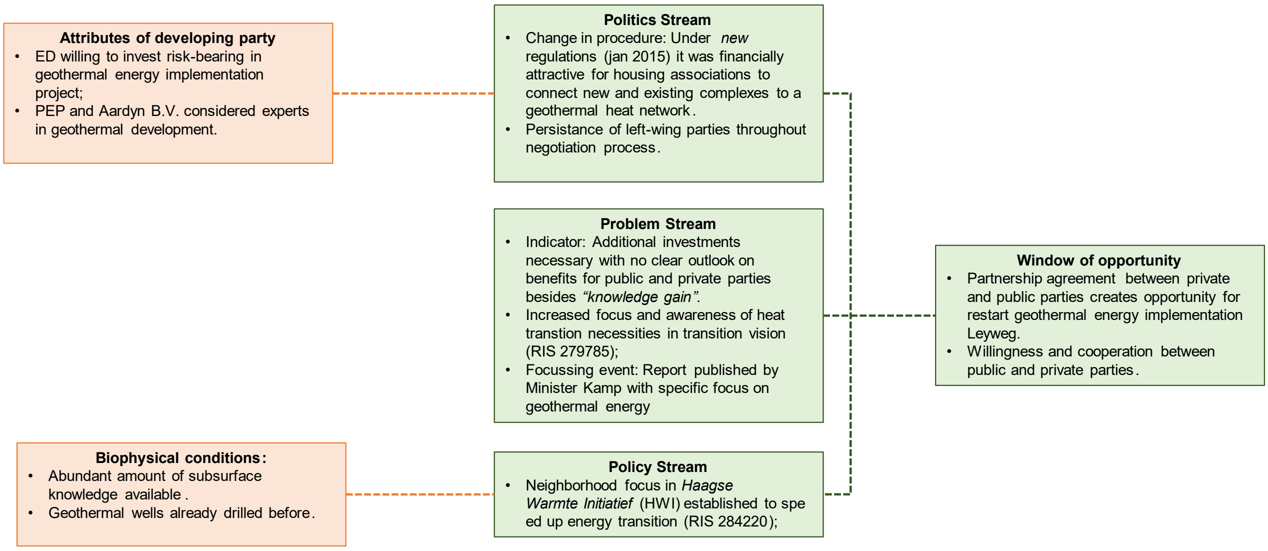

Figure 12: Coupling different streams project Leyweg

From this moment, it can be seen how the policy stream matches the politics stream. Arguments made in the politics stream were based on the (minor) indicators in the problem stream. However, it was a were the **attributes of the developing party** that convinced in the political debate about the actual implementation of geothermal energy. The Energy Fund The Hague (ED) had geothermal energy as one of the spearhead in its investment strategy and was willing to invest risk-bearing. Moreover, the market parties Aardyn B.V. and Perpetuum Energy Partners, both experts and experienced in the field of geothermal energy, were willing to participate with ED and to invest in a private limited company for the redevelopment of the well. These elements in combination with the **biophysical conditions** showed in the first explorations that a profitable business case was **feasible**.

A visualisation of the different elements can be seen in Figure 12. The result showed that trust was created between the politics and private parties. The municipality **decided** to 2016 **to sign** the Letter of Intent with Aardyn B.V., PEP and ED for the purpose to of establishing an target company (in Dutch: *Special Purpose Vehicle (SPV)*) for the restart of geothermal energy in the Hague. Subsequently, the implementation proceeded largely in line with policy objectives. Due to the favourable balance of interests, a viable policy alternative and coordination between public and private actors, the implementation of geothermal energy was labelled ***successful***. The decision of both public and private parties to engage, is what brought the implementation further. However, looking at the identified elements of the analysis above, it can not (yet) be exactly stated *why* it was successful. In order to do so, the transaction needs to be explored in more detail. This will be done in the following part.

5.3. PATTERNS OF INTERACTIONS

The **action arena** in which the transaction happened can be characterised as of *collective choice level* as decisions were made to put in place a specific arrangement – which would result in a change in the neighbourhood infrastructure. As previously mentioned, the first heat project was already realized in 2007. Therefore, exploration in order to determine where the heat resource is located, was no longer necessary. However, after the project was completed, demand for the source was disappointing due to the unforeseeable credit crisis that brought housing production to a standstill (Haffner & van Dam, 2011). As the wells were already drilled there was interest in continuing this project by private and public parties. The municipality would benefit from a continuation of the project given their vision and coalition agreement (Gemeente Den Haag, 2014), however additionally geothermal expertise was required. Therefore, within the action arena, there are **two transactions** observed: the decision to restart the project and obtaining the renewal of the environmental license. The interconnectedness of the events and interactions taking place in the action arena are depicted in Figure 13. As a result, it does not show all of the causes and how they affect the actions.

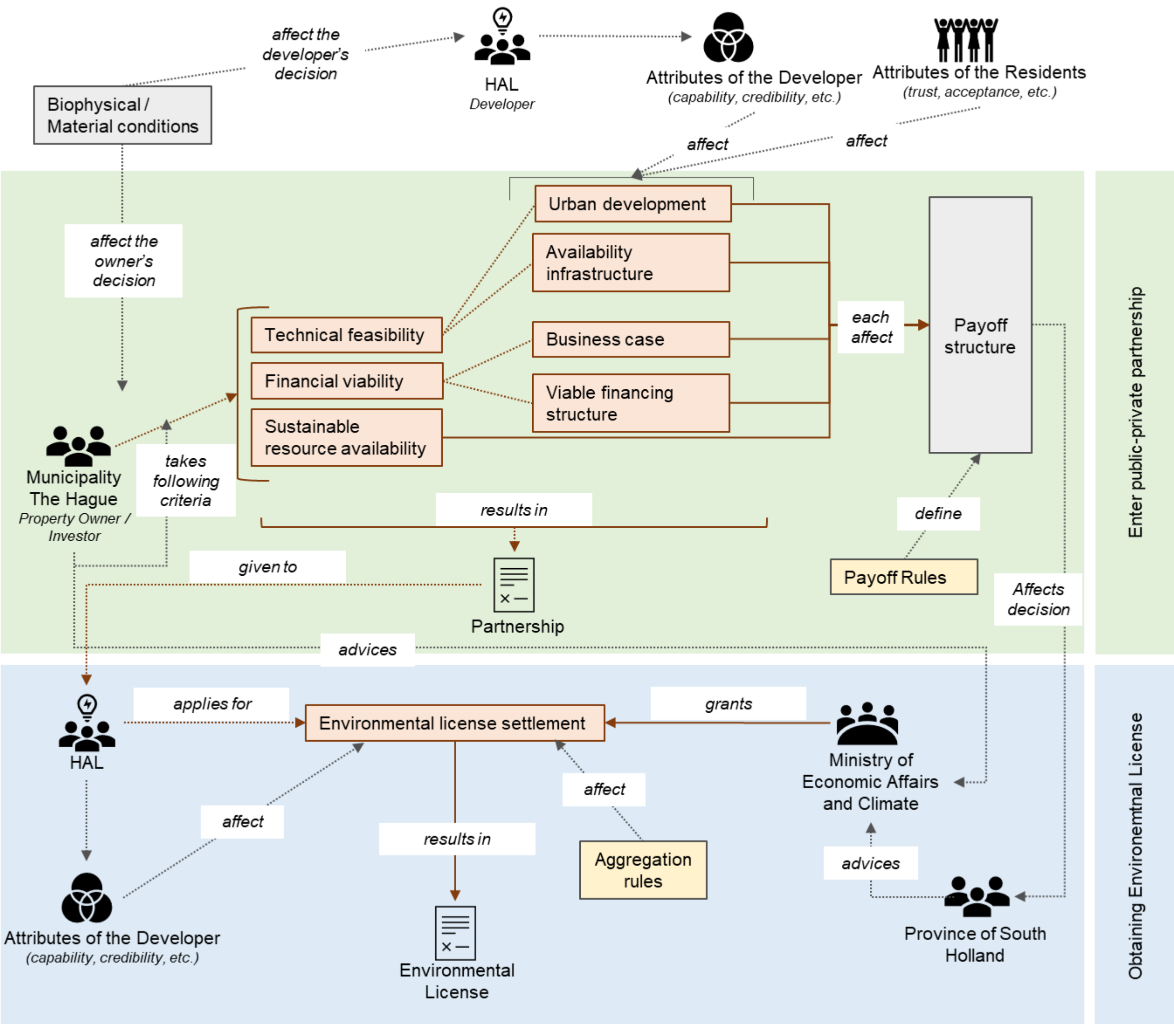

Figure 13: Actions and transactions within action arena - Project Leyweg

The **biophysical conditions** had one specific influence of interest. The original initiative was from the Municipality themselves. Therefore, there was already a significant amount of money invested in the project. Moreover, at the end of 2014 the opportunity arose for the municipality to purchase the wells from the trustee (de Snoo & van Aartsen, 2016). Therefore, the municipality had not only sustainability but also financial motives. There was some technical uncertainty present: the geothermal source had performed a test run for a short period of time, however it had not been used for several years (van Dun, 2022). Thus, the resource required cleaning, potential repairing and the drilling of a side-track, all quite close to a residential area in The Hague (Rösingh, 2022). However, even though the biophysical circumstances played a significant role in the trade-offs the different stakeholders *independently* made, it had no direct effect on the dynamics of interactions between the participants.

The **rules-in-use** and **community attributes** have been determined critical for the project process. First, the different positions of the stakeholders were for Leyweg important. Because of the expertise of Aardyn B.V. and PEP, the technical uncertainties were *perceived* as solvable (van Dun, 2022). The willingness of ED to bear a large part of the risks, made the entry barrier for the municipality significantly lower (Schoof, 2022). Lastly, the Municipality within the first action would sustain a facilitating role. The municipality would be making the necessary effort to grant the required permits for technical redevelopment of the geothermal heat source. Therefore the municipality would establish or grant an easement or contractual rights on the property installations and pipelines required for the redevelopment and exploitation of the source. As a result, the positions of the stakeholders and the specific payoffs resulting from that were decisive for the institutional arrangement in the first transaction. Both the rules-in-use and the community attributes were taken into account in the **evaluative criteria** for the geothermal system design. An overview of the most influential rules can be found in Table 5. A visualisation of all factors can be found in Figure 14.

Table 5: Authority Rule(s) and Payoff Rule(s) - Project Leyweg

	Position Rule(s)
	• Unconventional role distribution due to *newness* of project
Position	**Authority Rule(s)**
Property Owner *Municipality of The Hague*	• Power to direct activities on property. • Power to take action against the developing party if they fail to meet their responsibilities.
Developing parties *Aardyn B.V. and PEP*	• The right to manage the project on a daily basis and make decisions accordingly.
Investor *ED*	• The right to perform due diligence on the developing party. • The right to question the societal value of the project.
Position	**Payoff Rule(s)**
Property Owner *Municipality of The Hague*	• Achievement of an important spearhead of the 2014-2018 coalition agreement. • No financial loss.
Developing parties *Aardyn B.V. and PEP*	• Pioneer-knowledge about development of geothermal energy in urban areas. • Heat sales through specific contract.
Investor *ED*	• Project is in line with investment strategy. • Positive effect for residential community of the Hague.
	Scope Rule(s)
	• Limited scale due to first generation technology and surface location.
	Boundary Rule(s)
	• Early involvement municipality; • Small developing consortium;

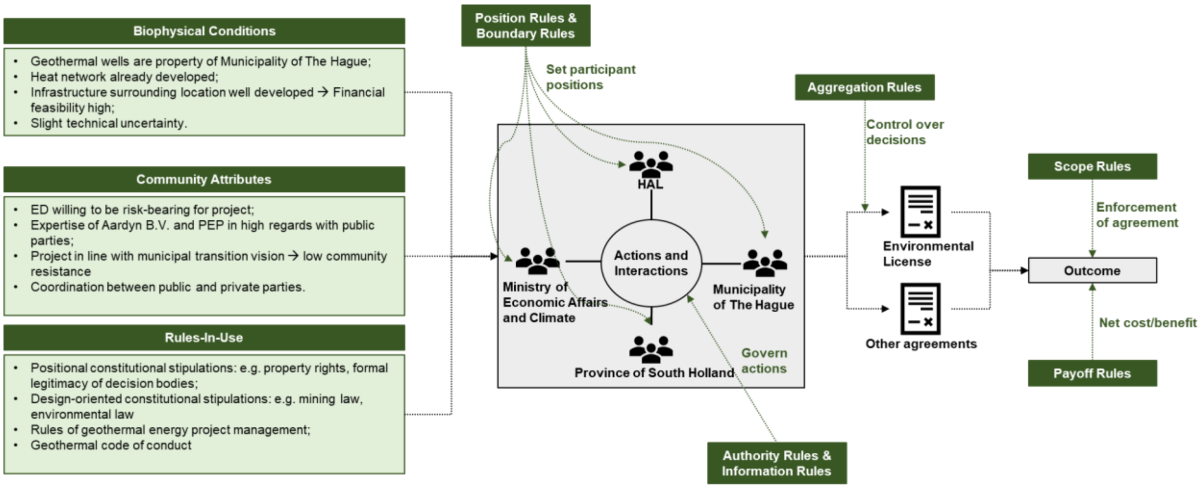

Figure 14: Overview interacting parties and external factors - Project Leyweg

5.4. OUTCOME: SUCCESSFUL IMPLEMENTATION

The previous parts have identified several factors which had affected the process development of project Leyweg and the decisions of the participants involved in the critical transaction. These factors had been identified through data coding. A brief overview of the important elements and the *cause(s)* of success in project Leyweg, can be seen in Figure 15.

- Elements from the policy stream matched timing with politics. This offered opportunity to initiate geothermal implementation.
- Within the action arena, the first transaction, *the public-private partnership establishment*, proved to be critical.
- Within the critical transaction, the payoff rules that affected the payoff structure in combination with the characteristics of the stakeholders as depicted in the community attributes proved to be most important as they were directly related to the evaluative criteria that were established.
- Community attributes affected the political stream significantly. The same goes for the biophysical conditions and the influence on the policy stream.

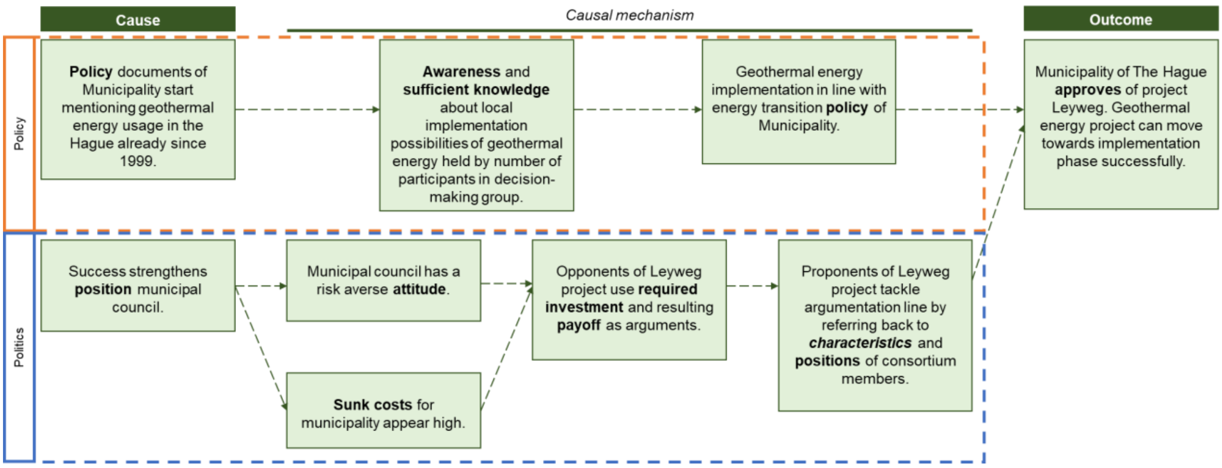

Figure 15: Process tracing - Case 01 Project Leyweg

6. LEAN PROJECT - UTRECHT

The goal of project LEAN in Utrecht was to conduct exploration drilling in order to extract geothermal energy in the province of Utrecht. ENGIE obtained in 2019 the exploration license for a specific area in the Province of Utrecht. However, in September 2021 the project initiators decided to stop project LEAN as it was not feasible anymore to continue. How the policy process proceeded, which institutions were involved with the critical transaction that led to the hold of the project will be explained in this chapter. First there will be an overview that explains the project development with important events and the key stakeholders will be elaborated on. Secondly, the pre-existing policy circumstances will be analysed for the LEAN Project. Thirdly, the patterns of interactions within the critical transaction and how these led to the outcome will explained. Lastly, the chapter will conclude with a brief result section that holds an overview of the important variables and how they relate to the outcome of the LEAN project.

6.1. CASE OVERVIEW

The LEAN demonstration project, which stands for Low-cost Exploration And deriskiNg of geothermal plays in white spot areas: the rotliegend demonstrator, conducted research on geothermal energy in the province of Utrecht (van der Ee, 2019). The goal was to conduct exploration drilling in order to extract geothermal energy and to supply it to Eneco's heat network. **Warmtebron LEAN**, the project consortium, is made up of ENGIE, Huisman, TNO, Utrecht University, IF Technology, EBN, WEP, and Eneco. The project started in December of 2016 when **ENGIE** announced to build two geothermal doublets in mid-2017 for both the projects LEAN and GOLD (Peijster, 2022). Warmtebron Utrecht is the result of the joint branding of the two projects. In May 2018, ENGIE applied to the competent body, the Ministry of Economic Affairs, for a geothermal energy exploration permit for a broad exploration region around the municipality of Utrecht. Based on a reinterpretation of old geological research data, it was explored at the beginning of 2019 where in the exploration region possibly acceptable geothermal layers were present for LEAN, what the expected temperature of these layers is, and whether these layers display fractures (TNO & Universiteit van Utrecht, 2020).

The subsurface potential was then projected on the location of ENECO's heat network in Utrecht and Nieuwegein in April 2019 (TNO & Universiteit van Utrecht, 2020). The municipalities of **Utrecht** and **Nieuwegein**, as well as the province of Utrecht, were involved in the search for prospective areas outside of drilling-free zones that are not contaminated and had the size of about a football field. Warmtebron Utrecht evaluated 12 areas, which resulted the feasibility study of Royal Haskoning, based on district heating connectivity, distance to buildings, above ground space, distance to geological target, and logistics space (Peijster & Janse de Jonge, 2020). All the eliminations led to the conclusion that **corner Zuidstede** was the best suitable location to drill (Peijster, 2021; Steffens et al., 2020). However, shortly after the location announcement, the municipality announced that they needed more time to create an **assessment framework** for geothermal energy in order to estimate the efficiency of the LEAN project on that certain location (De digitale Nieuwegein, 2021). Shortly thereafter, project manager Peijster announced that there would be a temporarily hold on the activities until it would have been clear for both sides, the municipality and the consortium, what could be the next possible steps (Peijster, 2021b). Unfortunately, this led to a **definite stop** in September that same year (Warmtebron Utrecht, 2021).

By means of coding the aforementioned information, a timeline was visualised in Figure 16 and a closer look will be taken on the **key stakeholders** that were involved in the process of the LEAN project. A more elaborate description of the stakeholders can be found in Appendix VI: Case 02 – Background Information.

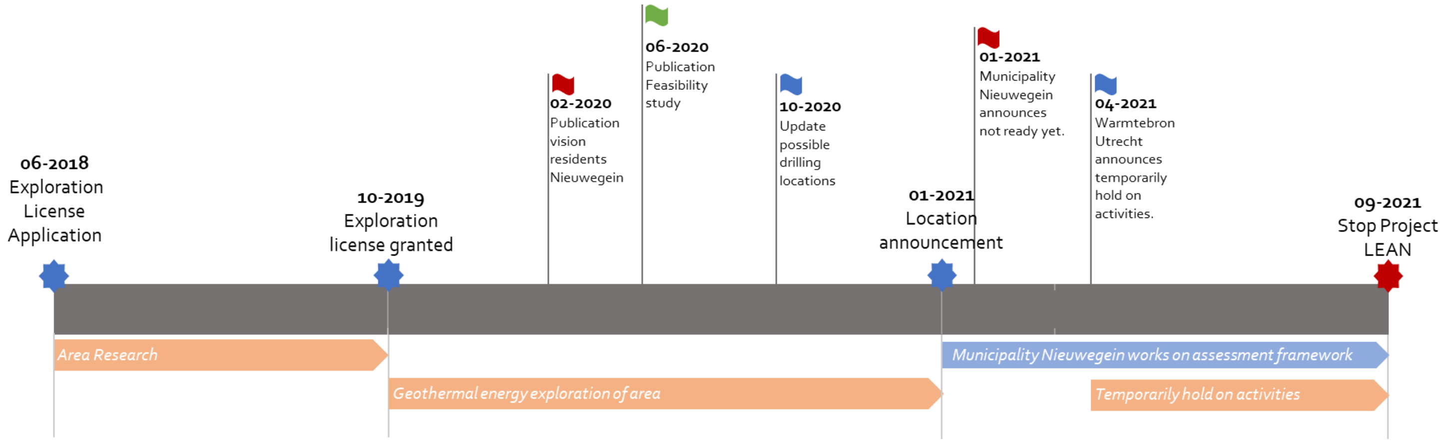

Figure 16: Visualisation timeline project LEAN (Utrecht)

In brief, the LEAN consortium includes not only public knowledge institutions like TNO and **Utrecht University**, but also market players like ENGIE and Huisman (Steffens et al., 2020). **TNO** and the university add knowledge and research to the consortium (TNO & Universiteit van Utrecht, 2020). **ENGIE** has the requisite knowledge with geothermal energy from its French parent firm, in addition to a broad perspective on the development of energy projects (ENGIE, 2020). **Huisman Geo** has extensive drilling knowledge and experience both in the Netherlands and overseas (Huisman, 2017). With the geothermal energy business, **EBN** shares its understanding of the Dutch subsurface gained via oil and gas extraction (Geothermie Nederland & EBN, 2021). **IF Technology** contributes to subsurface analysis as one of the most advanced agencies in the Netherlands. They are part of the consortium, but are no shareholder. The underground part of the project is being engineered by **Well Engineering Partners** (WE-P, 2019). Finally, **Eneco** was mentioned as a potential geothermal energy buyer and owner of the Utrecht district heating network (de Voogt, 2021).

The **municipalities** of **Nieuwegein** and **Utrecht** were probable locations for the LEAN project. Both of these municipalities have their own sustainability and energy transition visions and policies. The Municipality of Utrecht was taking part in research into geothermal energy extraction as well as the feasibility of the LEAN project (Steffens et al., 2020). The municipality of Utrecht believed that the project and the potential fulfilment of the LEAN project would have been a step in the right direction towards realising Utrecht's goal of becoming a climate-neutral city. The municipality of Nieuwegein has an infrastructure with 50% of houses connected to the district heating system, and it's the owner of the ground on which the potential geothermal facility would have been built (Steffens et al., 2020). Lastly, the **province of Utrecht** fosters and supports (financial) research into the application of geothermal energy, including the LEAN project (Warmtebron Utrecht, 2019a).

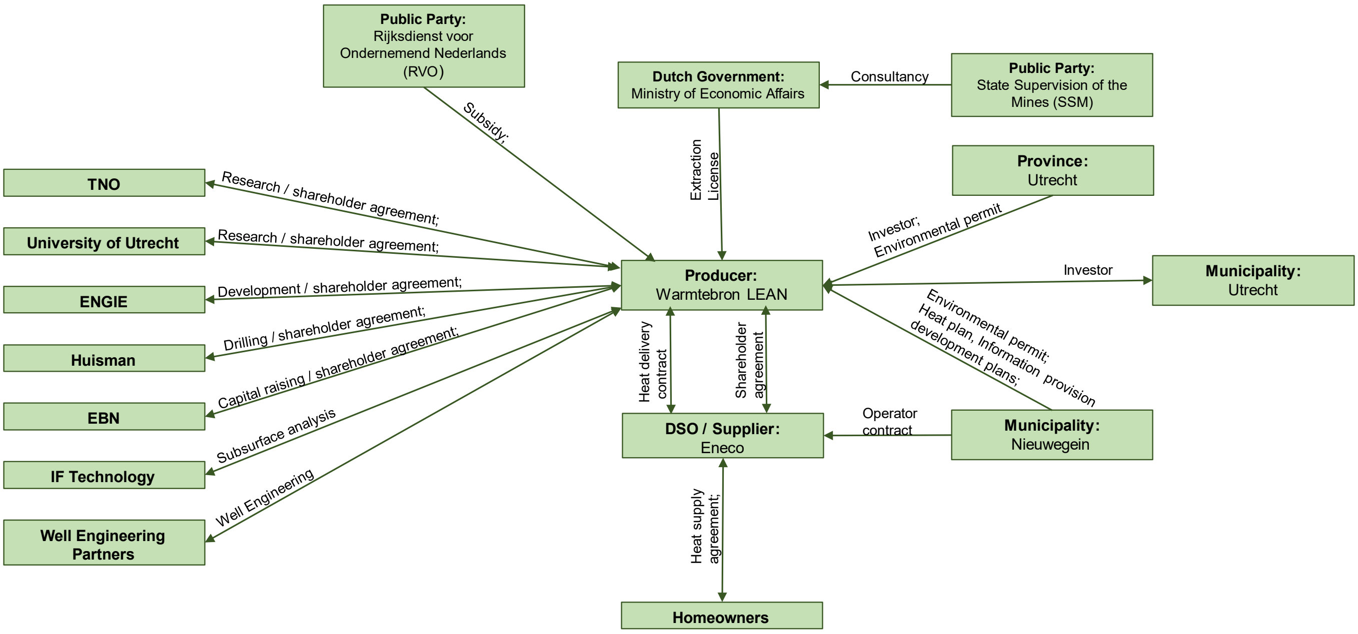

Figure 17: Stakeholder analysis - project LEAN

6.2. PRE-EXISTING CIRCUMSTANCES

Process-wise, the geothermal implementation of the LEAN project was **successful**: it reflected innovation, information was plentiful and stakeholders have gained experience in urban implementation of geothermal energy. At the same time, the procedure was met with some public and bureaucratic criticism after that. Meanwhile, the **initiative** was mostly **unsuccessful**: while it appeared to meet the Province of Utrecht's sustainability objectives, the anticipated effects were not completely realised, unforeseen consequences developed, and criticism grew over time. Looking at the elements of the theoretical framework it can be stated what developments led to project LEAN to be called *unsuccessful*.

The **problem stream** shows one important focussing event that occurs at the start of the policy process: TNO submitted a subsidy application to the Netherlands Enterprise Agency (RvO) for geothermal energy research for the demonstration and de-risk project LEAN, and the Province and Municipality of Utrecht formalised their collaboration with the consortium partners to further develop this project (van Wees et al., 2020).

During the exploration phase of project LEAN, the **policy stream** shows developments at national and local level. Minister Wiebes of the Ministry of Economic Affairs and Climate declared in 2018 that a change in procedures was required for the geothermal energy sector, which was expected to happen by 2020 (Wiebes, 2018). The government unveiled the national Climate Agreement in June 2019, with aims of a 49% decrease in CO_2-emissions in 2030 and a 95% reduction in 2050 compared to 1990 (Gooijer & Mennen, 2021). On the basis of this agreement, two observations can be made: the sector's ambition is in accordance with the ambitious aims for geothermal energy implementation during this period; the concrete implementation would have to be done locally in the Regional Energy Strategies (Gooijer & Mennen, 2021). Following that, the province of Utrecht was tasked with developing an adequate energy transition policy, and they released the programme plan 2020-2025, in which it stated that they would actively encourage sustainable energy projects (Team Energietransitie, 2019). The province initially produced a programme plan outlining their concrete sustainability targets for the years 2020-2025, and then played a major role in developing an investor-friendly support environment for sustainable technologies such as geothermal energy. While the programme plan was independent in theory, the Province's municipalities were consulted for the design of the plans.

Thus, the submission of TNO fitted the values of the policy community members, the Municipality and Province of Utrecht. What is more, is that **politicians** actively advertised the role and importance of the energy transition. Hence, LEAN consortium's collaboration among bureaucratic and private agencies improved the project's technical feasibility and financial viability (Warmtebron Utrecht, 2019a, 2019b), as well as attracting new partners to the coalition. Partially connection between the policy and politics streams can be seen at this point: high ability of the province and municipality of Utrecht, a favourable balance of interests among the consortium participants, a feasible policy solution, and cooperation between the two streams' stakeholders. This isn't to say that the problem stream didn't play a part in the project's early success; it just wasn't as important at the time.

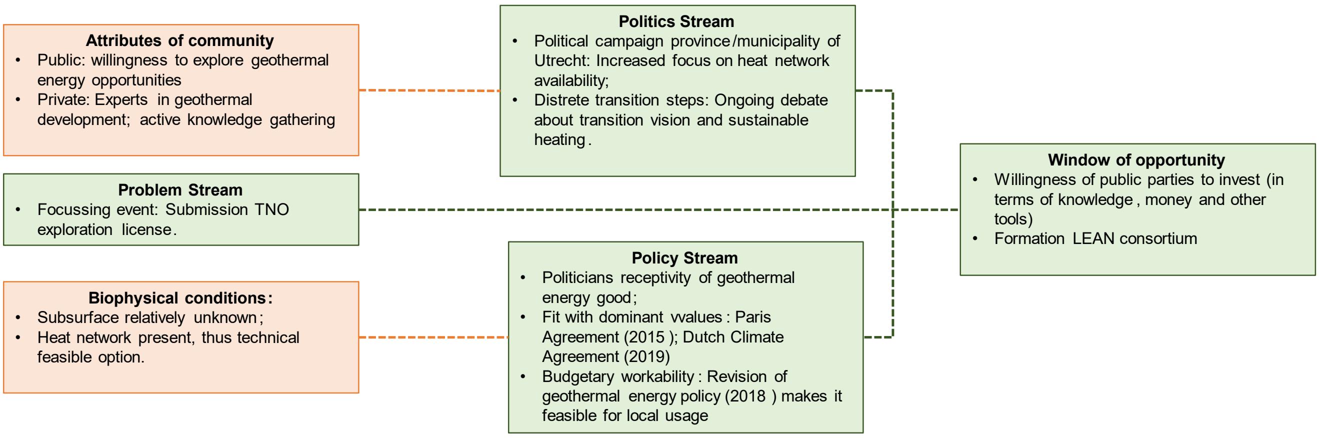

Figure 18: Coupling different streams - project LEAN

The **policy stream** however, started to show different movements after the initial start of the project. The allocation of a concrete drilling position proved to be difficult, as expected (Peijster, 2022). While the consortium had originally planned to carry out the project in the municipality of Utrecht, the **feasibility assessment** conducted by Royal HaskoningDHV and subsequent research revealed that the project's technical feasibility required it to be carried out in the municipality of Nieuwegein (Steffens et al., 2020). Parallel to the changes in the policy stream, the **problem stream** shows two causal focussing events. A small party of the residents publicly notified the politicians about their concerns of the geothermal energy implementation, which is partly caused by the earthquakes in Groningen in 2012 and the thereafter perceived safety of drilling technologies.

The **political stream** showed at this point in time a different political landscape. Due to the municipality of Nieuwegein's announcement that they required more time to assess the geothermal project, project LEAN was placed on hold through agenda denial in early 2021 (Geijsman & de Wit, 2021). Furthermore, discontent grew as a result of the project allocation. Due to various events that occurred in Huizinge in 2012 (Dost & Kraaijpoel, 2013), the residents became apprehensive of project LEAN and had a general suspicion of the national governmental parties participating in the licencing procedure (ban-groep, 2020; Jongerius, 2022). With political and sustainable arguments (f.e. How the LEAN consortium would not be able to provide adequate potential damage support), political willingness to support the project dwindled, decoupling policy and politics. The municipality had stated that no projects such as LEAN would be allocated until they had developed a clear policy (assessment framework) (Geijsman & de Wit, 2021). This suggests that the problem and the politics were only loosely connected at this point in time. This, along with resident opposition, caused a shift in the consortium partners' perceptions of project LEAN's financial viability, and the process to implementation geothermal energy was labelled as ***unsuccessful***.

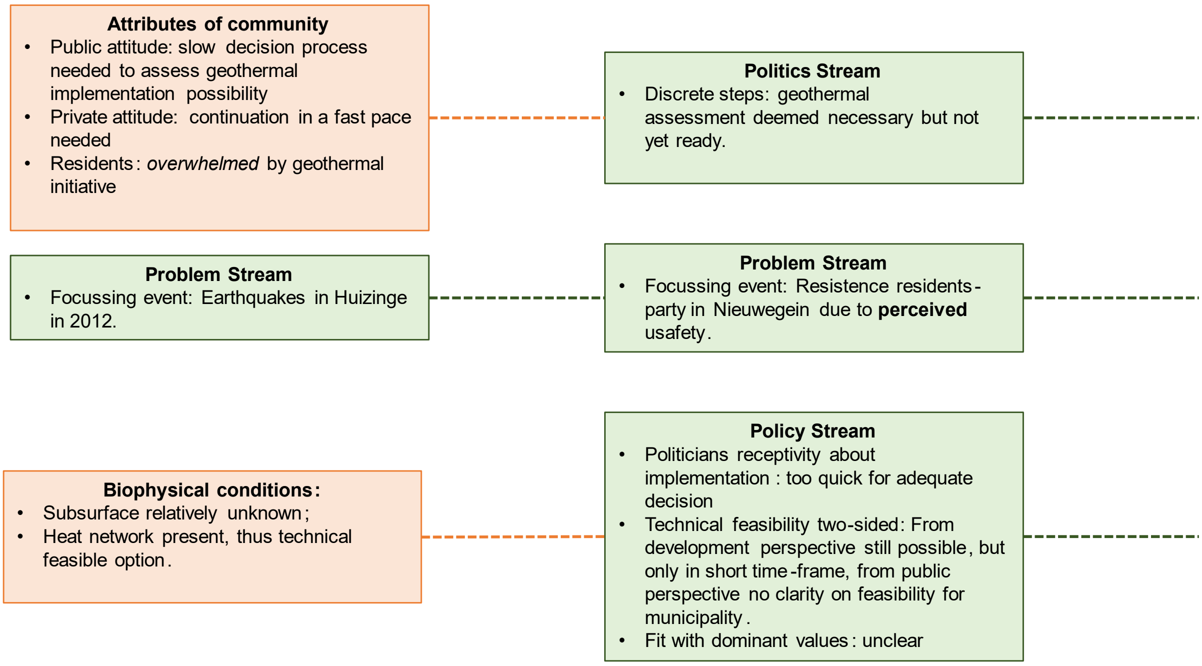

Figure 19: Uncoupling streams - project LEAN

The decision of the municipality that they needed more time to assess the geothermal implementation was mentioned as the moment in time the project did not seem feasible anymore for the developing party. However, it is (yet) unclear *why* exactly the implementation was unsuccessful. In order to find out, the transaction needs to be explored in more detail. This will be done in the following part.

6.3. PATTERNS OF INTERACTION

The **action arena** can be characterised as of *collective choice level* as decisions were made to put in place a specific infrastructure – the LEAN project in the municipality of Nieuwegein's urban environment. As previously stated, the Corner Zuidstede location was determined to be the best fit for the project by Warmtebron LEAN (Peijster, 2021a). The exploration phase had come to an end with the announcement of this location, and it was up to Warmtebron Utrecht to begin constructing the test drilling installation. An environmental license is required by law for this action (Sayginer, 2022), which can therefore be considered as an important **transaction**. The operator had to request this from the Ministry of Economic Affairs and

Climate. The municipality and the province have the authority to give advice on permit issuance (Sayginer, 2022).

However, Warmtebron LEAN needed first obtain authorization from the landowner, the municipality, to carry out the activities before submitting an application for a permit. The municipality agrees to make the location available for follow-up investigations by signing the Model Permission (van Essen & Bruins Slot, 2019). The Model Permission does not yet permit the renting, selling, or leasing of land or the circumstances associated with it. The municipality had informed RVO in 2019 already that they intended to establish a meticulous approach with the environment before deciding whether or not to make their property available (van Essen & Bruins Slot, 2019). This approval was also required for Warmtebron Utrecht's SDE+ subsidy application. Therefore, within the action arena, there are **two transactions** observed: obtaining permission for property usage by the Municipality and obtaining the environmental license.

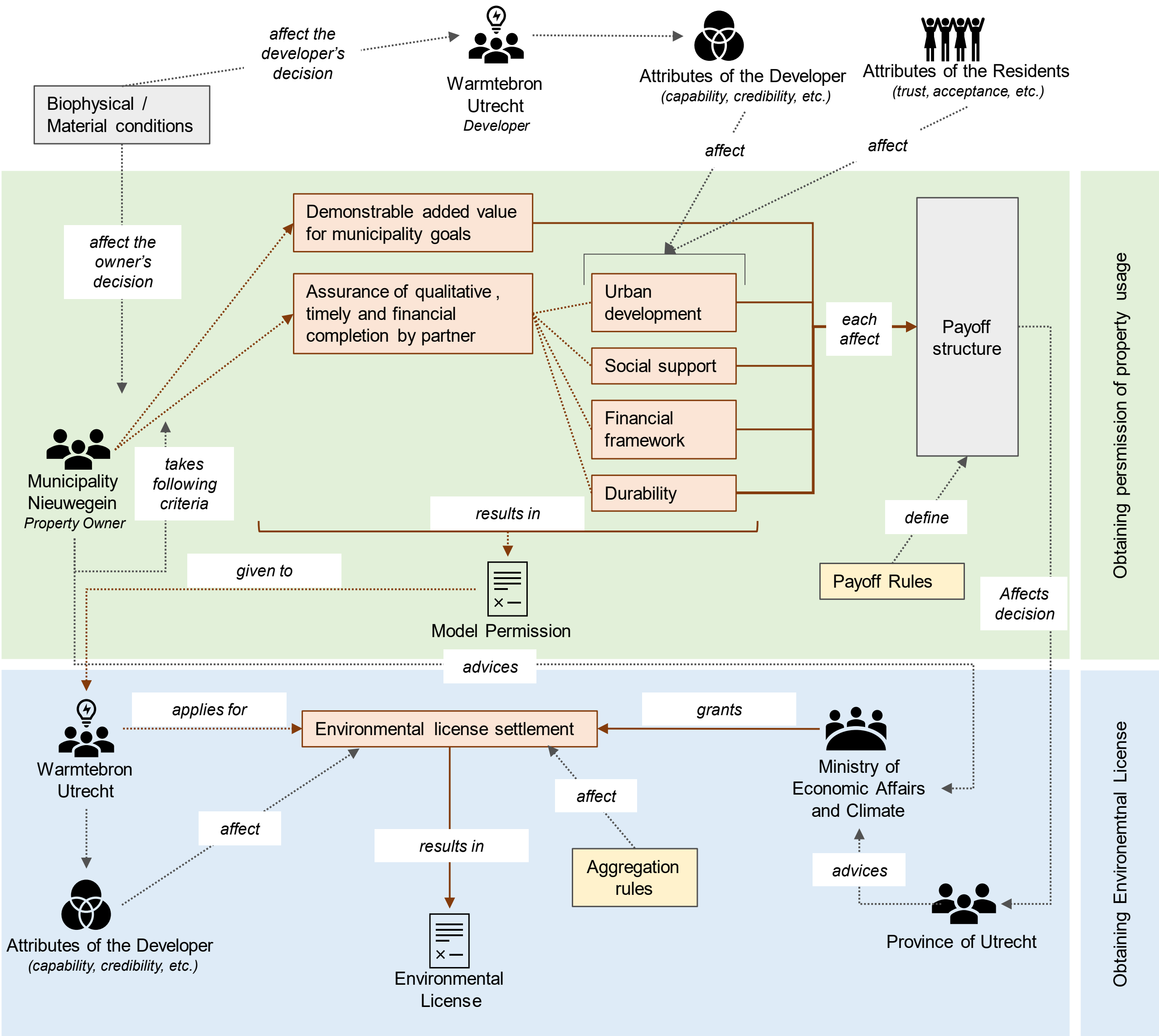

Figure 20: Actions and transactions within action arena - project LEAN

The interconnectedness of the events and interactions taking place in the action arena is depicted in Figure 20. As a result, it's critical to dig further into the factors that have a substantial impact on participants' decisions. Figure 20 does not show all of the causes and how they affect the actions. For example, the scope regulations, which deal with enforcing the agreement in order to avoid expropriation or temporal inconsistency issues. More information about these factors can be found in Appendix VI: Case 02 – Background Information.

The **biophysical conditions** had no substantial impact on the action situation in this case. Based on the estimated composition of the subsoil, the depth of the drilling, the flow rate, and temperature of re-injected water, among other factors, PanTerra assessed the chance of earthquake events for LEAN as *'medium'* in their analysis based on information available at that time (Panterra, 2020). This assessment did not include a QRA, which is mandatory but comes at a later stage in time, and would have, if applied appropriately, reduced the risk to *'negligible'.* Furthermore, the location was deemed financially feasible for Warmtebron LEAN (Peijster, 2021a; Steffens, 2022). It was discovered that biophysical factors such as those described above had no effect on the direct dynamics of interactions between participants.

The **rules-in-use** and **community attributes** have been determined critical for the action situation. First, it was discovered that the fact that the LEAN consortium was a *geothermal* developer considerably influenced the municipality's consideration criteria in the first transaction. As a result, the asset specificity of the sustainable technology did not meet the municipality's evaluative criteria. The residents' stance toward the geothermal energy implementation also influenced the consideration criteria. Both of these community characteristics appear to emphasise the policy-making arena's direct political exposure. Second, in both transactions, the payoff structure, influenced by the payoff rules, can be seen to be a central focus. The existing regulatory structure permits the developer to get government support in the form of a subsidy from the Dutch government (ECN & Lensink, 2013). However, the developing party cannot obtain this advantage until the property owner, in this case the Municipality, has granted approval for their activity. In addition, the payoff structure has an impact on the Province's and Municipality's advice in terms of the priority of the energy transition. Both the municipality and the province found the project's relevance ambiguous: on the one hand, it was deemed necessary that a few geothermal energy projects get off the ground in the area (to gather knowledge about the deep subsurface), on the other hand, the municipality had several options for improving local heat supply that had not been traded off with geothermal energy (Geijsman & de Wit, 2021; Panterra, 2020). As a result, the time that was deemed necessary for the decision-making process did not match the pace needed to efficiently, and more importantly financially feasible, implement the geothermal energy. The authority rules embodied in current Dutch legislation combined with the informal payoff rules appear to be inefficient for geothermal energy implementation in project LEAN. An overview of the most influential formal and informal rules can be found in Table 6. An visualisation of all factors as explained can be found in Figure 21.

Table 6: Authority Rule(s) and Payoff Rule(s) - Project LEAN

	Position Rule(s)
	• Changing role of the municipality during the process.
Position	**Authority Rule(s)**
Property Owner *Municipality of Nieuwegein*	• Power to decide over activities taking place. • Power to decide design heating infrastructure.
Developing parties *Warmtebron Utrecht*	• The right to conduct research and (sub)surface exploration.
Province of Utrecht	• The right to question the sustainability aspects of project and withdraw potential investment(s) in case project goals do not align with provincial goals.
Position	**Payoff Rule(s)**
Property Owner *Municipality of Nieuwegein*	• Achievement a more sustainable form of heating.
Developing parties *Warmtebron Utrecht*	• Pioneer-knowledge about development of geothermal energy in urban areas. • Heat sales through specific contract.
Advisors *Municipality of Utrecht / Province of Utrecht*	• Knowledge gain about subsurface in province of Utrecht.
	Scope Rule(s)
	• Limited time-frame due to governmental procedures (f.e. subsidy)
	Boundary Rule(s)
	• Gaining support of public (party) as a condition to reach demand.

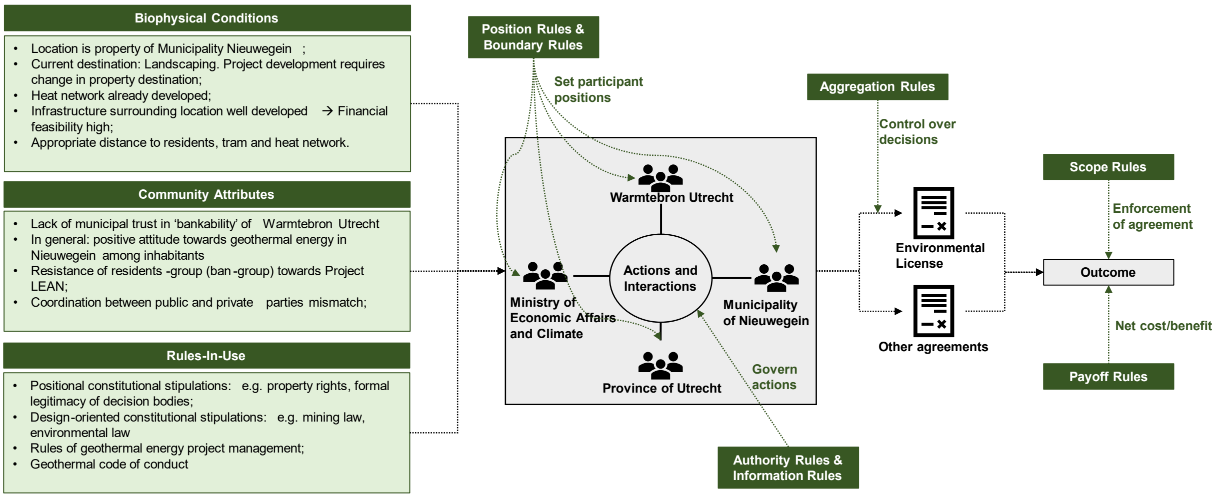

Figure 21: Overview interacting parties and external factors - Project LEAN

6.4. OUTCOME: NO IMPLEMENTATION

The previous parts have identified several factor which had their influence toward the process development of the LEAN project and the decisions of the participants involved in the critical transaction. These factors had been identified through data coding. A brief overview of the important elements and the *cause* of no success in Project LEAN can be seen in Figure 22.

- The matching of politics a policy ensured an adequate start for the LEAN project. However, the change of municipal grounds resulted in a change of political arena. Therefore, later on the elements from the policy and political stream did no longer matched.
- The biophysical conditions were not considered critical for the interactions within the action area. Interestingly, the biophysical conditions were in interviews named as a driving force for the initiation of project LEAN. However, the policy and political streams did not show any signs of this. There was feedback to the policy stream considering the infrastructure of system in place. Nevertheless, the design of the program plan of Utrecht with the biophysical condition of a heat network being present did lead to significant investor interest of private parties at the start.
- The community attributes seem to underline the political circumstances of the action arena and played a central role in the outcome of the LEAN project.
- The institutional arrangement of the action arena was deemed inefficient for continuation of project LEAN.

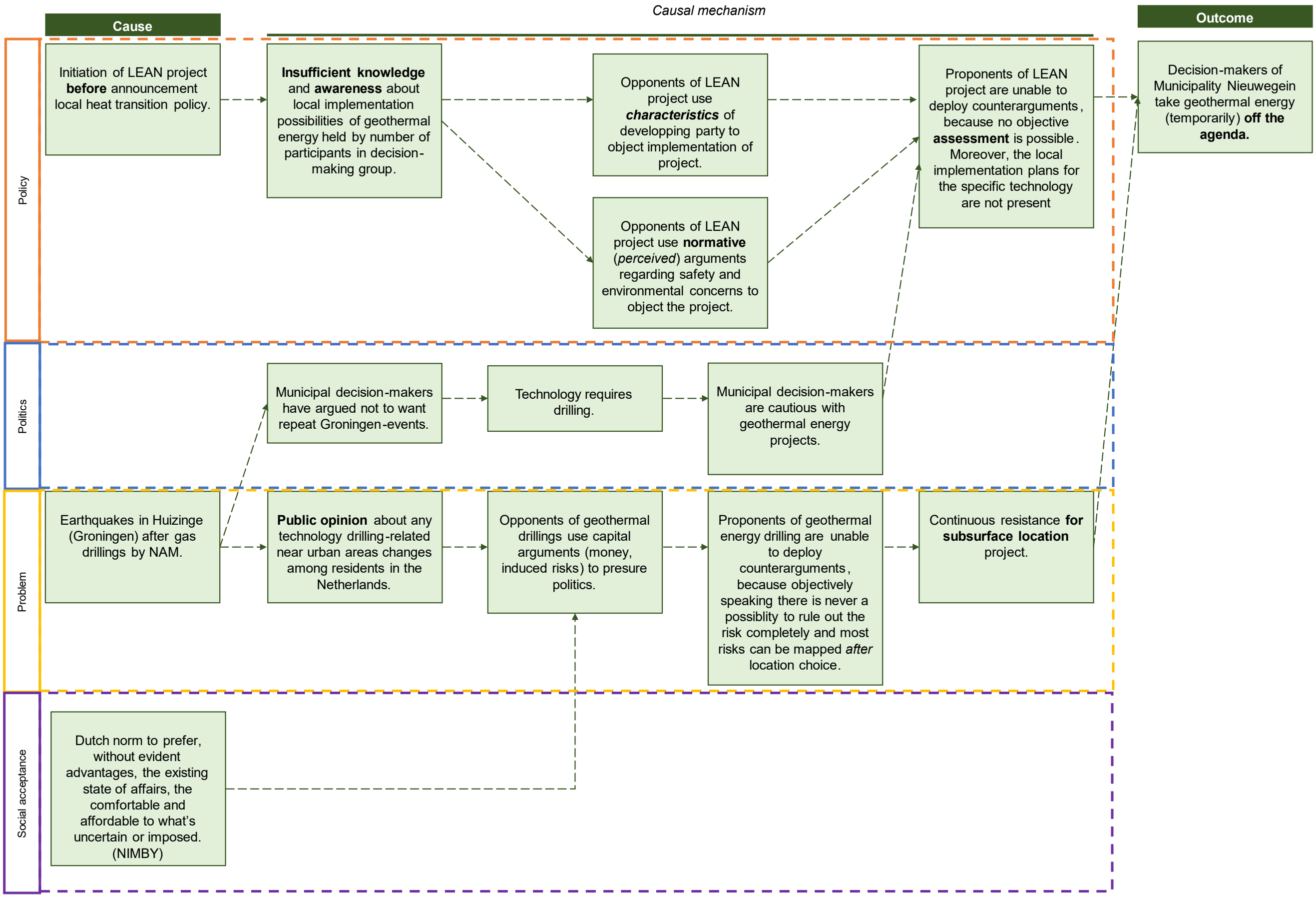

Figure 22: Process tracing - Case 02 Project LEAN

7. COMPARATIVE CASE ANALYSIS

Are there similarities and dissimilarities concerning the policy implementation of geothermal energy in urban areas and can these potential differences be explained by the institutional interactions? This question is relevant to be able to contribute to the hypothesis of the importance of including institutional interactions in policy implementation. Two types of comparison are conducted in this research: 1) a pairwise comparison of selected variables used in the research, to understand similarities and differences of the cases; 2) a cross-case comparison of both cases using a limited set a variables, to investigate the current state of institutional interactions within geothermal energy implementation as well as most significant potentials for future urban development.

7.1. PAIRWISE COMPARISON

Revisiting the outcomes of Project Leyweg and Project LEAN in Figure 15 and Figure 22, this Table 8 compares the most noteworthy factors. Before looking at the differences, a brief overview is shown of factors that were comparable in both cases.

Table 7: Similarities between case Leyweg and case LEAN

Similarities between cases	
	Pre-existing variables
Problem Stream	• **Demand driven** due to required capacity in urban areas. • **Need** for sustainable heating present among inhabitants.
	Patterns of Interactions
Biophysical Conditions	
Physical Conditions	**Infrastructure** for collective heating in place.
Economic Conditions	Subsidies present, high **upfront costs** for project.
Rules	
Boundary Rules	**Selection criteria** consider the developing party's responsibilities, knowledge, as well as the potential affected users.
Scope Rules	**Institutions match** with ecological scale to determine geothermal allocation and efficient environmental outcomes.
Choice Rules	(Geothermal) activities are specified through choice limitations in **mining law**, **environmental law**, and **heat act**. All legislation involved determined the positions of different stakeholders.
Evaluative criteria	
Municipal criteria	Fit with urban **development plans**, offers sustainable and **durable** heating option and add value to **society**.
Developer's criteria	**Technical** feasible, **economical** viable, proven sustainable resource **available**.

Table 7 shows that the biophysical conditions and some of the rules can be seen as comparable. This was to be expected as the cases were selected based on specific criteria in order to observe the implementation of geothermal energy in similar settings. The **boundary rules** were both in the decision-making processes promoting and limiting the initiative. It was promoting that in both cases the project initiators formed a partnership with (geothermal) experts which then were part of the project. The enrolment of more stakeholders, which expanded in both cases the resource base of the geothermal innovation, was an effective *strategy*. In the project Leyweg, the local government had established strict financial criteria that the project had to meet to be allowed to take on the restart of the geothermal wells and development of envisioned renewable district heating connection. The impact of **choice rules** on the decision-making procedures both stimulated and limited the introduction of geothermal energy in both projects. The decisions made by both municipalities to install a district heating grid might be viewed as a first trigger. On the downside, project LEAN demonstrated how choice rules can also be disabling in the case of geothermal energy implementation. Interestingly, the **evaluative criteria** were also quite similar for the outcome of the geothermal energy implementation. Nevertheless, the outcome of the cases was not the same.

Even more intriguing than the similarities are the differences between the cases. First of all, while both cases demonstrate an increased awareness of the need to speed up the energy transition, there is one significant distinction between **problem streams** in both cases. Apart from the need to speed up the energy transition, there was no specific focus event or indicators over time that emphasized the problematic nature of this and the importance of geothermal energy implementation. On the other hand, after the earth quakes in Groningen in 2012, drilling technology in general was gaining prominence as a key issue from 2012 onwards. This issue was extensively recognised and addressed by developers in the geothermal sector (Peijster, 2022; Rösingh, 2022; van Dun, 2022) and public parties (Jharap & Trienekens, 2022; Jongerius, 2022). The issue of the nature of geothermal energy technology and geothermal energy implementation was initially not linked to each other, but came forward later in the project. Within the **political stream** there was one significant difference. The municipality of The Hague had already history with the Leyweg project and therefore success of the project could mean strengthening of the coalition's position. Another significant difference in the political stream between Leyweg and LEAN can be observed in the *national mood*. Whereas in project Leyweg the public orientation was largely positive and favoured the geothermal energy project, the public orientation had shifted from general acceptance to a more divided perspective in case LEAN. The shift is a consequence of several factors including the earth quakes in Groningen in 2012. When looking at the **policy stream**, municipal policy was essential due to the local implementation of geothermal energy. In the Leyweg project, the municipal decision-makers were effective in generating solutions that were debated and refined. In contrast with the LEAN project, where the policy was made on municipal decision-makers did create a collection of possibilities, but did not match timewise with the scheduled implementation plans. In both cases, it is clear that geothermal energy was not directly tied to the problem stream, but held connections to the politics stream.

Second of all, it was observed that the first **transaction** within the action arena of both cases could be considered critical. The biophysical conditions can be seen as an initial stimulant for the project initiating, however it was shown that the **attributes of the community** and **rules-in-use** had significant influence on the patterns of interaction and decision-making process. The way the Dutch law currently prescribes certain governmental parties tasks, severely limits the actions of the organisations.

The roles and responsibilities stayed more or less the same during the geothermal implementation process of both cases, and stakeholders could incorporate their expertise. **Position rules** "determine the roles and position of the participating stakeholders" (Polski & Ostrom, 1999). Due to the early involvement of the municipality in case Leyweg, the stakeholder composition was affected in an informal way. This resulted in a different positioning of the stakeholders and was a significant difference with the LEAN case, where this was not the case. Therefore, the informal way stakeholders organized themselves differentiated and the municipality implicitly had a different position in the implementation process.

Table 8: Pairwise comparison case Leyweg and case LEAN

	Case 01: Project Leyweg	Case 02: Project LEAN
		Pre-existing variables
Policy Stream	• Geothermal **policy** was presented **early** on in process. • Coalition agreement 2014-2018 emphasizes local heat production. • Geothermal energy as a means to deal with growing sustainability awareness and succeed local policy goals.	• In 2017 the Municipality showed a local roadmap to sustainability, however only in 2021 the specific *transition vision* appeared with a heating strategy per neighbourhood. In this transition vision there is **no specific focus** on geothermal energy.
Politics Stream	• Increased focus on **political success** and sunk costs of project.	• Public orientation was largely negative regarding geothermal energy development. • Change of political arena due to change in location.
Problem Stream	• Technical **uncertainty** due to bankruptcy.	• Initiative after **events in Groningen**.
Policy Window and Policy Entrepreneur	• **Municipality acquired** geothermal wells in 2014 and politician Baldeswingh pushed implementation forward.	-
		Patterns of Interactions
Biophysical Conditions		
Economic Conditions	• ED fund as public investor • Municipality of The Hague as additional investor	• Province of Utrecht as public investor
Available Means ("other")	• **Awareness** and **urgency** at both public and private side.	• **Lack** of urgency, knowledge and awareness on public side. • **Momentum** for sustainable heating introduction due to national events.
Attributes of Community		
Attitudes of stakeholders	• Clear overall **target** of project • Trust in consortium. Members developing and operating the geothermal installation. • Good relationship between public and private parties.	• Lack of specific target of project at municipality. • Hesitation from public side regarding responsibilities of developing consortium. • Differing perception on level of participation and development pace.
Residents involvement	• **Important role** for inhabitants in municipal policy *"Haagse Kracht".*	• Support from the neighbourhood required to acquire position in district heating system.
Rules		
Position Rules	• Local government takes **proactive role** in development.	• Local government acts as **regulator** more than promoter of development.
Scope Rules	• **Limited scale** due to first generation technology.	• Implementation in urban area regarded as **non-ideal**.
Information Rules	• **Widely available** knowledge about subsurface due to rich history.	• **Little** availability of **information** on the subsurface required additional time and effort to determine a location. • **Transparency** between Warmtebron Utrecht, Municipal parties and residents.
Aggregation Rules	• Municipality has **clear view** on district heating and role geothermal project.	• Municipality has **not** yet made the **concrete decision** for type of district heating, but is the stakeholder to do so.
Payoff Rules	• Financially and technically **feasible** business case.	• Benefits and losses are **not agreed** upon between parties from an economic-oriented perspective, which considers impacts and causalities.

In both cases the **payoff rules** strongly influenced the decision-making processes on the introduction of geothermal energy in the local environment. Although subsidies can help projects materialise, in both situations the goals of the initiatives were not achieved by just awarding the subsidies. Studying the successful case showed that the decision-making procedure benefitted from having rigid guidelines on how costs and benefits are shared. All consortium members discussed and came to an agreement on how costs were to be shared, but in the end, it was the clarity regarding which stakeholder is responsible for which risks that proved to be the deciding factor. In project LEAN, the path dependency of choices led to an insufficient cost-benefit ratio which was determining for the process. The difference can be explained by two factors. First, the municipality of The Hague already had stakes in the project and thus urgently wanted to come to a feasible business plan to cover their *upfront stakes*. This influence the payoff in the first case greatly. In the LEAN case, this was not present: the payoff structure had to be decided upon from scratch, which took (too much) time and required lengthy discussions. Second, more information was present in the Leyweg case about the subsurface. This made is easier for the participants to trade-off the benefits of the payoff.

7.2. EMERGING THEMES

Generalizing these case findings to theory offers several emerging themes. Process tracing revealed for project Leyweg that the geothermal energy initiative emerged when a policy entrepreneur placed the *issue* on the agenda. This **top down approach** ensured alignment between politics and policy, helping the process move forward to implementation. Project LEAN emphasized how the absence of this factor proved to be significant in hindering. The analysis showed that *the issue* does not necessarily need to be present, but that the matching of policy and politics result in a successful policy process.

Furthermore, it can be inferred from the analysis that the **policy-making arena** is **directly** exposed to **political circumstances**. A policy which adopts a geothermal energy project such as project Leyweg and project LEAN may cause polarisation if the enforcement of one has an impact on the general public interest. There are two observations that can be made regarding this point. Firstly, the analysis showed that attributes of the developing party and attributes of the residents affected indeed the political stream. This was the case in both project Leyweg as Project LEAN. Government parties, the municipality and the Province, used in both cases for example the argument of bankability of the developing parties. Both cases slightly differ when it comes to the term *bankability*. In the Leyweg case, municipal parties were resistant due to the high upfront costs of the project in general (Omroep West, 2015). In the LEAN case, parties deemed it difficult to recover potential damage from the company SPV LEAN, which was specifically established for the drilling, and were therefore hesitant (De digitale Nieuwegein, 2021; Panterra, 2020). Secondly, it has been mentioned multiple times how the residents perceived a technology that employs drilling as less safe and that other environmental concerns were raised. However, both cases underline the critical position of the attributes of the residential community. As depicted in Appendix V Action Arena: Heat Governance, the retail of the heat influences the payoff greatly. The retail price of heat from collective heating is a sensitive matter which affects residents directly (McDonald, 2019). Meanwhile, the purchase of heat from the renewable energy resource is considered to be a burden to the heat operator's cost of supply (Yılmaz Balaman & Selim, 2016). Both arguments outline the centrality of the payoff rules in the policy stream. The analysis of both reveals that the system has a propensity to repeatedly run into the issue of time inconsistency because of the dynamics present in the collective-choice arena. Table 9 shows the influences of institutions on actions that are related to the policy implementation process of geothermal energy, but were not considered to the critical in this research.

Table 9: Parallel actions that may influence the policy implementation of geothermal energy

Development [Action Situation]	Influence of institutions			Overall
	Regulatory	Strategy	Normative	
Large scale heat network investments to facilitate collective heating.	For planning, investments, permissions, and other activities, the regulatory environment is crucial. Due to Heat Act 2, the municipal level is a very crucial arena.	Though influential, perceptions of grid stability and flexible sustainable heating solutions are shifting in favour of acceptance.	Is collective heating seen as a clean future option or is it associated with price monopoly?	If public support cannot be maintained, the action looks to be sensitive to all institutional characteristics and may fail.
Increased use of geothermal energy for heating in urban areas.	Requires flanking policies to protect other environmental goals as well as support policies in a number of areas to complement collective usage.	It's crucial to consider perceptions regarding the best way to use geothermal energy. Does daily use become the norm?	Other than the energy sector, there are numerous other interested parties who have strong preferences and values about competing land uses. The topic of the debate is drilling close to a residential area.	Although the action seems rather sensitive, the overall picture is quite complex due to the split of property rights and the potential for numerous competing technologies.
High levels of energy efficiency in new and existing residential area.	Strong building regulations and standards are necessary. Planning and local conditions are crucial.	It is crucial to communicate with the building sector as a whole. Considering the rapid increase in demand and the required base-load generation of a geothermal system, is zero energy a benefit or a burden?	Combining the use of geothermal energy with zero-energy generation is certainly feasible, but there is a danger that the demand-search process will take longer and be more challenging for geothermal developers.	Institutional change is necessary for action, but it doesn't seem to be extremely volatile or sensitive to changes.

8. DISCUSSION

This research entails elements from studies in geothermal energy combined with policy implementation and institutions. This chapter will reflect on two questions: 1) *What was the added value of this research*?; and 2) *Would this research apply to other forms of renewable energy?*

8.1 INFLUENCES ON URBAN GEOTHERMAL DEVELOPMENT

Geothermal energy policy implementation in the Netherlands has so far mainly focussed on two aspects: economically feasibility of geothermal energy and conceptual market potential for new geothermal technologies. In order to promote sustainable heating with geothermal energy, literature has suggested that governmental policies should concentrate on raising natural gas rates, carbon pricing, investment subsidies, or combinations of these avenues (Rehling et al., 2019, 2020; Ziabakhsh-Ganji et al., 2019). This research adds the governmental policies designed to promote geothermal energy can't solely focus on instruments but should also clarify specific spatial design aspects that take into account the **division of property rights** in an urban area.

Institutional analysis for geothermal energy has mainly been focussing on institutional barriers for commercial usage (Citron, 1977; Hooimeijer & Tummers, 2017; Tsagarakis, 2020). Academic literature has identified that there are enough options to start integrating into the current urban structures and plans with the existing policy instruments (Hooimeijer & Tummers, 2017). The findings of this research indeed confirm that the current institutional arrangement in the Netherlands stimulates geothermal development. However, the case comparison showed the importance of specific policy targets before implementation initiation and how a more precise **frame of reference** was required for concerns and plans as the current one does not fully support the geothermal culture.

The IAD framework has been utilised more frequently in research on policy implementation. These studies generally show that the IAD framework may be applied to comprehend institutional settings for policy implementation and evaluate the effectiveness of policy implementation. The IAD framework was found to be a useful tool for analysing how policies are implemented, but more research is needed to understand **critical elements** of policy implementation (Fallin et al., 2014; Imperial, 1999; Luo et al., 2021; Zhou et al., 2022). This research has brought insights into the significant elements of policy implementation.

Prior studies that linked institutional analysis with policy implementation mostly concentrated on locating and detangling policy conflicts, bottlenecks, and disparities in order to suggest a course of action (Bazilian et al., 2011; Davidescu et al., 2018; Heikkila & Weible, 2018; Oteman et al., 2014). This research offers two things in contrast to earlier empirical studies of institutions and policy implementation. On one hand, the study offers a theoretically solid way to combine analysis of policy implementation processes with institutions. In fact, the study presented here suggests that important explanatory components may have been overlooked in the individual evaluations of the numerous policy systems engaged in geothermal energy development. Institutions such as laws, customs and beliefs in addition to institutions such as laws have a considerable influence on policy implementation. On the other hand the study offers a theoretically solid way to combine analysis of policy implementation processes with

different levels of institutions. Finally, the findings of this study provide a theoretical contribution to the themes that are currently arising in the Dutch geothermal energy industry.

8.2 GENERALIZABILITY OF RESEARCH

Literature on renewable energy policy implementation and institutional analysis shows that it can be stated that renewable energy policies in general need to be inclusive, context-based and **equitable** as well as efficient to have a huge and lasting distributional impact (Chowdhury et al., 2014; Koelman et al., 2022). However, the influence of institutions is less present in the policy implementation of other forms of renewable energy (Nykvist & Nilsson, 2009) for three reasons. Firstly, the implementation of geothermal energy involves multiple forms of legislation because of its **size** and **type of activity**. Secondly, the distribution of geothermal heat is bounded to be done via heat network (García-Gil et al., 2020). However, **heat governance** for collective heating is still in its early developments in the Netherlands (Tempelman & van den Berg, 2019). Lastly, there are certain rules that have been identified that specifically relate to the technology in question. One of the boundary rules for example states that the developing party will have proven that the geothermal resource will produce heat for an estimated period of time (Steffens, 2022). This means that a certain amount of money is already spend on exploration activities before the developer can enter Heat Purchase negotiations, which is called **sunk costs**. Even the very minimum of required exploration for both cases proved to be already in the millions of euros.

Besides the upfront investment costs being significantly higher than other forms of renewable energy, the usage of this technology is also **highly specific** in terms of transaction costs economics (“Scientific Background: Oliver E. Williamson’s Contributions to Transaction Cost Economics,” 2010). The final transaction in a geothermal project is expected to be realised through the heat-sales. Moreover, geothermal energy has the characteristic trait to be site specific and own a physical asset specificity. **Asset specificity** is, as formulated by Williams, the case when investments are highly transaction specific (“Scientific Background: Oliver E. Williamson’s Contributions to Transaction Cost Economics,” 2010). This is indeed the case with geothermal energy: the development can only take place at the designated location on the license and other activities, transport, materials, installation, drilling, are solely economically interesting when the heat production is functional at the end of the process. According to Williamson, the likelihood of opportunism in the interactions increases with asset specificity. Opportunism can occur independently of institutional or legal frameworks, and uncertainty is an inherent aspect of life. However, due to the high upfront costs and the uncertainty regarding the production of geothermal energy, the probability of opportunistic behaviour is higher compared to the development of other renewable energies. Therefore, given the three arguments, the analysis is more suitable for geothermal energy than other forms of renewable energy development.

9. CONCLUSIONS

In the introduction of this research it was identified that even though there is ambition among policymakers in the Netherlands and stakeholders in the geothermal sector, the development of geothermal energy usage is stagnating, especially in urban areas. Academic literature identified that there is a gap in the connection between geothermal energy allocation in urban areas and the influence of institutions. The performed case analysis showed the dynamics between problem politics and policy entrepreneurs and the institutions thereof. Social acceptance was shown to be embedded in the attributes of the community and was shown to influence the attitude of policy entrepreneurs. Likewise, different types of rules affected progress of decision-making in the political arena. In this chapter, the main research questions will be answered, the scientific contribution and implications of the findings will be discussed and limitations to this research and recommendations for future research will be addressed.

9.1. RESEARCH QUESTIONS

The **aim of this research** was to consistently track institutions in geothermal energy policy implementation in urban areas in the Netherlands. In the following answers are provided to the four sub-questions in order to answer the main research question of this thesis. For this purpose 4 sub-questions were defined, which will be answered first.

1| How can institutions in the policy implementation process be conceptualized?
The first sub-question aimed at formulating a systematic approach in order to identify the influence of institutions on the policy implementation process. For this purpose, a **theoretical framework** was constructed combining two bodies of literature. First, the Multiple Streams Framework (MSF) was used to formalize the dynamics between occurring issues, policy formulation and politics (Béland, 2016). Second, the Institutional Analysis and Development (IAD) framework was used to depict the circumstances surrounding a crucial transaction in which the influence of institutions contributed to certain results (Ostrom, 2011). In order to identify the rules-in-use in this aspect, the Grammar of Institutions was employed to define principles, standards, and tactics (Polski & Ostrom, 1999). This led to the framework designed in this research (Figure 5).

The theoretical framework made it evident that different institutional elements **inherently influence** policy implementation as a process, which in turn affects pre-existing variables. As a result, implementing geothermal energy policy stimulates the development of several institutional components and their interactions. Moreover, the combination of policy implementation and institutions showed that participants in the policy implementation process had overlapping usage of strategies and norms in the policy implementation process. Moreover, the policy window has been observed to be not just a turning point in the policy implementation process. The framework shows that the policy window can be observed to be a **momentum** where change is less limited than before and after. Even though the framework does stimulate the integration of an in-depth analysis within the policy implementation process, it is yet unclear if the insights would have been different if the analysis would have taken the causality and influences of various action arenas. This should be further researched.

2| What does the geothermal energy implementation process in the Netherlands entail?

The policy implementation process in the Netherlands consists of five main steps: Initiation, exploration, building, winning and end-of-life. Every geothermal energy implementation process start with determining whether there is a heat demand. Then the developer will have geological calculations performed that provide more details about the exact location for the extraction. Moreover, the developing party needs to make **agreements** about future heat supply with governmental authorities, the energy company and heat consumers. When there is more certainty about the location, heat customers, the presence of geothermal heat, financing and a heat network, the developer can apply for the necessary permits conform the mining law and environmental law. After permission and construction, the geothermal operator must test the production well to determine whether sufficient heat can be recovered. Once the test has been executed successfully and the Minister of Economic Affairs and Climate Policy has approved the extraction plan, the second well can be drilled and the installation completed. The geothermal heat extraction can then actually start. Geothermal heat is supplied to the users via the heat network. If a heat network is not yet available, this must be installed. If the geothermal energy company wants to start extracting geothermal energy after the installation and testing, it will apply for a production permit. After 30 to 40 years, geothermal energy production will be phased out and discontinued.

Performing this policy implementation process in **urban areas**, two specific **challenges** have been identified: 1) land suitability and availability in urban areas given the population density and divided property rights; and 2) clearance for concessions takes longer than expected due to complexity. The analysis additionally demonstrated the existence of land policy by the federal government, the provinces, and particularly municipalities to be critical for the implementation process. The characteristics of the municipal land policy affected how both significant transactions turned out. It was noted that this policy's objective is to ensure timely and adequate land availability. Additionally, population is growing and the environment is developing. As a result, the environment's design needs to be modified frequently. In terms of land policy, municipalities in metropolitan areas have a general choice of three options: active, facilitative, and in public-private cooperation. Additionally, the state has a unique level of accountability for the land policy framework, which frequently makes reference to the Spatial Planning Act. In contrast to Nieuwegein, which combines an active and facilitating land strategy, the municipality of The Hague mostly pursues a facilitating land policy.

3| How do institutions influence the outcome of the geothermal energy policy implementation process?

There were multiple institutions addressed as *influential* with regard to successful geothermal energy implementation. The most influential rules that were determining the patterns of interaction were identified as: position rules, payoff rules and choice rules. It was shown how the payoff of the potential implementation of geothermal energy influenced the behavioural choices of policymakers. The observed **rules-in-use** and **perception norms** reinforced extensive deliberations and broad agreements among participants, creating a decentralised setting. Partly due to some stakeholders' **willingness** to make significant concessions regarding specifics like the policy's applicable timeframe (e.g., Project Leyweg took longer to restart the boreholes due to technical uncertainty after the bankruptcy-stop), partly because each stakeholder could contribute unique expertise (or "*worth*") to the project, the geothermal policy implementation process resulted in the development of a mutual-deal-policy that received widespread support. The institutions therefore moderate the impact of general policy (read: MSF) variables on the process and result of policy implementation by influencing how stakes that affected decision-making authority were actually distributed among different actors and what kind of solution was likely to be most feasible.

Additionally, the analysis revealed that the aforementioned **social acceptance** is a variable that can be scaled under attributes of the community. Acceptation of the required land usage in comparison to alternative heating technologies and foreseen collective heating had become crucial arguments that needed to be addressed by politicians, because those were the *moods* observed among the inhabitants. The **positioning of information** (rules) was an intriguing result of the occurrence of social acceptance within community attributes in this research. One important finding was that when residents were given information (online and offline), they frequently depended on that knowledge. However, when there was no such information present, experience was used as an argument. This is crucial for (future) policy design since it emphasises the importance of choosing the right channels of communication between developers and locals to avoid miscommunications.

At the same time, it was important to see who delivered the information. Residents in both case analysis displayed scepticism to the national government, regulator, and developers. They addressed their concerns to the local government. Information asymmetry wasn't present because there was an abundance of information, especially in the LEAN project (Peijster, 2022; Provoost, 2022; Van Og, 2022). It was noted that the primary means of communication were one-way and went from authorities or politicians to the residents. Residents, however, continued to not feel entirely included and showed resistance. The citizens' disturbing sense of **scepticism** and pessimism about the Dutch political system's **trustworthiness** is another issue that has been brought up (Jongerius, 2022; Peijster, 2022). According to (Jharap & Trienekens, 2022), open communication and enabling involved residence to assess the benefits and drawbacks of the proposed implementation on their own is essential for overcoming the lack of confidence. This leads to the thought that the social acceptance can be categorized in the framework under attributes to the community and is in the urban environment of the Netherlands indeed a factor that hinders successful geothermal energy implementation.

4| What are key institutions that contribute to the success of geothermal energy policy implementation process?

For both cases the policy implementation was being confronted with an expanding number of difficulties and possibilities, complicating and polarizing the process. Case Leyweg showed strong local political commitment, which was critical in seeing the geothermal energy project through to implementation in 2019. This demonstrates the critical importance of political will in the implementation process of geothermal energy policies. In contrast, Case LEAN's policymaking process was characterized by a tightly tied problem and politics stream and a loosely coupled policy stream. On the one hand, this was caused by the focussing event of earthquakes in Groningen which caused a more distrustful mood among participants in the LEAN case, contrary to the Leyweg case. On the other hand, this was caused by a lack of specific focus on the fit of geothermal energy in the local sustainability policy, contrary to the Leyweg case. The biophysical conditions can be seen as an initial stimulant for the project initiating, however it was shown that the attributes of the community and rules-in-use had significant influence on the patterns of interaction and decision-making process. Especially the differences in the positional and payoff rules were critical.

Given the answers to the sub-questions, the **main research question** can be answered.

> *How and to what extent do* ***institutions*** *influence the success of geothermal energy* ***policy implementation process*** *in urban areas in the Netherlands?*

Institutions influence the decision-making process in **multiple ways**. Legislative decision-making is centralised in accordance with the Dutch law(s), however consensus-oriented interactions generated a decentralised environment that prioritised negotiations and called for agreement among a substantial number of stakeholders in the geothermal implementation process. When the political stream did not support a connection of the policy and problem stream, the implementation process led to failure. Additionally, the inclusion of institutions revealed the following. First, existing systems for implementing geothermal energy are considerably more focused on **cost recovery** from both the public and private sides, which took long as there were no set guidelines available. Second, the interactions moderated the impact of general MSF variables on the implementation process and output by influencing how decision-making authority was really distributed among participants and what kind of solution was most likely to be practicable, but that the **lead of a public party** was significant.

The influence of institutions mostly **resulted in** a **prolonged** implementation process. Consequently, the financial feasibility was affected greatly and the general attitude changed. It was identified that most emphasis was placed on the payoff structure. The analysis has demonstrated that taking institutions and the general public into consideration influences the political and policy flow directly. The primary issues raised by the analysis of both cases relate to social, ethical, and politically significant transactions. The lengthy policy implementation process was tainted by a general (mis)**trust** of the decision-makers, and concerns were expressed about the **equitable allocation of risks and rewards** and the willingness to work together for a sustainable system.

Hence, the success of the policy implementation process was impacted by the **interrelationships** by the feasibility of the environment, such as financial feasibility of the business case, and attributes of the community, such as stakeholder positions, attitudes and benefits and costs. The **rules-in-use** were identified to be drivers as well as barriers, and emphasized the necessity of more (pre-defined) guidance for local policymakers and operators. The integrated approach in this study can be used to understand how the many institutions affect the implementation of geothermal energy policy. Since traditional policy analysis is not defined by institutions, the institutions enrich the theory of policy implementation process in this way. A novel approach in this study to researching political relations is made possible by an institutional perspective.

9.2. POLICY RECOMMENDATIONS

In light of the study's conclusion, the following question arises: How can we determine when and under what conditions geothermal policy has to be revised? From the case comparison, it can be seen that: 1) the local government must provide strong support for the implementation of geothermal energy; 2) participants and affected stakeholders pay special attention to external variables, such as environmental concerns and damage control; and 3) in order to balance decision-making structures, governments, organisations, residents, and market players must interact. This means that in order to benefit the key interactions in the identified action arena, the following geothermal policy design recommendations can be formulated:

- **Responsibility and Liability and Damage Control.** The focus on damage management was a significant interaction that was seen in both situations. Before the project begins, it is important to identify the risks involved as well as the uncertainties caused by the subsurface's inherent characteristics. The limitations that a geothermal project must follow are spelled forth in the Mining and Environmental Law. However, the complicated split of property rights in urban settings makes it difficult to determine liability. It was noted that the culpability of various project components came up frequently in debates in the action arena. Consequently, it is necessary to formally include this section in legislation. As a result, some of the essential interactions are then predetermined, which could speed up the decision-making process locally.
- **Governmental guidance.** Both cases demonstrate how important it is to have governmental leadership. Before the project begins, it should be understood by all stakeholders what the possibilities are, who makes arrangements, who is liable and accountable for what, and who is required to take action and/or bear responsibility if things do not go as planned. Since subsurface use is related to public interest, it stands to reason that local government should oversee its sustainable management, or that government should make arrangements for it to be taken care of. However, the LEAN-case in particular has shown that fully outsourcing stakeholder management to the developing party is thought to run into opposition. The local government is where inhabitants turn for information because, under Dutch law, it is the only entity with jurisdiction over the area's real estate. The use, effects, and repercussions of something for the common good are usually what matter in the end.
- **Assessment.** Prior to both geothermal projects, there was an evaluation phase in which the terms *demand*, *agreement* and *consequences* are extremely essential. In this context, consensus generally relates to the technical data and implications of the physical, chemical, and biological aspects, which are frequently detrimental. Both instances have demonstrated that the assessment is generally substantively broad and that a number of "values" are relevant. These qualities connected to the project's and the developing party's characteristics (data availability, suitability of the land, etc.), usefulness and necessity, the effects and consequences, and potential alternatives. However, it became obvious that utility and necessity might be better laid out, particularly in the examination of LEAN. Residents' defences centred on potential resource shortages and the geothermal project's efficiency in comparison to alternatives. Therefore, it is advised that the assessment clearly take the above-ground alternative into account. To avoid interference with one another, subsurface activities must be spatially organised. On a local level, subsurface structural design planning could be advantageous.

9.3. SCIENTIFIC CONTRIBUTION

The scientific contribution of this research is **threefold**. First, by illuminating the role of institutions in the success of geothermal energy diffusion, this research **advances the field of energy studies**. This research adds that governmental policies designed to promote geothermal energy can't solely focus on instruments but should also clarify specific spatial design aspects that take into account the division of property rights in an urban area. The findings show the importance of specific policy targets before implementation initiation and how a more precise frame of reference is required for concerns and plans as the current one does not fully support the geothermal culture.

Second, by emphasising the function of institutions within the MSF, this research will add to the body of knowledge in the field of policy studies. Rather than analysing policy implementation processes separately, this study provides a theoretically sound means of **integrating analysis** of policy implementation processes with interactions. The study shows that communities and instruments, financial and informational, can influence policy decisions at any point in the policy implementation process. Additionally, the study shows that researching policy implementation with institutional variables makes it possible to comprehend debates over governance dilemma's and the creation of (sub)surface management strategies examining stakeholder coalitions and dynamics.

Third, by placing institutional analysis within broader policy implementation processes, this study will add to the body of knowledge on institutional analysis. The study shows that policy analysis elements provide significant explanatory elements, such as the **causality** and the structural approach of policy processes. As no action should be studied in isolation, this is a comprehensible manner of analysing complex transactions.

9.4. FUTURE RESEARCH AGENDA

There are three main theoretical **limitations** that this research has and based on these theoretical limitations, future research is suggested.

First, there are numerous methods and a variety of frameworks and ideas that can be used to perform institutional analysis and policy implementation analysis. It was decided that the **MSF** and **IAD framework** would serve as the sole theoretical foundation for this study's investigation. Both frameworks were created in an effort to offer a set of universal building blocks for undertaking an analysis that takes both characters into consideration. However, as demonstrated by Hayden (2011) and Herzog et al. (2022), it could be instructive to conduct the analysis using various frameworks to determine if the analysis still leads to the same interpretation.

Second, in order to understand how and why various stakeholders made certain decisions regarding the projects, as well as what variables were deemed relevant, this research based a part of its data collection on **interviews**. The interviews were performed with the intention of analysing various points of view on project-related issues in a balanced manner. Nevertheless, due to the Master thesis' time constraints, it has been challenging to include all the many viewpoints. As a result, there's a chance that the analysis at the end could be considered somewhat off-balance (Harvey-Jordan Sarah, 2001). For instance, there was little information available regarding the viewpoint of the citizens of the various municipalities. The operational issues and difficulties associated with social acceptance as a result were not adequately taken into account. Therefore, future study should look for more tangible data that can be used to support residential claims as well as a more thorough understanding of the various perspectives within communities.

Third, the analysis into the potential effects of the particular institutions on the outcomes of policy implementation heavily relied on **Dutch sources**. The results have demonstrated that neighbourhood characteristics do have an impact on the factors that policymakers consider. Therefore, by investigating how comparable activities are carried out in other jurisdictions and how the institutions there affect the outcomes, the research can be made more extensive. As a result, it is easier to pinpoint the elements that contribute to policy implementation success. The insights of this study suggest the importance of the payoff structure and its influence on the implementation process of geothermal energy. Therefore, there are two perspectives that are recommended to study in **future research**.

First, the study was developed to analyse one action arena for both cases. The aspects considered in this study were limited while certainly there are many other factors which affected the decisions and interactions of participants. For instance, in some of the interviews the issue concerning **heat governance** as outlined in the Heat Act 2 has been discussed as incredibly challenging. This aspect was out of scope of the main analysis and has only been addressed briefly in the appendix, but it certainly affects decisions as well. The legislative procedures parallel to the implementation of geothermal energy, can prolong the total time horizon of the investment. Moreover, risk mitigation insights could be advanced by creating a geological economic model that incorporates geological, technical, and market uncertainty while also taking surface flexibility into account. This is because the current state-of-the-art in (deep) geothermal energy development appears to be focussed around traditional NPV calculations with a sensitivity analysis (Compernolle et al., 2019). Therefore, future research should be able to capture other relevant factors such as a biophysical condition that is less favourable to analyse decisions in a more comprehensive manner. In order to improve heat-infrastructure management and get more insights into the influence of investment decisions, an agent-based modelling approach is deemed appropriate.

Second, in the analysis of the action arena, limited attention was given to the interaction between the developer and the financial agreements they have signed with partners since little information was obtained either through the interviews or other sources. Moreover, at the same time the **policy instruments** used to assist both projects greatly were the subsidies (Peijster, 2022; van Dun, 2022; Zaman Ziabakhsh-Ganji et al., 2019). This implied that there is still a gap present regarding the exact efficiency of the subsidy system on the decreasing investment risks. Future study ought to be able to improve the analysis and highlight the difficulty in securing financial assistance in the industry.

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Ziabakhsh-Ganji, Zaman, Nick, H. M., & Bruhn, D. F. D. F. (2019). Investigation of the synergy potential of oil and geothermal energy from a fluvial oil reservoir. *Journal of Petroleum Science and Engineering*, *181*, 106195. https://doi.org/10.1016/j.petrol.2019.106195

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Zuurman, H. L. (2022, March 11). *Prijzen voor gas, benzine en levensonderhoud rijzen de pan uit: "Het is een keuze duur te leven".* NederlandsDagblad. https://www.nd.nl/nieuws/economie/1113744/prijzen-voor-gas-benzine-en-levensonderhoud-rijzen-de-pan-uit-h

The literature review should be limited but at the same time contain information about geothermal energy in combination with policy adoption or policy implementation. The choice was made to only use Scopus for the literature research, performed on February 7th 2022, for the literature review as this is one of the largest databases in the world and hence allows for results of high quality (Falagas et al., 2008).

There were a couple of concepts that were used to define the research before performing the literature review. A sustainable heating system is essential for the development of a sustainable energy system and plays a significant role in climate change mitigation (Liu et al., 2021). It makes it easier to fulfil sustainable development goals (SDGs) like inexpensive and clean energy (Laakso et al., 2021). Measures to reduce fossil fuel intensity on the demand side, enhance energy efficiency on the supply side, and replace fossil fuel with renewable and recoverable heat sources are all part of sustainable heating systems (Späth & Rohracher, 2015). **Geothermal energy (GE)** is heat that exists within the earth's crust (Huenges & Ledru, 2011). For the literature review itself, several forms of geothermal energy exploitation are included: heating and cooling of buildings with geothermal heat pumps, generating electricity with geothermal power plants and heating buildings with direct-use geothermal energy. An **environment** is defined as relating to or caused by the surroundings in which geothermal energy is implemented or exists. In this proposal there are mainly two types of environment mentioned. The **technological environment** refers to external factors in technology that impact geothermal energy implementation and/or operation (Colovic & Lamotte, 2015). The **institutional environment** refers to a series of legal systems and government governance, which means that this is the economic and social environment used to establish the basis of production and distribution of geothermal energy (Henisz, 2000). **Policy adoption** is the third phase of the policy process, in which government bodies approve policies for future execution (Lumencandela, 2019). Policy adoption in this proposal is meant as *local policy adoption*, which means that a local governmental body has included the usage of geothermal energy in heat transition vision. A *local governmental party* is any governmental party other than the national government. **Policy implementation** is defined as the moment a policy is put into action to

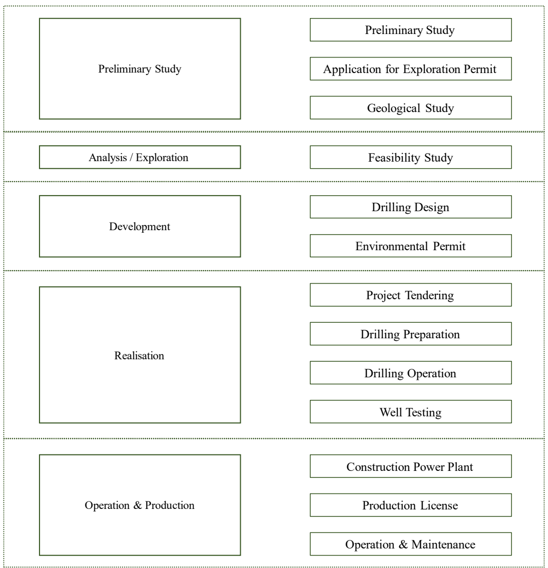

Figure 23: Phases geothermal implementation based on literature

address a public issue (PEPD, 2021). The actual process for geothermal energy implementation in general is described by several steps (Schoof et al., 2018), which are indicated in Figure 23. There is no concrete definition as to when people consider the implementation of geothermal energy as a success or a failure. Therefore, in this research the following definitions will be used. A **unsuccessful implementation** means that the project has been put on *indefinite hold* with no clear prospects of continuing before the *drilling operation* has started. A **successful implementation** means that the drilling operation stage has been completed successfully including the well testing and that production and supply can commence.

The following search term, which is constructed from concepts as explained above, was used:

(**TITLE-ABS-KEY** ("geothermal energy") **AND TITLE-ABS-KEY** (policy) **AND TITLE-ABS-KEY** (adoption OR implementation))

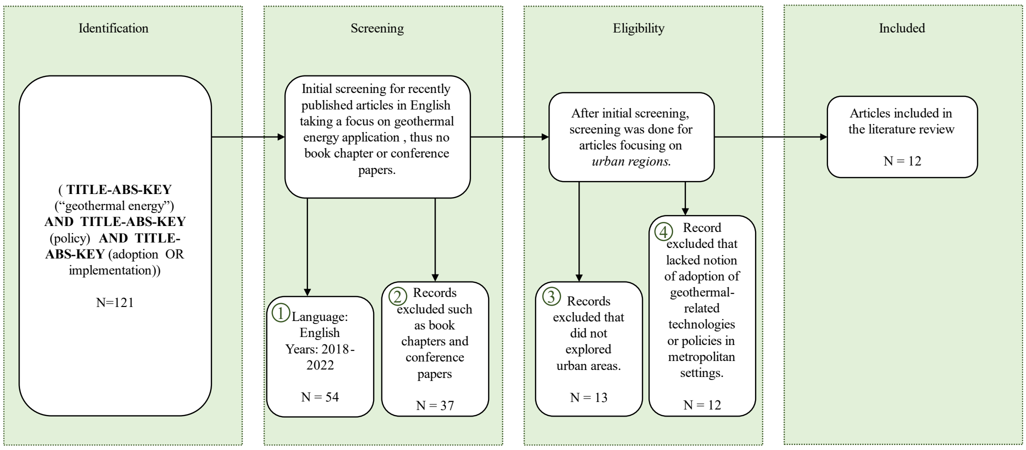

Figure 24: Search strategy research

There were 121 matches for this search phrase, which can be seen in Figure 24. The first criterion was the elimination of research that were not published in English. After removing these, there were just 114 documents remaining. The inclusion of only research published within the recent five years was the second criterion considered. This was done because geothermal energy metropolitan areas have only recently been examined (van Mersbergen, 2020). As a result, all further studies are excluded from the year range of 2018 to 2022. The use of this criterion resulted in the production of 54 documents. Conference papers and book chapters were excluded as the third criterion in order to obtain high quality peer-reviewed results, resulting in 37 documents. Because this research will primarily focus on urban regions, the abstracts of these 37 documents were searched for the word "urban." The document was omitted if there was no mention of a connection to metropolitan areas. This resulted in 13 documents. Finally, one article was excluded due to the fact that it lacked an observational methodology that examines the adoption of geothermal-related technologies or policies in metropolitan settings. In total, this leads to 12 articles which are included in the analysis.

Table 10 shows an overview of the documents that were analysed for the literature review. The table also contains important (indexed) keywords that the documents contained. This highlights the first connection that can be made between the different documents.

Table 10: Documents literature review

	Article	Policy Adoption	Technology Implementation	Geothermal Energy	Resource Governance	Technology Development
1	Blum et al., 2021		√	√	√	
2	Bujakowski et al., 2020		√	√		
3	García-Gil et al., 2020	√		√	√	√
4	Kotarela et al., 2020		√	√	√	
5	Muela Maya et al., 2018	√		√	√	
6	Norouzi et al., 2021	√	√			√
7	Pan et al., 2019	√		√		√
8	Pellegrini et al., 2019		√	√	√	
9	Raza et al., 2020	√		√	√	√
10	Washim Akram et al., 2021	√		√		√
11	Xiang et al., 2021	√		√		√
12	Zeng et al., 2021	√	√	√	√	√

KNOWLEDGE GAPS

Resource allocation – Separate scenarios demonstrate how geothermal energy systems can function while taking into account a variety of constraints that are important to consider when developing small- or large-scale systems (Norouzi et al., 2021). Geothermal systems should be considered a suitable available technology for generating huge volumes of heat when environmental risks and advantages are taken into account (Pan et al., 2019). However, Norouzi et al. (2021) adds that, in order to make geothermal energy commercially viable, most single cases employ the technology in a hybrid combination with another form of energy for economic feasibility (Bujakowski et al., 2020; Pellegrini et al., 2019). As a result, the viability of geothermal energy in general may be regarded case-specific, and the lack of regulation and standards for geothermal energy implementation in metropolitan settings makes stakeholders wary of entering the market (Washim Akram et al., 2021). This results in unclarity regarding the (investment) decisions of stakeholders after the geothermal energy has been set on the political agenda (Washim Akram et al., 2021).

Technological development in metropolitan areas – The increasing rise and implementation of GE systems in urban environments has raised serious questions regarding the technology's long-term technical, environmental, economic, and social viability (Blum et al., 2021). García-Gil et al. (2020) demonstrated how the management structure consists primarily of an open, elaborated 'checklist' of risks, objectives, strategies, and measures organized around sustainable development and exploitation of geothermal resources; environmentally friendly use of geothermal resources; geothermal energy coordination with other urban subsurface uses; and successful geothermal management. However, this mostly demonstrates the emphasis put on the technical side, whereas the notion of the compatibility with legal frameworks and social norms are missing (Raza et al., 2020). Thus, it is apparent that transitions cannot be realized just through technological innovation, and it is yet unclear how and to what extent regional rules and regulations influence the development of these systems (Xiang et al., 2021).

The absence of social acceptance in literature – Many articles support Zeng et al.'s (2021) assertion that an integrated methodology that also include public opinion is an effective way for identifying, defining, and mapping the knowledge base of this topic. In general, one can state that the opinions are based on energy security, energy equity, and environmental sustainability. These are the three basic characteristics of energy sustainability (Heffron et al., 2015). They form a ‘trilemma’, with strong performance on all three requiring intricate interwoven relationships between public and private players, governments and regulators, economic and social variables, national resources, environmental concerns, and individual behaviours (Heffron et al., 2015). As a result, energy security, energy fairness, and environmental sustainability will be the challenges for sustainable heating in metropolitan settings. Renewable energy is well-positioned to play a crucial part in the Dutch energy mix, given the present rising fossil fuel prices and worries about energy security (Zuurman, 2022). The government now has another instrument to better manage its economic future by increasing the use of geothermal energy to include metropolitan regions. Furthermore, using geothermal energy as a heat source will reduce CO_2-emissions significantly. When compared to natural gas, the CO_2 reduction for an average project is 88% (Schoof et al., 2018). The average CO_2-emissions from the sources identified so far are around 7 kg/GJ, compared to 57 kg/GJ for natural gas (Schoof et al., 2018). Another benefit is that geothermal energy is a local, renewable source of energy that is not affected by day/night or seasonal cycles. As a result, it contributes to environmental sustainability by allowing for supply and demand-side energy efficiency, as well as the development of energy supply from renewable and low-carbon sources. The opinion on energy equity is still up for debate. This is not attributable to geothermal energy, but rather to the fact that in order to accomplish lucrative heat-sales in a metropolitan area, geothermal energy must be coupled to district heating. According to Dutch law, owners of owner-occupied properties can always choose whether or not they want to be connected to a heat network; this applies to both existing and new dwellings (KlimaatExpert, 2019). For rental residences that are connected to a heat network, there is usually a requirement. However, this is not a level playing field: because only one heat provider is connected to a heat network, homeowners are unable to switch heat suppliers. Furthermore, the cost of heat is currently connected to the cost of natural gas, which is not perceived as being economical. However, even with these perspectives identified, none of the publications, in general, discuss the importance or function of user social acceptance that comes with the implementation of geothermal energy in metropolitan areas. This is an intriguing tendency, especially given the social status of drilling technologies in current Dutch newspapers.

ADDITIONAL INFORMATION: DUTCH GEOTHERMAL LEGISLATION

Due to the institutional perspective taken, it is important to from the start already define which legislation plays a role for geothermal energy implementation in the Netherlands. Therefore, this will be addressed here. Activities from 500 meters underground are classified by the government as mining (Overheid.nl, 2017). That is why geothermal energy is also considered a mining activity. Various permits are required for this under the Mining Act, which will be revised in 2022. An environmental permit is also required on the basis of the environmental law. In addition, there are other laws and regulations that are important.

MINING ACT [BWBR0014168]

All rules relating to the exploration, extraction and storage of minerals and geothermal heat are laid down in the Mining Act. The Mining Act has been elaborated in the Mining Decree. The Mining Regulation is a detailed elaboration of the Mining Act and the Mining Decree. A revised Mining Act is expected to come into effect in 2022.

Under the Mining Act, the Ministry of Economic Affairs and Climate (EZK) can grant an exploration license to a geothermal energy company. According to the law, detecting means '*to investigate the presence of geothermal energy or into data about it'*. Geological preliminary research and a financial plan are part of the application. The Ministry will submit the application to expert organisations: TNO assesses the size of the research area, RVO (Netherlands Enterprise Agency) investigates the financial underpinning of the plan and State Supervision of Mines (SodM) looks at the applicant's experience and knowledge (geothermal heat developer) and advises the Ministry on the way in which the applicant intends to carry out the investigation activities, the technical possibilities of the applications, the previously demonstrated efficiency and sense of responsibility of the applicant and any adverse effects on the environment. The central question is: is the applicant able to perform the desired activities safely? Other government organizations may also express their views on the plans. For example, the water board looks at how the operator controls the discharge of water that is released during drilling. The province checks whether the extraction fits in with the spatial plans. The province also asks the municipality for advice. The municipality can advise on all kinds of aspects, from safety and enforcement of rules to the way in which the environment is involved in the project. Based on these results, the Mining Council advises whether the Ministry can grant the permit.

If the **exploration permit** is granted, other companies will not be allowed to explore the area. With an exploration permit, an operator can also install a geothermal energy installation and test the production of heat. The operator must submit a work plan to SSM within four weeks after the exploration permit has been granted. This work plan provides an overview of the most important activities that will take place in the permit area over the next five years. In any case, the **work plan** contains:

- An overview of the main mining activities in the next five years;
- A comprehensive overview of the mining activities in the coming year such as seismic surveys, drilling and possible construction work;
- A safety and health plan for employees;
- An organizational chart including the names of the responsible persons
- Maps of the structure of the subsoil.

Before extraction starts, the operator must have a **production license** and an approved **extraction plan**. As soon as these are in, the geothermal energy company / operator can start. The production license describes the area and the period within which the license holder has the exclusive right to extract geothermal energy. The developer needs this exclusive right, because there are very high costs in the preparation. (Note: The production license is separate from permission to drill a well, build a geothermal energy installation or start production. An environmental permit and an approved work plan are required for this). The application for a production license includes a multi-year extraction program.

The Minister may also grant the permit subject to restrictions or attach conditions to the permit. For example, by prescribing or prohibiting techniques or activities for (parts of) the area. In the decision, the minister states whether the permit is granted and why. In the permit, the minister appoints the applicant(s) as 'permit holder' and records the area concerned. The permit states which permit holder is responsible for carrying out the activities. Within four weeks of granting the production license, the geothermal heat developer or operator must submit a work plan to SSM. This provides an overview of the most important activities in the permit area in the coming five years. It also contains an extensive overview of activities in the first year, a description of the drilling, construction of the installation and additional structures. The work plan also contains a health and safety plan for employees and a schedule. The work plan must be updated annually.

The operator must also submit a **mining plan**. This contains all the details about the extraction, such as the working method and duration of geothermal heat extraction. The operator indicates how and how much geothermal energy is extracted (the extraction rate) and what the expected effects are on the subsurface. In addition, an operator must demonstrate that sufficient measures have been taken to absorb any adverse effects. The minister has the extraction plan checked against the Mining Act and seeks advice from SodM, the Mining Council and the Technical Committee on Soil Movement. Provinces, municipalities and water boards also have the right to advise on the extraction plan. The minister can also grant approval subject to restrictions or attach regulations to it. The extraction plan must comply with various legislation such as the Water Act, the Environmental Management Act, the Nature Conservation Act and the environmental law. In the case of a draft decision for an extraction plan, stakeholders such as local residents have the opportunity to submit their views. Interested parties may also be able to appeal directly to the court.

THE ENVIRONMENTAL LAW [BWBR0024779]

The Environment and Planning Act applies to the above-ground aspects of the geothermal energy installation. These are in particular: the extraction site; the buildings; the vicinity of the extraction site. The Environment and Planning Act relates to, among other things, building requirements, environmental effects and spatial integration (these are matters that are not or only to a limited extent addressed in an exploration permit). Before starting a seismic survey or drilling a well, the operator must have an environmental permit. The operator requests this from the Ministry of Economic Affairs. Because geothermal energy is a mining activity, the national government is the competent authority.

The municipality and province have the right to advise when granting permits. Local residents can put forward their views on a number of aspects. For example, about safety, the consequences for the environment or the provision of information. This means that residents can influence geothermal energy plans in the area. Interested parties (such as local residents) can object to the municipality up to six weeks after the environmental permit has been granted. An objection does not mean that the operator is not allowed to carry out the activities. The municipality will make a decision about this. The operator announces the geothermal energy plans and organizes information meetings. Municipalities also have a duty to involve local residents.

With the **environmental permit** for the construction of a geothermal energy installation, the minister must assess whether an environmental impact statement (MER) is required, on the basis of the Environmental Management Act (chapter 7 – article 7.1 to 7.42) (Akerboom et al., 2016). An **EIA** must ensure that the environmental interest is fully taken into account in the preparation and decision-making about activities that may be harmful to the environment. If an EIA is required, the operator must submit this report together with the application for the environmental permit. The operator must therefore first inform the Minister of Economic Affairs and Climate of the intention to apply for an environmental permit. The minister then decides whether the operator must draw up an EIA. If the drilling is planned near a sensitive area (water abstraction or nature reserve), an EIA is usually required. Operators may also draw up an EIA on their own initiative.

The **Heat Act [BWBR0033729]** contains rules about the supply of heat, cold and source heat (Tempelman & van den Berg, 2019). The Netherlands Authority for Consumers & Markets (ACM) checks whether suppliers comply with these rules. The Heat Act protects heat consumers against, among other things, high prices for heat supply. For example, the costs of geothermal energy supply may never be more expensive than those of natural gas supply (including costs of the central heating boiler). The Heat Act is revised in 2022.

When extracting geothermal energy, wastewater is released, which is discharged into the surface water or the sewer. The operator is obliged to apply for a discharge permit for this from the water board, according to the **Water Act [BWBR0025458]**. Discharges into national waters require a permit from the Ministry of Infrastructure and Water Management.

OTHER LAWS AND REGULATIONS

Other laws and regulations may also apply to geothermal energy.

- **Special environmental protection regulations** [BWBR0023771] are included in the General Regulations Environmental Mining Decree.
- The **Soil Protection Act** [BWBR0003994] lays down rules to protect the soil. The law considers groundwater to be part of the soil. In addition, the remediation of contaminated soil and groundwater is regulated in this law.
- The protection of animal and plant species is regulated in the **Flora and Fauna Act** (Ffw) [BWBR0009640]. As far as is known, geothermal heat extraction has no adverse effects on flora and fauna, but these cannot be ruled out.
- The Nature Conservation Act (Nbw) [BWB0009641] regulates the protection of areas that must be protected within the framework of the European Birds Directive and Habitats Directive.
- The central government, the province and the municipality must establish structural visions on the basis of the Spatial Planning Act [BWBR0020449]. Structural visions are indicative plans that outline the development of a specific area. An example is the Subsurface Structural Vision. The **Spatial Planning Act** [BWBR0020449] obliges municipalities to adopt a zoning plan for the entire territory. For example, the zoning plan may stipulate that an environmental permit is required for certain works or activities. Zoning plans often include exclusions from drilling and seismic surveys.
- The **Soil Protection Act** (Wbb) lays down rules to protect the soil [BWBR0003994]. The Wbb makes it clear that groundwater is part of the soil. In addition, the remediation

of contaminated soil and groundwater is regulated. Discharges into or on the ground can also be regulated on the basis of the Wbb.

- The **Basic Safety Standards Radiation Protection Decree** (Bbs) for working with, storage and transport of natural radioactive material [2013/59/EURATOM].

This appendix further explains the different elements of the MSF and IAD Framework and the definitions as used in this research.

POLICY IMPLEMENTATION

Schneider (1982) claims that the field of policy implementation is dominated by case studies of single policies executed by single agencies and/or authorities. The democratic side of policy implementation, on the other hand, is not often mentioned in the literature (O'toole Jr, 2000). This can be a challenge because implementation is typically a multigroup activity, particularly in a heavily populated urban context. In comparison to other policy change theories, Kingdon & Stano (1984) highlight the MSF's conceptual strengths by emphasizing the presence and effect of policy entrepreneurs. As a result, this framework was chosen as a means of comprehending public policy agenda building within the instances' fragmented political system.

KINGDON'S MULTIPLE STREAM FRAMEWORK

The Multiple Streams Framework (MSF) is a theoretical framework developed by Kingdon & Stano (1984) in their book *Agendas, Alternatives, and Public Policies* that is used to analyse and comprehend the policy process by assuming three different and independent streams: problems, policies, and politics (O'toole Jr, 2000). MSF has been widely utilized in the political sciences to investigate the reasons for and methods of governmental policy adoption, or to explain the decision-making process. MSF's capacity to explain much of the policy process and so contribute to other theories is a strong quality, as is its ability to describe the function of essential elements like as institutions, networks, socioeconomic activities, preferences, and concepts. Another strength of the MSF is its ability to describe not just the interaction between policy concerns and their environments, but also to investigate causal relationships between variables that lead to the adoption of a certain policy (Kagan, 2019).

The MSF's **exploratory strengths** were not overlooked by policy experts. The MSF has been involved in a rising number of research in recent years, ranging in governance and policy level (Angervil, 2021). MSF has contributed significantly to policy theory and empirical research. First, Kingdon defines what we refer to as "universal" policymaking challenges, which might arise at any time or in any location (Béland, 2016). Kingdon's research concentrated on a single location, a certain time period, and a limited number of policy issues (Cairney & Jones, 2016). However, it offers a **flexible and practical streams metaphor**; and it develops ideas that could be applied to any case study, like the function of bounded rationality and the process of choice in the face of uncertainty and ambiguity (Cairney & Jones, 2016). Second, as compared to other policy process techniques such as the Institutional Analysis and Development Framework (IAD) (Ostrom, 2009, 2011) and the Avocacy Coalition Framework (ACF), the **'threshold to usage'** is low (Sabatier, 1986). The MSF provides users with unrivalled flexibility: no extensive codebook is required to test hypotheses or advance general policy theory. However, methodologies like IAD or ACF do not have the same sense of co-ordinated theory development or application, which could be done to make the study more methodical.

THE STRUCTURE OF THE MSF

The MSF explains how issues find up on political agendas and how policies evolve over time. Problem stream, policy stream, politics stream, policy window, and policy entrepreneur are the five concepts that it revolves around (Béland, 2016). Problems, policies, and politics are usually thought of as three separate streams, each with its own set of activities, accompanying behaviours, and participating individuals, see Figure 25. Only contextual or structural 'policy windows,' in which policy change can be implemented, and 'policy entrepreneurs,' a phrase coined by Kingdon to characterize individuals who exploit policy windows to achieve their policy objectives, remain (Copeland & James, 2014). Each of the five elements is briefly described in the next section.

The **problem stream** is made up of conditions that are considered *important* (Béland, 2016). Problems, in essence, are conditions that are believed to be something for which action should be taken. To put it another way, problems are subjective descriptions of objective facts (Cairney & Jones, 2016). Policymakers use numerous key operational subcomponents, such as 'focused events,' indicators (e.g. data), and feedback channels (e.g. media), to transform conditions into issues (Béland, 2016). The **policy stream** is a collection of policy ideas, options, and recommendations created in policy communities that may or may not solve the situation at hand (Béland, 2016). The policy stream metaphorically entails a flow of ideas and possibilities that develop, improve, and discard or endorse solutions through an iterative process of modification, reconsideration, and softening (Cairney & Jones, 2016). The technical feasibility, resource adequacy, and value acceptability are all factors that contribute to an idea's survival (Cairney & Jones, 2016). The institutional environment, cultural background, and political processes (e.g. legislative politics) that inspire policymakers to focus on specific problems and possible solutions for the agenda are all part of the **political stream** (Ackrill et al., 2013; Zohlnhöfer et al., 2016). **Policy entrepreneurs** are prominent players who devote their time and effort to influencing policy outcomes within a policy stream (Béland, 2016). Policy entrepreneurs employ their understanding of the policymaking process to promote and push policy options onto the agenda as answers to problems at the appropriate moment (i.e. window of opportunity). Within the policy window, these policy entrepreneurs are willing to devote resources (time, energy, money) to advance engagement and boost their self-interest and possible rewards (Cairney & Jones, 2016). As a result of focusing events in the problem stream or activity of policy entrepreneurs, the **policy window** offers the institutional setting in which the streams (problems, politics, and policy) come together (Béland, 2016). Although opening a window may not always result in a solution to a problem, it does make policy acceptance far more likely (Béland, 2016). Within these time frames, public interest in specific problems has grown, policy solutions are available, and political motivation has acquired traction (Copeland & James, 2014).

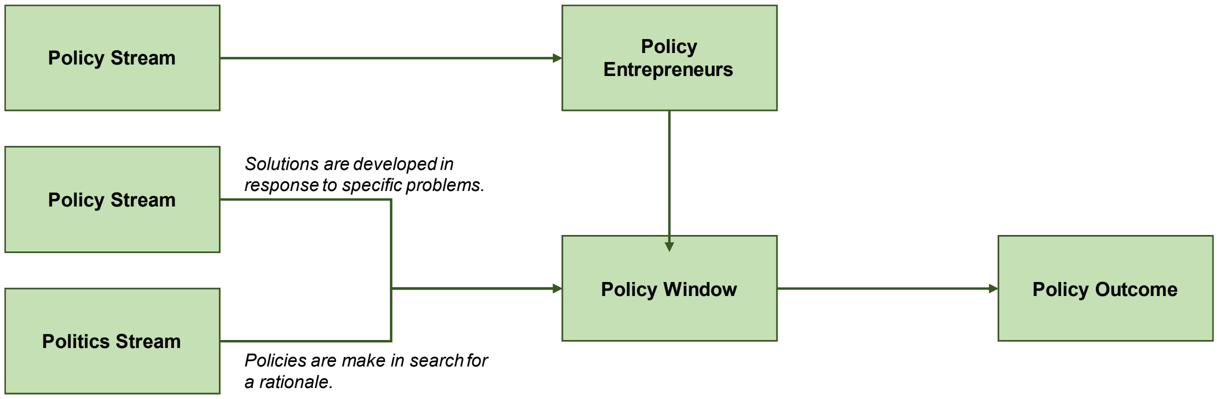

Figure 25: MSF structure visualization based on Kingdon & Stano (1984)

INSTITUTIONAL ANALYSIS

The field of social science known as institutional analysis examines how institutions, or the structures and mechanisms of social order and cooperation that control the behaviour of two or more people, behave and operate in accordance with empirical and theoretical rules, informal rules-in-use and norms, formal rules and laws, and so on (Mcginnis, 2017; McGinnis, 2011). When planning and implementing projects, a grasp of existing institutional structures and procedures, as well as the dynamics of relationships between different stakeholders, is critical, and so this method is critical in the case analysis.

OSTROM'S INSTITUTIONAL ANALYSIS AND DEVELOPMENT (IAD) FRAMEWORK

The IAD Framework (Ostrom, 2009, 2011) is a **road map** for figuring out what influences institutional policy processes and outcomes. This approach has been utilized in research into urban growth policies that aid sustainable development in a variety of countries (Luo et al., 2021). The IAD is divided into **three levels of action**: constitutional, collective choice, and operational (Ratner et al., 2013). The setting in which institutional policymaking takes place is the constitutional level (Mcginnis, 2017). The **constitutional level** is involved in policymaking at both the national level in this study. At the **collective choice level**, local policymaking is involved, and activity is coordinated by the city council (Imperial & Yandle, 2005). The **operational level** encompasses the degree of operation necessary to put a policy into practise. Each of the three action levels—constitutional, collective, and operational—is distinguished by the following two characteristics: Rules, laws, and boundaries that are in effect, as well as communal characteristics like culture and values (Mcginnis, 2017). Relevant laws in use at the constitutional level include the existence or absence of national legislation regulating geothermal drilling in metropolitan areas in the Netherlands, as well as Dutch culture, conventions, and values surrounding geothermal energy use. The rules in use at the collective decision, or local policymaking level, are the regulations controlling policymaking bodies (e.g. the policy process within municipalities), while the community characteristics are the municipality's culture, norms, and values connected to (geothermal) heat utilization. Programs and other initiatives affecting policy acceptance and implementation in the community are included in the operational rules. The culture, norms, and values of those directly involved in geothermal energy projects, such as business owners, law enforcement officials, and knowledge institutes, are examples of community characteristics. Institutions, according to Ostrom, are "common conceptions employed by humans in recurring circumstances that are organized by rules, norms, and strategies" (Ostrom, 2011). Human interactions in regularly occurring or repetitive circumstances, according to Ostrom (2011), generate and adapt rules, conventions, and strategies. Polski & Ostrom (1999) further explained the Institutional Analysis and Development (IAD) framework to illustrate the setting in which institutions function. To understand how institutional interactions between actors are shaped, it is necessary to understand the underlying structural elements and their broad links, which are defined by the IAD framework.

An essential conceptual component of the framework is the **action area**. Actors and action scenarios make up an action arena (Ostrom, 2011). Actors can be single people or a group of people that work as corporate actors. In the action setting, the actors interact with one another. Persons in action arenas may exchange products or services, work toward problem-solving or control one another (Ostrom, 2010). In this regard, the IAD paradigm views actors as "fallible learners", who operate in the face of uncertainty, have limited cognitive and information-processing capabilities, but are able to learn from previous encounters over time (McGinnis, 2011).

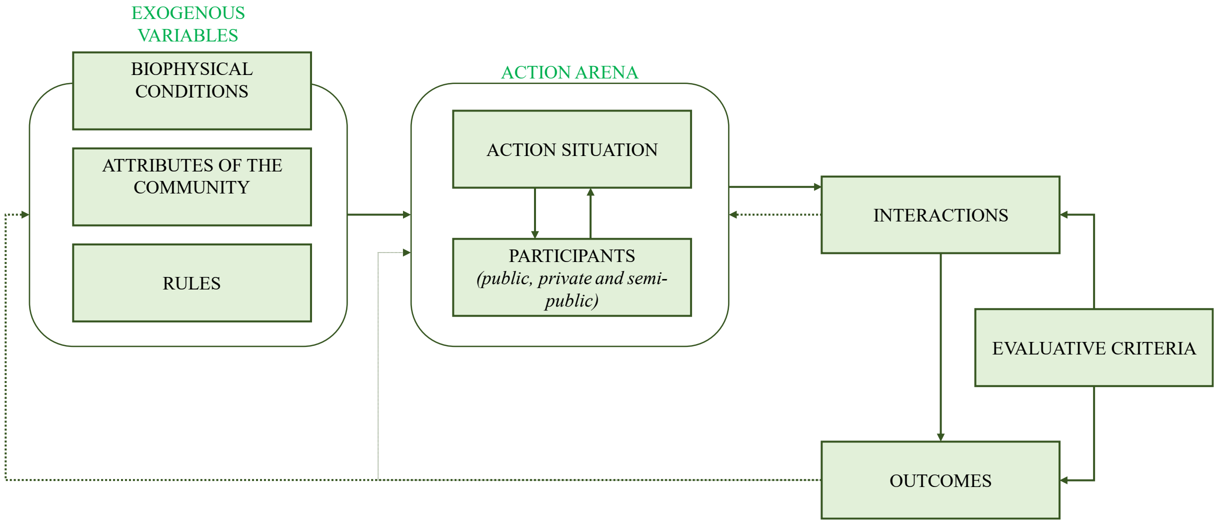

Figure 26: IAD framework based on Ostrom (2009;2011)

The qualities of the physical world, the attributes of the community, and the attributes of the rules in use are three sets of external factors that affect the action arena. **Biophysical and material conditions** affecting the action arena are examples of physical world attributes (Polski & Ostrom, 1999). Biophysical resources, capital, labour, technology, finance, and distribution routes are all examples. Size, abundance, and vulnerability are all important characteristics of these resources (Clement, 2010). The **community's characteristics** are more cultural. These cultural characteristics have to do with a community's recognised norms, the degree of trust and understanding between members of the group, and how uniform the beliefs, opinions, and preferences are (Polski & Ostrom, 1999).

The term **rules-in-use** refers to both formal dictums and more informal behavioural norms (Polski & Ostrom, 1999). Formal and informal institutions may at times be at odds with one another. As a result, the rules-in-use refer to the institutions that actors actually adhere to in practice. As a result, the action arena is a social area that is used to describe actor behaviour patterns (Ostrom, 2011). It can be used to forecast expected outcomes by figuring out what factors influence the structure of a situation. A sequence of interactions will result in results based on the structure of the action arena. Criteria will be applied to the outcomes and the methods for reaching the objectives to see if the desired outcomes can be attained under the current institutional arrangements. Feedback procedures occur to world qualities, community attributes, and rules-in-use through **evaluative criteria**. This is the process of institutional reform. The action arena is modified as well, because the actors involved may have altered their plans or objectives, for example. This is entirely dependent on the criterion in question. These standards could be based on economic efficiency, fiscal equivalency, distributional equality, accountability, morality, or long-term viability (Ostrom, 2009).

The action arena is the focus of the IAD study (Ostrom, 2010, 2011). The qualities at each level (f.e. community attributes) have an impact on action arenas, which can occur at any of the three levels (constitutional, collective choice, and operational) (Mcginnis, 2017). Institutions can be further classified in these three ways to better understand how they influence the behaviours and consequences of the participants. Based on the aforementioned explanation of the different levels and variables an overview of the different levels in this research has been given in Figure 27. The operational level refers to actual choices made by actors who have received permission (or are permitted) to do so as a result of collective-choice processes (Mcginnis, 2017; McGinnis, 2011). In essence, constitutional decision-making and institutional pronouncements have an impact on collective choice, which in turn has an impact on operational level. The lower levels, in turn, can have an impact on the higher levels.

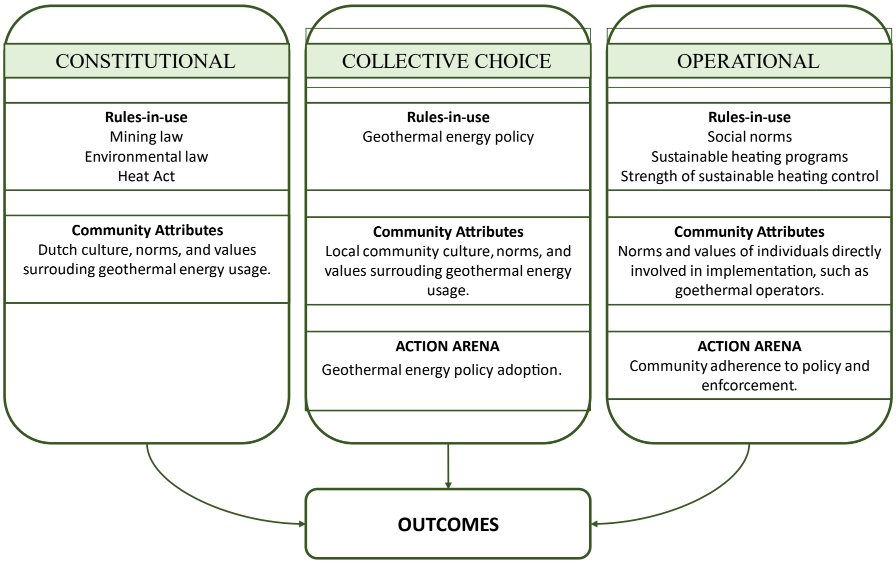

Figure 27: Different types of action arenas in geothermal energy policy based on Ostrom (2010)

An institution can serve one of seven functions, depending on the component of the action situation it affects (Mcginnis, 2017). In the action situation, there are positions to which people and actions are ascribed. Actor classifications are essentially positions. There is a distinct cast for each class. An association is a type of group where each member has a certain role. The acts are acting behaviours that actors, or classes of actors, value according to the action's perceived instrumental utility. Boundary statements, position statements, and choice statements all have an impact on actors, positions, and actions (Ostrom, 2009). Boundary statements specify whether and under what conditions actors are allowed to participate in the action situation. This includes their characteristics and resources, as well as the consequences of leaving. **Boundary statements** are closely related to position statements because they determine eligibility for a position. **Position statements** essentially assign distinct classes of actors to different types of behaviours in a given context (Ostrom, 2009). **Choice statements** describe the options available to actors in terms of the actions they can take, such as permission, which requires specific information kinds and flows, and shared control over action. Control indicates that an actor has more or less influence on the course of events, based on the position to which he is assigned.

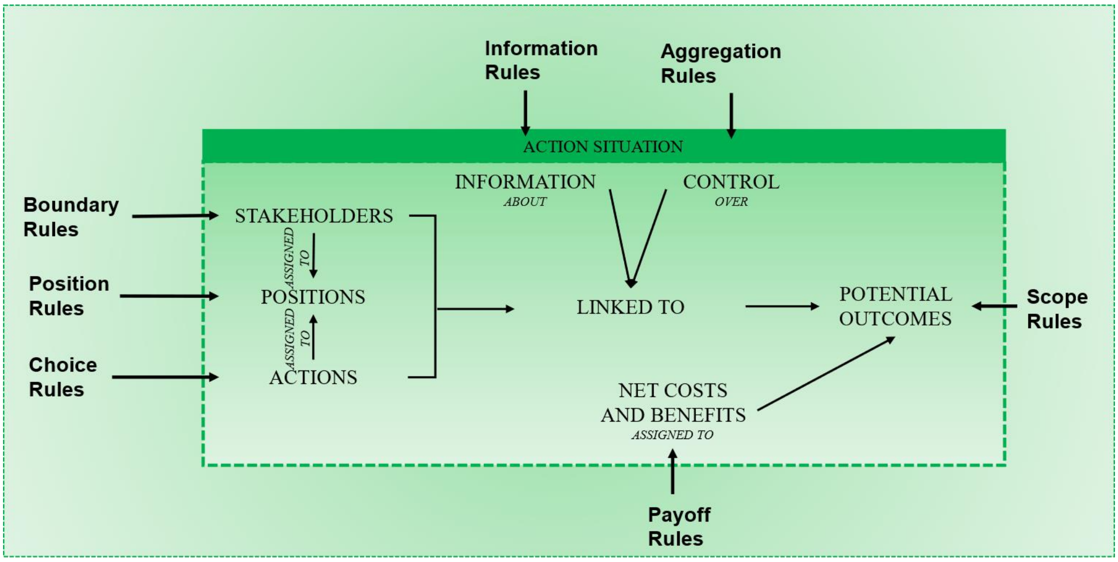

Figure 28: Action Situation governed by rules based on Ostrom (2009;2010)

Aggregation statements specify the shared control over an action, such as how many people must decide on an issue or how many people must approve it (McGinnis, 2011). The knowledge sets of participant classes are related to information. The sorts of level of information that the participants classify are influenced by the **information statements**. The types and levels of information that the participants have are influenced by the information assertions (Ostrom, 2009). Statements determining whether information is held public or private, as well as with whom information is shared, are examples of information statements. Different outcomes could potentially arise from an action circumstance depending on the activities that people take. In this regard, **scope statements** limit the range of possible outcomes and connect the outcomes under discussion to the actions that actors can take (Ostrom, 2011). Costs and rewards of actions and outcomes can incentivize or dissuade actors from taking action. Benefits and costs associated with actions and outcomes are influenced by **payoff statements**.

THE STRUCTURE OF THE IAD FRAMEWORK

From the theory as explained in above it is now necessary to explain how these different elements from the IAD framework will be operationalized in this research. Table 11 revisits the definition of the different elements of the theory including their operationalization for the analysis.

Table 11: IAD elements defined and operationalized according to Polski & Ostrom (1999)

Element	Definition	Operationalization
Action Situation	"Individuals communicate, exchange goods and services, solve problems, dominate one another, or fight in this social arena" (Polski & Ostrom, 1999).	Certain **arrangements** that have induced results/outcomes.
Participant	"A single individual or a group acting as a corporate actor can be considered an actor in a circumstance" (Polski & Ostrom, 1999).	**Public actors: "**governmental organisations and entail authorities such as the Dutch national government, provinces and municipalities." **Semi-public actors:** "social enterprises without a commercial interest but function as private organisations." **Private actors "**are all entities that take part in economic traffic from a commercial or profit point of view."
Biophysical conditions	"The environment being acted upon in a situation influences what actions are physically possible, what results can be created, how (inter)actions are linked to outcomes, and what is included in the players' information sets" (Polski & Ostrom, 1999).	• **Spatial characteristics** of the area. • Scale of Project; • **Funding** • Business case; • Government policy; • Rules and regulations; • Subsidy systematics
Attributes of the community	"The values of understanding that potential participants share (or do not share) about the structure of particular types of action arenas; the extent of homogeneity in the preferences of those living in a community; the size and composition of the relevant community; and the extent of inequality of basic assets among those affected are all important community attributes that affect action arenas" (Polski & Ostrom, 1999).	• Consensus for activities; • Willingness to cooperate • Measure of participation.
Rules	"Rules refer to enforced prescriptions on what behaviours are necessary, banned, or permitted, and they are shared understandings among those involved" (Polski & Ostrom, 1999).	• Boundary rules • Position rules • Scope rules • Choice rules • Aggregation rules • Information rules • Payoff rules
Interactions	"Actors' evaluations of actions and outcomes, based on the information they can observe and process, trigger feedback and learning processes; feedback can affect any component of the IAD framework, and different levels of learning loops can be used to distinguish more extensive processes or reconsideration" (Polski & Ostrom, 1999).	Feedback
Evaluative criteria	"Participants or external observers can utilize evaluative criteria to assess which components of the observed outcomes are satisfactory and which aspects need to be improved" (Polski & Ostrom, 1999).	**Efficiency** in use of resources, especially capture of economies of scale. **Equity** in distributional outcomes and processes. **Legitimacy** as seen by participants in decision processes. **Participation** tends to increase legitimacy. Consistency with the **moral values** prevalent in that community. (Polski & Ostrom, 1999)
Outcomes	"Outcomes are determined by the interaction of a specific action situation's outputs with those of other closely related action circumstances and exogenous variables that are not always under the control of human intervention" (Polski & Ostrom, 1999).	-

There is no single, globally agreed definition of institutions, according to (Scott, 1995). Therefore, the operationalization of **rules** deems more explanation. In previous studies, the distinction between formal and informal rules that direct and shape the behaviour of stakeholders is commonly stressed (Scott, 2008). Official authorities enforce formal rules such as constitutions, laws, rights, and regulations, but informal norms are unwritten customs that impact stakeholders' beliefs and behaviour (Watkins & Westphal, 2016). Problematic is the emphasis on rules alone when describing institutions since it suggests that there are no other influencing factors at play in a social environment (Suchman, 1995). Cultures, structures, and practices can all be transmitters of these institutions, as seen in Table 12. The grammar of institutions, commonly known as the ADICO syntax, is an important instrument for operationalizing institutions (Crawford & Ostrom, 1995). The syntax is based on the discovery that each institutional framework (rules, norms, and strategies) is built on a separate foundation for understanding observable behavioural patterns. Internalized social frames, which explain regularities in behaviour patterns, are the focus of strategies (Scott, 1995). An institutional statement is a common linguistic constraint or opportunity that directs, endorses, or counsels stakeholder actions or results (Crawford & Ostrom, 1995).

Table 12: ADICO explained based on Scott (1995)

Components of institutions			Type of institution		
Letter	Component	Meaning	Strategy	Norm	Rule
A	**A**ttribute	The actor whom an institutional statement applies to.	■	■	■
B	O**b**ject	The inanimate or animate part of a statement that receives the action.	■	■	■
D	**D**eontic	The prescriptive operator that indicates whether the attribute is required, forbidden or permitted to carry out the action of the statement.		■	■
I	A**i**m	The action of the statement.	■	■	■
C	**C**ondition	The temporal, spatial or procedureal boundaries in which the action of the statement is or is not to be performed.	■	■	■
O	**O**r else	Incentives for performing the focal action.			■

In this Appendix the codebook will be explained and an example will be given of how certain text is coded. The coding scheme was made by first operationalising the different elements of the theoretical framework. In Table 13 the framework-variable, the operationalized sub-elements and the coding syntax are explained.

Table 13: Operationalization separate elements and coding Syntax

Framework-variable	Operationalized Sub-Elements	Coding Syntax
Problems	• Focusing events • Indicators • Policy feedback • High-Profile issues	ProFE ProIND ProPF ProHPI
Political	• Institutional Procedures • Political-administrative turnovers • Political campaigns • Discrete steps of influential policy makers	PolIP PolPAT PolPC PolIP
Policy	• Policy Community • Development of new technology • Accumulation of knowledge • Technical feasibility • Budgetary workability • Public acceptability • Politician's receptivity • Fit with dominant values of policy community members	PolicyPC PolicyNT PolicyKN PolicyTF PolicyBW Policy PA PolicyPR PolicyFV
Policy Entrepreneur	• Political connections • Negotiating skills • Coupling streams • Softening-up system • Willing to invest own resources • Persistency	PePC PeNS PeCS PeSUS PeWIR PePE
Policy Window	As a result of focusing events in the problem stream or activities of policy entrepreneurs, the institutional setting where the streams (problems, politics, and policy) pair.	-
Action Situation	-	AS
Participant	• Public actor • Semi-public actor • Private actor	P-PS P-SP P-Pri
Biophysical/Material conditions	• Spatial characteristics of the area. • Scale of Project; • Funding • Business case; • Government policy; • Rules and regulations; • Subsidy systematics	BC-En BC-Ec BC-RR
Attribute of the community	• Consensus for activities; • Willingness to cooperate • Measure of participation.	AoC-Con AoC-Coop AoC-Par

Rules	• Boundary rules • Position rules • Scope rules • Choice rules • Aggregation rules • Information rules • Payoff rules	Rules
Interactions	-	IF
Evaluative criteria	• Efficiency • Equity • Legitimacy • Participation • Moral values	EC-Ef EC-Eq EC-L EC-P EC-MV
Policy outcome	-	PO

After the coding and in case the code *Rules* was used, institutional statements were created using the ADICO-syntax in order to find out what the function of the rule was.

Table 14: ADICO explanation based on Crawford & Ostrom (1995)

Element	Definition
Attribute	"The person to whom an institutional statement is addressed. Because it is the organization being questioned or conducting the goal, the procedure of selecting the attribute (A) is frequently simple (I)" (Crawford & Ostrom, 1995).
O**b**ject	"The part of a statement that gets the action, whether it is inanimate or animate." (Crawford & Ostrom, 1995).
Deontic	"The prescriptive operator that specifies whether an attribute is necessary, prohibited, or permitted to complete the statement's focal action" (Crawford & Ostrom, 1995). "The deontic denotes the firmness with which a statement is enforced. Should (not) and must (not) are both words that communicate the compulsory nature of a statement; however, "must" is more likely to be connected with a rule than with a standard, whereas "should" could be an indicator of both sorts of institutions." (Crawford & Ostrom, 1995)
A**i**m	The statement's activity (Crawford & Ostrom, 1995). This is the "what" of an action and can be found in any sentence.
Condition	"The chronological, physical, or procedural boundaries within which the statement's action will or will not be carried out'' (Crawford & Ostrom, 1995). When the reply does not identify any specific criteria, it is considered that the statement applies "at all times and in all places."
Or else	"Explicit sanctions in the event of non-compliance with the institutional statement by the attribute" (Crawford & Ostrom, 1995). Multiple sanctions or rewards may be encoded in a statement, which are imposed progressively over time or all at once.

At the very least, an institutional statement should include an attribute (who), a goal (what), and a condition (when and/or where) (Watkins & Westphal, 2016). Second, the level at which the institutional statement functions is determined: operational, collective-choice, or constitutional. As previously stated, the operational level of analysis is where operators make everyday decisions that have a direct impact on on-the-ground conditions. The analysis at the collective-choice level focuses on policy decisions regarding which institutional assertions should regulate operational actions. The authorized actors for collective-choice decisions and the institutional statements governing such decisions are examined at the constitutional level (Polski & Ostrom, 1999).

EXAMPLE PARAGRAPH CODING

How did the coding look like in Atlas.ti? In this section two examples have been provided. One that visualizes how policy implementation coding was performed Figure 30, and one that visualizes how the Institutional coding was performed, Figure 29.

Pas op de plaats voor gezamenlijke verkenning realistisch toekomstperspectief onderzoek LEAN.
Warmtebron.nu 07-04-2021

Afwegingskader
In antwoord op de bekendmaking van onze voorkeurslocatie heeft het college van burgemeester en wethouders [P-PS | 04-2021] laten weten dat de gemeente eerst een afwegingskader [BC-RR | 04-2021] voor aardwarmte wil vaststellen. “Pas daarna kan er over locaties worden gesproken”, zo laat Hans weten. “De gemeenteraad vervolgens eind januari aangegeven de winning van aardwarmte voor verduurzaming van het stadswarmtenet [Bc-En | 04-2021] een realistische optie kan zijn. Maar de raad heeft ook gezegd dat het afwegingskader om dat te beoordelen eerste aangescherpt moet worden met meetbare en realistische indicatoren [AS | 04-2021]. De gemeente is hard bezig om dat te organiseren. Met het aangescherpte afwegingskader toets de gemeente of het winnen van aardwarmte in Nieuwegein op een maatschappelijk verantwoorde manier mogelijk is op voorgestelde geschikte locaties” [EC-MV | 04-2021].

Vervolg uitlijnen
Zorgvuldigheid [Ec-MV | 04-2021] in het proces is volgens Joris enorm belangrijk. “De gemeente is aan zet met een eigen afwegingskader om zo voorbereid te zijn op een eventueel voorstel voor een locatie. Dat kost iets meer tijd dan wij van tevoren hadden ingeschat. Dat betekent dat wij onze eigen planning ook opnieuw moeten herzien. Daarom maken we [P-Pri | 04-2021] nu afspraken met de gemeente om van beide kanten duidelijk te hebben waar we aan toe zijn” [AS | 04-2021].

Figure 29: Example coding - institutions

EXAMPLE RULES CODING

In this section there are provided a couple of statements that have been analysis in this research by using the ADICO-syntax. An small overview can be found in Table 15.

Table 15: Example ADICO-coding

Units		A	B	D	I	C	O	Type
1.	For potential locations for the LEAN project, they (LEAN consortium) made the trade-off, what are the costs for a connections to the heat network compared to the costs for the drilling, and these were very different.	LEAN consortium	Trade-off		Made	If costs are know	-	Strategy
2.	Geothermal developers must provide a thorough work plan if they apply for the production license.	Geothermal developers	Work plan	Must	provide	If they apply for the production license	-	Rule (Level = constitutional; class = boundary)
3.	We (LEAN consortium) have asked Royal Haskoning to make this (feasibility study) in order to take away the uncertainty.	LEAN consortium	Feasibility study	-	Have asked	If the study has been performed	-	Strategy
4.	Residents in the direct neighbourhood may ask for additional information about the project at any time if they are worried.	Residents	Additional information	May	Ask	If they are worried	-	Norm (Level = operational; class = information)
5	Each geothermal developer has its own partners with whom they work in general.	Each geothermal developer	Its own partners with whom they work	-	has	In general	-	Strategy
6	Geothermal developers may go to TNO with subsurface questions, particularly about its geographical characteristics.	Geothermal developers	-	May	Go to TNO with subsurface questions	Particularly about its geographicl characteristics.	-	Norm

APPENDIX IV: OVERVIEW OF INTERVIEW TOPICS

In this section, a small overview is given of the topics addressed in the semi-structured interviews. Most of the information is already presented in the Appendix V and Appendix VI, however a couple of statements from the interviews that were especially interesting for the analysis have been noted here.

CASE 01 – PROJECT LEYWEG

"Which environmental risks of the geothermal heat extraction have been considered?"

Section 5.4 of the draught consent order, published by the Ministry of Economic Affairs and Climate, addresses potential harm brought on by soil movement. Any harm to structures or other infrastructure is minimal because the greatest soil displacement after 35 years of production has been estimated at 1.7 mm. Residents who believe they have been harmed by the extraction of geothermal heat must first disclose their suspicions to the mining company. You can appeal to the Technical Committee Soil Movement if you disagree with the claim's settlement or compensation. Additionally, TNO notes that the model computations have been done for 35 years. The likelihood of ground vibrations is low, it was determined during this time. TNO won't conduct tests during the extraction after that. The operator conducts the tests during the production phase and is required to inform the government and SSM of the results. Additionally, SSM will regulate safety when doing tasks and during manufacturing. In order to monitor the local subsurface in the event of seismicity, SSM has asked the operator to establish a monitoring system. The consent decree further mandates that, in the event of measured findings from 1.1, the geothermal energy plant will be shut down. This is accomplished via the traffic signal system, a so-called mitigating mechanism. As an example, tremors that register at 1.1 on the Richter scale are probably not felt by people. Previous earthquakes are undoubtedly taken into account while evaluating safety.

The expected effects on nature and the environment are taken into consideration when evaluating the extraction plan. This is described by the operator in the extraction plan. The Ministry of Economic Affairs and Climate receives advise on this issue from SodM and the local authorities. This considers factors including how close Natura 2000 areas and groundwater zones are to one another. In order to prevent leaking wells, well integrity must also be carefully taken into account and adequate precautions must be taken. The minister came to the conclusion that there were no environmental dangers based on the recommendations made. The draught consent decree includes mitigating steps to make sure that these dangers don't recur in the future. As a supervisor during inspections throughout the production phase, SSM also supervises this.

"… a household must be connected to the heat network before it can be heated with geothermal energy."

Eneco is responsible for distributing water that has been heated using geothermal energy. The heat network will initially be connected to 1,200 houses. 2,500 additional homes could be added eventually. Residents may opt to connect to the heat network if it passes via their street. Which residences will be wired into the heat network is up to Eneco. The heat supplier must pay expenses that are translated into an appendix for connection costs and/or expenses for the cover contribution in order to join a home to the heat network. Numerous factors affect the costs. In general, the cost per home decreases as more homes may be connected at once.

Connection costs of €2,000 are typically attainable in projects with 200 or fewer residences. This works out to about €4,000 per home for lesser projects. A more alluring offer results from a joint or collective application from various building owners. If the connections for the residences are built virtually simultaneously, there will be more economies of scale and lower costs for the heat supplier than with staggered connection. The presence of a suitable location for the delivery set is also crucial (for example: metre cupboard). A caveat applies to this story: the fundamental tenet is that the residences can be connected since the current capacity of the heating network and the heat source is sufficiently large and sustainable.

CASE 02 – PROJECT LEAN

"People are worried about their health, quality of life, and drilling-related concerns."

The initiator was responsible for choosing a preferred place. The initiator supported his decision before the local government and citizens. However, the municipality of Nieuwegein has not declared a preference for any particular area. This led to confusion. The public administration was in charge of making the final choice on the drilling location. Warmtebron Utrecht was unable to make the ultimate decisions. It was critical that the municipality and the LEAN consortium communicated with local inhabitants through a conduit, despite the fact that the interests of governments and market players differed. The group did not always coordinate with the local government in terms of timing and planning, though.

"Public participation is essential"

The public dialogue can ensure that the opportunities and risks associated with geothermal energy extraction are trusted among locals once the topic of geothermal energy is on the local social agenda. Residents are given the chance to take an impartial part in the conversation, particularly when there isn't yet a tangible project. The LEAN consortium had been in the exploring stage for a while, so it is remarkable that the local community suddenly viewed the project as final and exerted all of its efforts to have their voice the instant any mention of a suitable location was made.

"One of the practical solutions for increasing the sustainability of the Nieuwegein heat network is geothermal energy. That won't alter until study project Lean is over."

Time is needed to make good decisions about geothermal energy. More time than fits in the subsidy conditions associated with this project of Warmtebron Utrecht. A good Assessment Framework for Geothermal Energy Nieuwegein is and will therefore remain necessary for the municipality to be able to assess geothermal energy initiatives and locations. The public decision-making process for the Nieuwegein Geothermal Energy Assessment Framework has therefore continued after the LEAN shutdown. Both the municipal executive and the municipal council see geothermal energy as a realistic option for making district heating more sustainable. The condition is that it is done safely and in a socially responsible manner. The Municipal Executive and the municipal council have adopted the Geothermal Energy Assessment Framework Nieuwegein on 20 December 2021. However, the chance that geothermal energy will be initiated at that location again in the short term is small.

"All businesses in the industry place a high priority on the safe and ethical extraction of geothermal energy and should absolutely continue to do so."

Safety precautions are performed before and throughout the production of geothermal energy in accordance with established protocols, and this is frequently audited. Compliance with laws and regulations is monitored by State Supervision of Mines (SSM), the municipality, and the province (via the environmental service). Within the Geothermal Energy Association, for instance, geothermal operators share their expertise and experiences. To ensure a safe and responsible operation, the operators employ the Geothermie Nederland-developed safety, health, and environment (HSE) care system. This also holds true for the Well Integrity Management System, a crucial tool for keeping track of well integrity. Since January 2021, well designs have complied with strict standards for the protection of the subsurface because of the Industry Standard Sustainable Well Design. Leyweg's wells date back a generation. Later on, this can present problems. Geothermal energy has a negligible earthquake risk. This is further demonstrated by the fact that no earthquakes have been brought on by geothermal plants to yet (after almost 15 years of output). It is crucial to record a number of things as a precaution because local folks must have faith that everything is being done to ensure their safety. For instance, we are creating a screening tool for projects to map the possibility of seismicity (SHRA) for particular projects with EBN and TNO (on behalf of the Ministry). Monitoring seismicity is another crucial component. Despite the low likelihood of seismicity, it is crucial to concentrate on close monitoring in order to learn more about and develop confidence in geothermal energy. To do this, the Ministry plans to broaden the KNMI's national network. In order to do this, Geothermie Nederland will negotiate the appropriate contracts with KNMI and offer a standard seismic reaction methodology as part of a standard seismic management system. The industry also wants to make sure that any harm brought on by seismicity is addressed and reimbursed in an open and honest manner. The claims procedure and the corresponding covenant are developed. In order to guarantee that confirmed damage resulting from seismicity in a geothermal project may always be compensated for, Geothermal Netherlands is collaborating with the ministry on a financial instrument.

"Like other sustainable heat sources, geothermal energy extraction is now reliant on subsidies."

Despite its pollution, fossil heat is still more affordable. Less and less assistance is required as the business case gets stronger. The heat demand is the primary factor that determines a geothermal source's business case (such as its size). The second factor is the price of gas in the future; the installation is paid for by the savings on gas purchases. The cost of geothermal energy is decreased by completing more projects. The cost price is decreased by increasing production per geothermal energy project. The SDE++ is the most significant tool for promoting sustainable energy. Mis-drilling is a remote possibility in a geothermal project. The Regulation on National EZ Subsidies - Covering Risks for Geothermal Energy, or RNES Geothermal Energy, can be used to partially mitigate this risk.

KEY STAKEHOLDERS

In 2014, there were 16,277 connections between large and small clients (Segers et al., 2019), and more importantly: with a heat infrastructure already in place.

Haagse Aardwarmte B.V. is the parent company of **Haagse Aardwarmte Leyweg B.V. (HAL).** HAL aims to develop several geothermal projects in the The Hague region and link them to the heat network (Haagse Aardwarmte, 2021). The shareholders of Haagse Aardwarme are Aardyn, Perpetuum Energy Partners B.V., Energie Beheer Nederland B.V. (EBN) and the Energy Fund The Hague. **Perpetuum Energy Partners B.V. (PEP)** consists of a team of experienced specialists from the oil and gas industry and the financial sector. In addition to its role as shareholder, PEP acts as process manager for the redevelopment and commissioning of the wells and PEP manages the company Haagse Aardwarmte B.V.

Aardyn B.V. is a developer and producer of geothermal energy (van Dun, 2022). It has been doing this for more than 10 years, with a lot of passion and a clear mission. It wants to play a major role in the energy transition. Aardyn believes that the heat from our own earth will contribute significantly to the transition to sustainable energy. That is why it is fully committed to the necessary improvement and acceleration of this technique, and operation and maintenance. Aardyn is part of EQUANS. Aardyn will fulfill the role of operator, project manager and operational manager for the geothermal energy projects in The Hague. An examination of Aardyn's developer position reveals that they accepted the risks of redeveloping a geothermal well for heat production and that they needed to recoup the redevelopment costs with future cashflow (e.g. heat sales) (van Dun, 2022). This is managed through a gate-structure that includes exploration, feasibility studies, licencing, and certification. This mean that contract with the intent to pay, subsidy tests, financial investment decisions and financial closure contracts are present. The substantial development risks and uncertainty of future cash flows are the reasons for following this type of structure in project Leyweg. There are financial hazards to development, production, and sales (Keçebaş et al., 2013). Future cashflows to fund development costs are divided into two categories: heat sales and subsidy. Aardyn B.V. is reliant on Eneco, which committed to an intentional contract for heat sales, in order to secure loan capital clearance (van Dun, 2022).

The final heat delivery contract between HAL and **Eneco** is agreed upon at the financial close. Both HAL and Eneco can be called heat corporations in this context because their primary activity is not real estate development. Eneco is in charge of heat transmission and distribution: responsible for managing and constructing district heating infrastructure, as well as acquiring (de Voogt, 2021). Eneco was reliant on the **Municipality of The Hague** and the **Province of South Holland** for the environmental permit evaluation for the installation of heating networks, which was requested (de Voogt, 2021). Eneco serves as a DSO and transmits the produced heat once the heating network is installed. As a distribution service operator, Eneco manages the heat balance to ensure that supply and demand are met. The housing association was initially responsible for the heat sales to individual flats for inhabitants of housing associations (de Voogt, 2021).

Energy Management Netherlands B.V. (EBN) is a company active in the energy sector, whose shares are 100% owned by the Dutch state. EBN has been added in order to use their knowledge, expertise and strength to make an active and significant contribution to the growing portfolio of HAL (HaagseAardwarmte, 2022). EBN provides a connecting force to the energy transition and converts social ambitions into reality. The inclusion of **RVO** subsidies ensures additional income that boost project feasibility (Jongerius, 2022). The SDE++ subsidy on geothermal energy appears to be essential in geothermal projects since it encourages the generation of energy from sustainable sources (Rösingh, 2022). Performing the subsidy test ahead of time increases the predictability of future cashflows

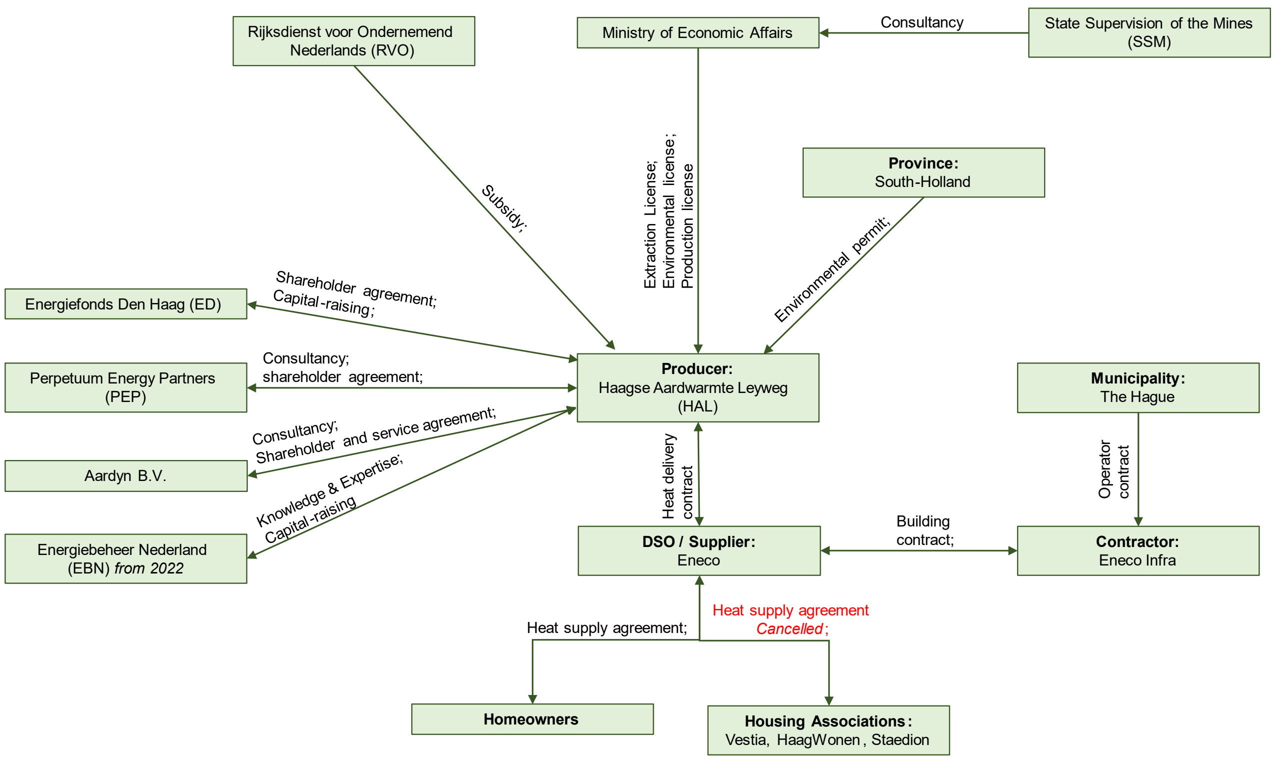

Figure 31: Stakeholder diagram - Project Leyweg [simplified]

An examination of recent presentation of Well Engineering Partners' (WEP) on geothermal energy in the built environment reveals the relevance of and reliance on many variables during construction in inhabited regions, which is reviewed during the environmental licencing assessment (Brinkgreve, 2021). Limited space, well design, noise, logistics, and noise emission are aspects that are relevant for urban geothermal development and are taken into account in the licencing assessment (Brinkgreve, 2021). Developers in urban development are normally real estate sector agencies that might be financial-organizationally related to banks, investors, and construction businesses, and are positioned at the crossroads of various disciplines (Younger et al., 2008). Aardyn's role in project Leyweg, as established by van Dun (2022), confirms that the developing party was tied to the bank, Distribution Service Operator (DSO), Dutch government, and public actors and PEP.

POLICY & POLITICS

From 2013 onwards, the Dutch government has attempted to undertake a variety of reforms to improve efficiency and effectiveness while addressing existing geothermal project implementations within resource and legislative limits (Schoof et al., 2018). Many of these proposals are the result of the Netherlands' decision to prioritise geothermal energy, which was enabled by the 2013 energy agreement. A variety of agreements are included in the national energy agreement with the goal of attaining the 2020 savings and sustainability targets (Nava-Guerrero et al., 2022). One of the pillars for CO_2 reduction in the greenhouse horticulture industry is geothermal heat, often known as geothermal energy (Agemar et al., 2014). A geothermal energy acceleration strategy for greenhouse horticulture has been agreed upon by the national energy accord. In an October 2013 policy statement for horticulture, former State Secretary Dijksma was announced (Van Dekken & Tijdink, 2016). Acceleration is both possible and essential for greenhouse horticulture to remain competitive.

According to Minister Wiebes' geothermal policy letter from 2018, geothermal energy is seen as a crucial step in the development of sustainable options for heat sources in the built environment (Wiebes, 2018). The administration will execute the climate pact on a district-by-district basis. The government has given towns a vital role in this, and by the end of 2021, they will have produced a heat transition vision (Wiebes, 2020). The Hague Municipal Executive decided in 2016 to accept the geothermal heat start-up document, as well as the preconditions and agreements specified in it. The Commission has also decided to sign a letter of intent with the ED fund, Hydreco Geomec, and Perpetuum Energy Partners to form an SPV to relaunch geothermal energy in The Hague.

The problem stream had two different origins: monetary issues throughout the project due to a lack of demand, and borehole instability and environmental complexity. Many implementation obstacles were encountered in the Leyweg project, including low demand and restricted area. These problems arise from structural problems in cities in general, while the 2008 financial crisis and consequent worker reductions have exacerbated the situation (Schoof, 2022).

The real estate market has been severely impacted by the financial crisis (Haffner & van Dam, 2011). A strange combination of securities reacted to the housing market. On the one hand, the housing market appeared to be unresponsive to purchase prices, interest rates, the amount of mortgage funding for homes, and the number of new-build homes completed (Haffner & van Dam, 2011). On the other hand, there were substantial reactions, such as an increase in the number of transactions, permits, and new-build home sales. Because the Housing Corporations opted not to proceed with the new construction project at the moment, this last element assured that the geothermal project had lost its demand (Schoof, 2022). The housing corporation HaagWonen was a shareholder in ADH, but only thirteen of the over 800 residences connected to the power station that would distribute the heat were. According to HaagWonen, the requirement to connect the residences had lapsed because the construction had been delayed (Omroep West, 2018). The housing associations Staedion and Vestia also left the firm, in addition to HaagWonen. The two remaining parties, Eneco and E.On, were then given permission to continue the business under the same name. However, they refused to do so and quit as partners as a result. As a result, at the time, the municipality of The Hague was the sole chevalier. As a result, the municipality's contractor, Haagse Hitte bv., would be responsible for 'basic indebtedness,' according to the alderman (Omroep West, 2013). The company did not like this and they also resigned as partners. Workforce imbalances presented a key challenge also later on during the project. Despite the fact that the project was restarted in 2016, technical difficulties had been identified at the wells. The wells turned out to be clogged for unknown reasons (van Dun, 2022). The company was not pleased, and they resigned as partners as well. Workforce imbalances became a significant difficulty later in the project. Despite the fact that the project was begun in 2016, technical issues with the wells were discovered. The wells were discovered to be obstructed for reasons unclear (van Dun, 2022). This meant that the project's launch would take longer than expected and would require a significant financial investment.

The complexity of urban difficulties had a considerable impact on the additional measures that were required. In 2009, work on a wall of 80 marine containers to keep drilling for geothermal energy from causing disruption began (Omroep West, 2010). This was primarily owing to the permissible noise levels (Jharap & Trienekens, 2022).

ACTION ARENA: HEAT GOVERNANCE

The start of a geothermal energy project in The Hague in 2010 resulted in a new network setup in which residents are more reliant on a collective heat source – primarily the heat network operator. As a result of the Leyweg Project's agenda-setting in 2014, two action arenas can be identified as having produced those outcomes: 1) the process by which the area was established and how the regulations governing it were determined, and 2) the range of factors that determine what heating alternatives are available to people locally. In general, investments were recognised as crucial for the Leyweg project throughout the interviews, which is why *heat governance* after establishment of project Leyweg is additionally of interest. This part of the appendix will elaborate a little more on heat governance after implementation of Leyweg, to illustrate what the role of rules will be after the critical transaction as mentioned in the main text. Moreover, this illustrates that only **one** critical transactions may not be enough to trace the path dependency of interactions.

CONCEPTUALIZATION OF THE ACTION SITUATION

Before the contextual elements surrounding the growth of the geothermal energy project in The Hague can be recognised, a clear grasp of the concept of investment in the industry must be gained. This allows for a more confident selection of action situations to be addressed in this study (Basurto et al., 2010). The development of the Leyweg project has specific characteristics and events that affect the heating market. As a result, the term *investment* will not be confined to investments made by developers and financiers in the context of this study. It will instead incorporate the investments or expenses made by multiple stakeholders whose combined actions contribute to the geothermal project's total life. The financial commitment of the developer is evident. Eventually, the developer will become a geothermal energy supplier, sending heat to the heat network (Rösingh, 2022). On the other side of the transaction, the network operator will be the sole buyer (van Dun, 2022). Finally, the Dutch government has a contribution dependent on the type of support it gives for resource development as the original resource owner.

The three primary parties stated above are linked in a network, indicating their mutual reliance. At various stages of the project, the Dutch government gives licences and, through a mechanism, entrusts resource development to a corporation (Jongerius, 2022). As a result, it appears that the following process should be investigated further in the research: 1) the exploration licence application process; 2) the production licence application process. Normally, the process of resolving the power purchase agreement would be of interest. However, there is insufficient information for this. As a result, this is regarded outside the scope of this study. Other agreements, such as the drilling contract between the developer and other firms, help to build up the project's development at the operational level. These two procedures, on the other hand, might be viewed as two milestones that encompass the project's beginning and commercial launch. In addition to these two processes, the interviews have highlighted the importance of the developer's financial situation in the project's success (van Dun, 2022). Due to financial difficulties, the Leyweg project has been delayed and was on the verge of being on definite hold. As a result, the conversation should also include the developer's financial component as an inseparable attribute. This factor might be factored in by considering another significant milestone: the developer's and its partners' commitment settlement. It's worth noting that the operational level's first understanding of action scenario is relatively simplistic. For example, the Dutch government is divided into Ministries, each of which has a particular impact on geothermal energy development. The Minister's goal for the geothermal energy sector may not always align with the Minister of Finance's ambitions (for example, in terms of nationwide coverage) (Jongerius, 2022).

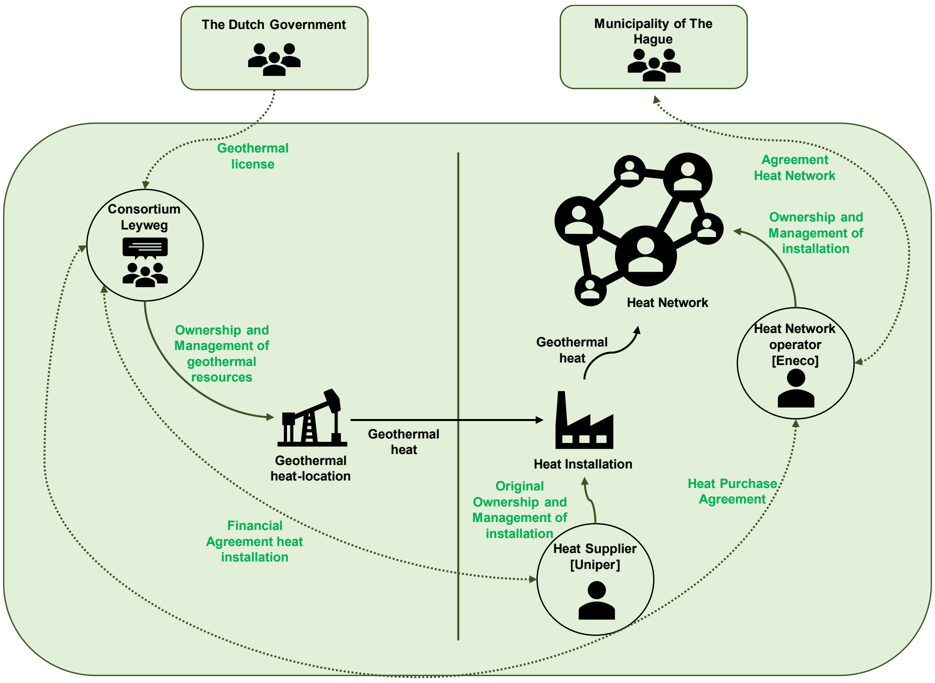

Figure 32: Conceptualisation action situation - heat governance project Leyweg

The discussion should focus on the context in which operational standards are negotiated, created, and put into practise at a higher level of analysis. Through the issuance of geothermal licences and the negotiation of power purchase agreements, the Mining and Environmental Laws regulate the cooperation between the government and the developer (Jharap & Trienekens, 2022). The entity with the authority and duty for managing the project's resources is at the centre of this action situation. The Ministry of Economic Affairs and Climate in the Netherlands is in charge of this. The mining legislation and the environmental law are two distinct laws within the ministry that regulate the development, application, management, and oversight of policies in the renewable energy sector (Jongerius, 2022). The State Supervision of Mines (SSM) is the mining law's advisory and regulating authority (SodM, 2011). Due to the required demand in metropolitan areas, the development of the Leyweg Project cannot be totally separated from the heat sector in the scope of this study. As a result, at a higher level of analysis, it is critical to engage stakeholders who are responsible for defining the heat sector's regulations and policies. The Heat Act is the statute that governs the heat network operator.

Geothermal energy is a capital-intensive project that requires a significant amount of funding (van Dun, 2022). Despite efforts to stimulate private money into the sector, government investment in the form of subsidies plays a big role in the project, according to (Rösingh, 2022). In comparison to the interactions at the operational level, the interactions between actors at this level are less visible. As a result, the complexity rises as the arena becomes a forum for discussion on a wide variety of topics with the goal of changing the game's operational play through changes in regulations and policies. It's worth noting that not all of the players will be present at the same time in the decision-making arena (Ostrom, 2011). It depends on the political situation and the problems under consideration.

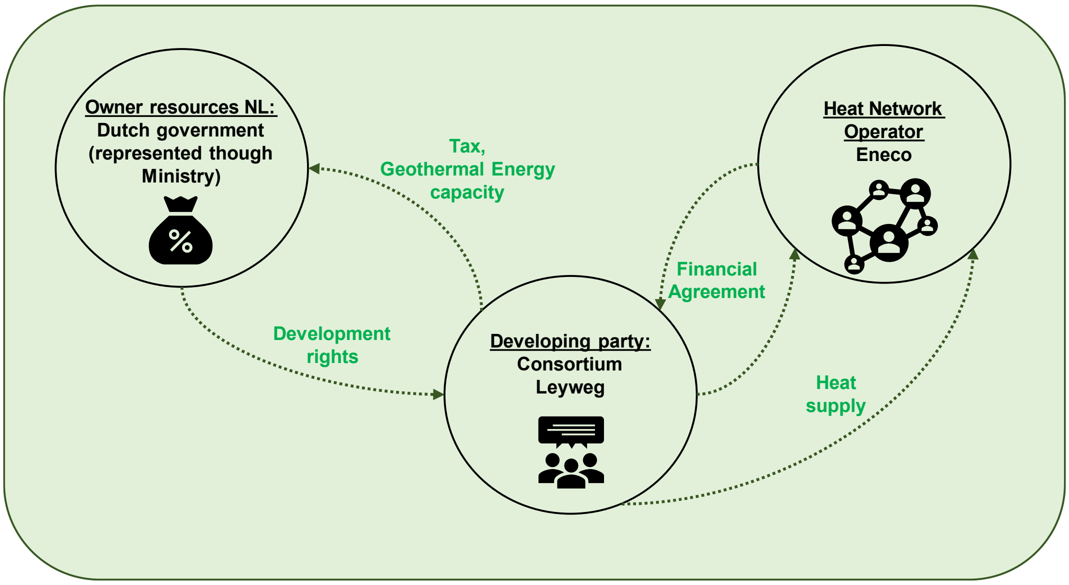

Figure 33: Conceptualisation collective action - heat governance project Leyweg

BIOPHYSICAL AND MATERIAL CONDITIONS

The location of geothermal heat The Haagse Aarwarmte Leyweg (HAL) will be operational soon in the province of South Holland, municipality of The Hague (HaagseAardwarmte, 2020). The goal of the extraction is to extract about 70,000 GJ of geothermal energy per year for use in the district heating network by the customer Eneco B.V. (HaagseAardwarmte, 2020). The geothermal energy system, which is located at Zuidwoldestraat 1K in The Hague, consists of two wells (doublet): a production well and an injection well (HaagseAardwarmte, 2020). The hot water is pumped up from the Delft Sandstone formation using an Electrical Submersible Pump (ESP). In the degassing installation, the pumped-up water is degassed, and the fines (small particles) in the filters are eliminated. The maximum flow rate of the geothermal heat recovery system is 165 m^3/hour, which is restricted by the well diameter (HaagseAardwarmte, 2020). The hot water is pushed up, cooled in a heat exchanger, and then pumped back into the same Delft Sandstone formation. Cooling injection temperatures range from 63℃ in the summer to 57℃ in the spring and fall, and 45℃ in the winter. The pumped water contains gas as well (1nm^3 per m^3 of pumped water). Before being burned in a gas combustion plant, this gas is caught and dried. The Delft Sandstone deposit, from which this project will seek geothermal energy, lies between 1750 to 2200 metres beneath the HAL site. The Delft Sandstone formation is 60 to 100 metres thick and includes water with an average temperature of 80℃. The Rodenrijs Claystone formation runs along the top of the Delft Sandstone formation. Near the two wells, there are minor fractures in the Delft Sandstone formation. Both of HAL's doublets have already been drilled in 2010. The wells were inspected by Hydreco in 2017 (van Dun, 2022). The wall thickness and cement quality were deemed to be adequate (HaagseAardwarmte, 2020). However, because the wells still have single-wall casing, they have not been drilled according to the most recent findings.

After a temporary halt in the project in 2013, it was decided to restart it in 2016. The geothermal source had provided heat for a brief time in a test operation before. Thus, it had been several years since the well had been used (Rösingh, 2022). This could have caused particle deposits, clogging, and drill wall damage. The state of the resource was briefly documented in 2010, however the issue was not documented further while the project remained on hold. As a result, the source has to be *reopened* first. This procedure was carried out in stages (Rösingh, 2022). First, the well's current condition was assessed, and then it was determined whether the well could be cleaned and/or repaired. At the commencement of the relaunch, redevelopment expenses were anticipated at a maximum of €3.13 million, including a €0.5 million contingency item. This was funded in the following way: Staedion and Vestia contributed €1.43 million, while the ED fund contributed €1.7 million (HaagseAardwarmte, 2020).

The source's exploitation was the subject of the second phase. The goal was to supply sustainable heat to the distribution network in Southwest and the existing high-temperature district heating network in The Hague, assuming sufficient heat output (Rösingh, 2022). Only supplying Eneco for the *low temperature* network in The Hague Southwest yielded insufficient returns, according to the business case. In order to make a profit, far more heat had to be created and sold at the source in the beginning than there is now. As a result, Eneco is also responsible for supplying the *high-temperature* district heating network. This district heating network is produced by E.On. As a result, an agreement on heat supply had to be arranged with E.On. The required investments for this phase were predicted at a maximum of €3.7 million in 2016, including the €0.5 million for unexpected events. This phase was funded by €0.49 million in investments from Hydreco and PEP, €2.51 million from the ED fund, and €0.7 million from the municipality of The Hague (HaagseAardwarmte, 2020).

RULES-IN-USE

The Leyweg Project's evolution has been influenced both directly and indirectly by the stated national rules and regulations that make up the current regulatory framework. This section has been divided into three parts as a result. The rules that have been put in place expressly to advance geothermal energy are listed in the first section. The second part of the article looks at laws that significantly affect the Leyweg Project yet aren't intended to control it directly. These rules control how geothermal heat is delivered from the producer to the heat operator. The last section is a list of additional major laws and ordinances that have a direct or indirect influence on the growth of the sector. It includes regulations and rules pertaining to the energy and heating sectors.

Formal Rules

Mining activities begin 500 metres underground in the Netherlands. As a result, geothermal energy is classified as a mining operation (Overheid.nl, 2017). The Mining Act BWBR0014168, which will be updated in 2022, requires a variety of licences. According to environmental law, an environmental permit is also required (Sayginer, 2022). There are also additional laws and regulations that may be relevant. This has been previously explained.

The above-ground parts of the geothermal energy installation are governed by the Environment and Planning Act BWBR0024779 (Sayginer, 2022). The extraction site, the structures, the environment, and the extraction site are among them. Three types of environmental licences are the most essential permitting activities for geothermal energy development and production:

- The use of land or structures in violation of a zoning plan, a management regulation, an exploitation plan, the rules laid down pursuant to Article 4.1, paragraph 3, or 4.3, paragraph 3 of the Spatial Planning Act, or a preparatory decision insofar as Article 3.7, fourth paragraph, has been applied, and that law (Rules of Spatial Planning)
- Starting, changing, or operating a business or mining operation (Environmental Permit).

Building requirements, environmental consequences, and spatial integration are all covered by the Environment and Planning Act. An environmental permit is required before beginning a seismic survey or drilling a well. The operator makes a request to the Ministry of Economic Affairs for this information. The national government is the competent authority because geothermal energy is a mining industry. When granting permits, the municipality and province have the power to advise. Residents can express their opinions on a variety of topics (e.g. safety). Interested parties have six weeks after the environmental permit is obtained to file an objection with the municipality. An objection does not preclude the operator from carrying out the activity. A decision will be made by the municipality. On the basis of the Environmental Management Act, the Minister must determine whether an environmental impact report (EIA) is required with the environmental permission for the building of a geothermal energy project. Environmental interests must be fully considered in the planning and decision-making process for activities that may be harmful to the environment. If an EIA is necessary, the operator must submit the report along with the environmental permit application.

The regulatory framework for geothermal energy is inextricably linked to the rules (Tempelman & van den Berg, 2019). As a result, various rules for heating arrangement, particularly transportation, will be established. Since January 1, 2014, the Heat Act BWBR0033729 has been in effect in the Netherlands. The law establishes standards for district and block heating, as well as heat and cold storage, with the goal of serving small-scale consumers like consumers. The Heat Act covers connections up to 100 kW, which covers practically every household. The Heat Act establishes a role for housing organisations as energy suppliers. This Act governs the following topics: national maximum heat rates; when a heat supplier may close a customer; when a customer is entitled to compensation in the event of a malfunction; what must be stated in the customer-heat-supplier agreement; a customer's rights and obligations when measuring heat consumption; the option to submit a dispute between the customer and the heat supplier to a disputes committee; The Provincial Council and local councils are not entitled to impose rules on the production and delivery of heat in the interest of energy supply, according to Article 39 paragraph 1. This means that they have authority over network installation, repair, expansion, and renewal.

Policies and other Procedures

The development of the Leyweg project involves various stakeholders which are embedded within a larger environment constrained by different rules. Municipalities must deal with legislation, federal policy, and provincial policy, and they have a variety of tools at their disposal to address the sustainability issue (Tempelman & van den Berg, 2019). The Netherlands joined the Paris Climate Agreement in 2015 (PBL, 2020). The international target is to keep global warming below 2 degrees Celsius. This goal has been grounded and developed by the national government in the Climate Act. The following are the main objectives:

- In 2030, there will be 49% less CO_2 than in 1990.
- In 2050, there will be 95% less CO_2 than in 1990;
- CO_2-neutral electricity generation by 2050.

Following that, the government delivered the Climate Agreement in June 2019. The climate goals are then translated into specific methods and measures. In order to meet the climate targets, practically all buildings in the Netherlands must be renovated. A Regional Energy Strategy is now being developed by each municipality, province, and water board (RES) (Gooijer & Mennen, 2021). The Haaglanden Urban District produced a Regional Structural Plan (RSP) in 2007 that included ideas for constructing a heat network with more sustainable heat sources. The municipality will tell you which locations it considers appropriate for geothermal energy application in a subsequent feasibility assessment.

(Informal) Rules

A series of exchanges between system members make up the conceptualized action situation. The Leyweg project's ultimate goal is to generate and distribute heat. The four roles in the arena have been identified based on the initial conceptualisation of the action situation: 1) owner of the geothermal resource; 2) developer and/or producer; 3) heat supplier and/or heat network operator ; 4) Investor. The **boundary rules** will be used to determine how various players can adopt or depart certain positions in an action situation now that the positions have been settled. Different boundary restrictions apply to each position in the arena (McGinnis, 2011).

Table 16: Boundary Rules - Project Leyweg

Position	Boundary Rules
Owner	Mineral Resources, and hence geothermal energy, are the property of the state, according to Article 3, paragraphs 1 and 2 of the Mining Act. Minerals and geothermal heat extracted under a production licence are transferred to the licence holder upon extraction. The underlying premise is that the complete yield of by-catch accrues to the permit holder for geothermal energy up to a particular level. According to Article 94, second paragraph, the 'free' by-catch standard for the production well has been set at 3.6 Nm3 of gaseous hydrocarbons per m3 of water and/or 5 m3 of oil per day. The state is represented by the Minister of Economic Affairs and Climate Change, as required by law. The Minister establishes the rates for expenditures associated with activities relating to assurances of origin for heat from renewable energy sources under Article 29(1) of the Heat Act.

Developer	The Leyweg project's developer is also the geothermal source's operator and will generate the heat. According to Article 93(3) of the Mining Act, the developer is not entitled to conduct mining activities until the approval is given. The producer connected to a heat network is required by Article 2, paragraph 8 of the Heat Act to engage with the supplier about making heat available at fair costs.
Network operator	A supplier shall ensure a reliable supply of heat under reasonable conditions and with due regard for good quality, according to Article 2 of the Heat Act. This also specifies the maximum price for heat supply, as defined in Article 5(1); the maximum rate, as defined in Article 8(1); and additional rates. It is permissible for the provider to also be the network operator under Article 12c, second paragraph. A network operator and a supplier that utilises its heat network will speak with a producer upon request about access to the heat network for heat transport. The network operator is required to give the applicant with information on the network's capabilities under Article 21, second paragraph.
Investor	Any financing agency having an interest and resources to operate in the sector can assume this role. In the case of the Leyweg Project, a partnership is involved in the development, while the licence is held by Hydreco.

The **authority rules** directly describe and explain the various actions made by participants in various situations, as well as how those interactions occurred (McGinnis, 2011).

Table 17: Authority Rules - project Leyweg

Position	Authority Rules
Owner	• The owner has the authority to perform the exploration and/or utilisation on their own or to delegate the development to other corporate organisations. Work under a geothermal heat permit may only be done by, or on behalf of, the (co-)holder who has been appointed as a 'permit executor,' according to mining legislation. Even if the licence provider outsources, the licence provider is still liable for some operations, such as borehole construction, and the fulfilment of certain duties. • To delegate, the owner may choose the scheme for selecting the Developer for the development of geothermal resources in a specific site (restricted tender, open tender, or direct assignment). • The Owner has the authority to monitor the Developer's commitments (if the developer is not the owner), such as the exploratory commitment made during the tender process, payment for project data and information, development monitoring according to the schedule and budget plan, and so on. • The owner has the power to take action against the developer if it fails to meet its responsibilities. • The owner has the power to order the heat supplier to take over the position.
Developer	• The developer could sell geothermal heat to the public or private sector. The heat could be sold to the heat network operator for public usage. • In terms of settling the heat purchase agreement, the developer has the authority to negotiate the heat purchase price to be paid by the customer or heat supply, as well as other terms relating to the transaction's rights and obligations. • The developer is free to select its own financing method.
Network operator	• The heat network operator has the authority to perform due diligence on the Leyweg Project developer and examine the feasibility of the proposed power supply. • The heat network operator has the power to negotiate the parameters of the heat purchase agreement, including the price.
Investor	The Leyweg Project's investors have the right to do due diligence on the developer. Investors have the right to participate in the decision-making process regarding the potential return on investment.

In the action situation, the **aggregation rules** define how decisions are made (McGinnis, 2011). It demonstrates how much power the people in the positions have over their activities. The costs and benefits of the exchanges in the action situation are mostly outlined in the agreements between different parties. There are three main types of agreement that are of interest for this case: the geothermal licence; the developing party's heat purchase agreement, and an investor's agreement. As a result, determining the aggregation rules should be based on how these agreements can be established in the end. However, due to limited data on the heat purchase agreement and an investor's agreement, only the geothermal license will be discussed in the next parts.

The Minister of Economic Affairs and Climate issues a geothermal energy exploration licence based on the Mining Act (Jongerius, 2022), as earlier explained. Additionally, when competition is mentioned, the Ministry asks competing candidates if they are willing to engage in discussions with one another. Mutual consultation may result in collaboration or changes to competing applications, but it is not required. If a licence holder wants to transfer part of his licence to another person, he must first file an application to split the licence, as described in Article 19(a) of the Mining Act. To transfer a permit, the permit holder must file an application for authority to transfer, as described in Article 20 of the Mining Act. The permit holder must submit an application for an extension as described in Article 18(3) of the Mining Act in order to extend the validity of the permit.

Exchanges between players in the region make up the action situation at the operational level of analysis. Information asymmetry must be avoided as much as possible for cooperation to take place (Lammers & Heldeweg, 2019). To begin, the government and the developer must exchange all data and information about the resource. All technical data and information must be made available to the Ministry under the Mining Law. Second, both the developer and the heat operator must have faith in the other's ability to fulfil its obligations. The standards allow one party to do due diligence to establish the other's financial and technological capabilities. In general, the quality of information improves when more studies, surveys, drillings, and other sorts of operations are conducted on the ground. As a result, laws impacting the quality of geothermal heat in The Hague should be included in the information rules. The government supports the collection of this information through two methods: the EBN's SCAN programme and involvement in projects (Rehling et al., 2020).

The **scope rules** define the jurisdiction over which outcomes can be influenced (McGinnis, 2011). Agreements between players are the outcomes of this action situation. Agreements undoubtedly include rights and obligations for/from all negotiating parties. Furthermore, the sector has a high asset specificity, making it vulnerable to opportunism ("Scientific Background: Oliver E. Williamson's Contributions to Transaction Cost Economics," 2010). Under the heat purchase agreement, the current governance structure takes the shape of a long-term contract. Project Leyweg's current geothermal production licence is valid until December 31, 2055, although the current permit is only valid for two years due to the transitory policy framework for geothermal energy (HaagseAardwarmte, 2020). Furthermore, in 2021, The Hague Municipality reached an agreement with the heat provider and heat network operator for a 12-year period. Long-term contracts help corporations reduce uncertainty, but they do not totally eliminate other risks, such as political threats (Putterman, 1987). As a result, the scope rules for action circumstances are those that limit the participant's activities in terms of enforcing the terms of the initial contracts in order to sustain the payoff.

Based on the actions and outcomes achieved, the **payoff rules** govern how the costs and rewards are allocated in the action arena (McGinnis, 2011). The regulations will be explained to each participant in order to better assess the costs and rewards they will get.

Table 18: Payoff Rules - project Leyweg

Position	Payoff Rules
Owner	For the owner, the cost depend on their stake in the geothermal activities.
Developer	Heat sales from specific contracts.
Network operator	By settling a contract with the heat developer, the network operator will on the long term be able to cover network investment costs.
Investor	Return of Investment

ATTRIBUTES OF THE COMMUNITY

The construction of the Leyweg Project can be seen as a means of achieving a number of objectives, including increasing energy source diversification, reducing fossil fuel consumption, and offering sustainable heating options. The development process involves a variety of stakeholders, each of whom places a distinct value on the outcomes and methods for achieving them. Analysing community qualities is required to comprehend the cultural milieu of policy activity as perceived by participants. At the operational level, the analysis is not limited to arena participants. This is due to the fact that the dynamics of collective choice and/or policy level influence a wide range of decisions.

The **developers**' principal purpose, as profit-driven corporations, is to make a sufficient return on their investment. A little aside: the programme was initiated with the purpose of generating more sustainable heating, not just from a financial aspect. Two key challenges face the project's development: 1) a significant initial expenditure; 2) substantial development risks (Rösingh, 2022). As a result, it took an extremely lengthy time from the start of exploration to the start of commercial activities. Despite the fact that subsurface knowledge was widespread, the bulk of dangers were still tied to upstream development outcomes.

Eneco is in charge of **heat transportation and distribution**. They are constructed differently than usual. The contractual actor Eneco infra is in charge of administering and building the district heating infrastructure (Rösingh, 2022). They are reliant on the Municipality and Province issuing an environmental permit for the development of heating networks. Eneco serves as the DSO and transmits geothermal heat when the heating network is built. As a distribution service operator, Eneco manages the heat balance to ensure that supply and demand are met. The Ministry of Economic Affairs has already been cited several times in the research and will not be discussed here again. As a result, they will be mentioned briefly here as the party that determines **policy** and **issues licences**.

OVERVIEW

A small overview can been seen in Figure 34 below. All the contextual factors that have been discussed up to this point will be used for the analysis of the action situation.

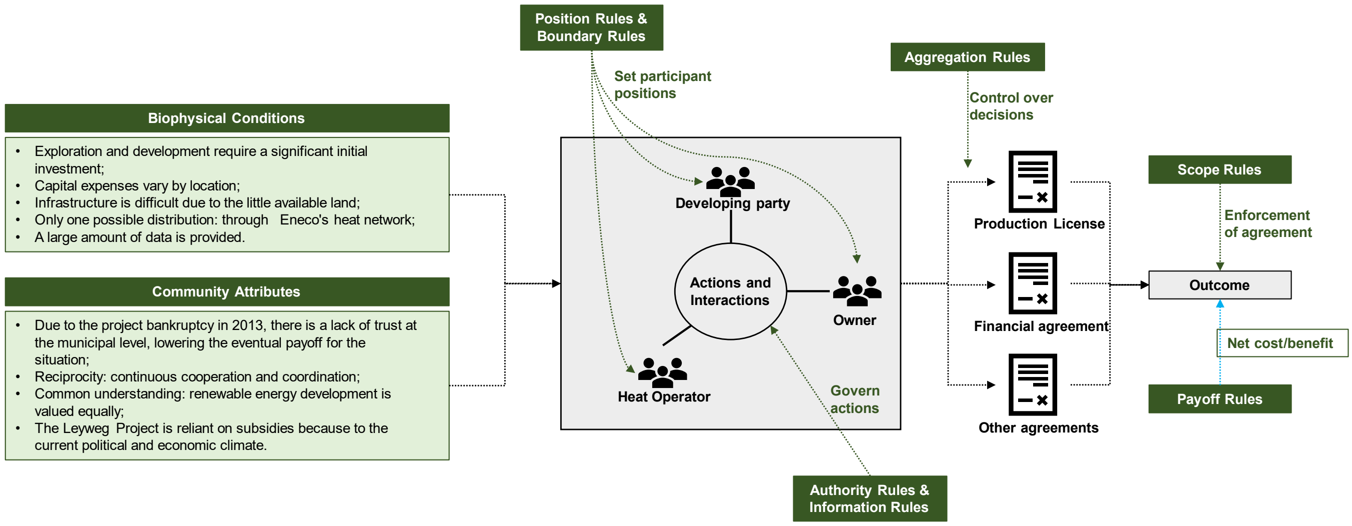

Figure 34: Overview action arena - heat governance Leyweg

ACTION SITUATION - EXPLAINED

Following the identification of contextual elements influencing Project Leyweg's progress, the information gathered is combined to analyse the action situation. This section will analyse the action situation at both the operational and collective-choice levels using the IAD framework concept. The first element of the analysis covers the action situation at the operational level. In addition, the second section of the analysis addresses the action situation at the level of collective choice.

ACTION SITUATION AT OPERATIONAL LEVEL

Figure 34 depicts how the actions and exchanges in the action arena are interconnected. As a result, it's critical to dig further into the factors that have a substantial impact on participants' investing decisions. Note that not all aspects and how they affect the participants' actions and decision-making will be examined.

The payoff clearly has an impact on the participants' investment decisions in the Leyweg Project. For example, the payback-time for the consortium consists of expenditures related with project development, costs of getting the licence, and benefits from heat sales as specified in the specific agreement. The ability of the developing party to fulfil its responsibilities effectively will have an impact on the final tariff paid by the heat operator.

Physical and material circumstances have an impact on the sector's appeal (EGEC Geothermal, 2019). When additional information about the location becomes available, the project will become more appealing to other parties. As a result, in this section, the following will be discussed: physical conditions affecting project information quality; acquiring a licence; payback time and its impact on project investment; and contract enforcement.

In the geothermal sector, the quality of resource information is critical (Hähnlein et al., 2013). During the interviews, it was asked if the lack of interest in continuing the project in 2013 had anything to do with the resource recovery tariff structure subsequently. However, it was asserted that due to a lack of demand, the partners did not consider the project region to be commercially attractive. That is, the partners were discouraged from engaging in the project due to a lack of information and communication. Over the course of the project, the number of enterprises involved in the industry has grown (SodM, 2021). Because of the tremendous rise the sector has experienced, the partners' understanding has gradually grown. As a result, there is more confidence in continuing to invest. With the SCAN initiative, the government has resolved to boost the attractiveness by improving the quality and reliability of resource information. The Leyweg project region did not suffer from a shortage of knowledge due to its rich history. Several interviewees indicated, however, that by completing the project, future developers will have better quality resource information and will be able to do a better and more accurate data assessment, which will improve / speed up the exploration phase (Rösingh, 2022; Schoof, 2022; van Dun, 2022).

When it comes to the issue of geothermal licences, the Leyweg Project comprises two aspects. First, given the massive investment and high-risk nature of the project development, the Leyweg Project has demonstrated the need of private sector involvement. There were minor modifications in the law addressing the regulatory framework during the Leyweg project, and while the procedure was described as ‘not ideal’, there were no major complications with acquiring the licence for the Leyweg Project at any point.

The ideal circumstance in the action arena is when all of the players freely participate in gaining all of the necessary agreements to move the project ahead (McGinnis, 2011). The current procedure is awarding the area to the development party directly. This method allows for quick development. The Heat Purchase Agreement is a crucial stumbling block in the payment process. Demand is essential for a geothermal energy project to succeed in the built environment. This was the deciding factor in the temporary halt in 2013. The presence of a heat network in the built environment, it can be argued, can be essential in making investment decisions. A number of important considerations have emerged in this regard, which can be grouped into three categories: availability, affordability, and manageability. It's critical to consider the distance between the source and the network's input, as well as long-term and short-term availability, when connecting to the heat network. A heat network also demands significant upfront investments. This means that a heat network is best employed in areas where there are a lot of buildings. Customers must be assessed as well, as must their willingness to connect to the heat network.

The contractual enforcement especially corresponds to the operational scope regulations of the action scenario. All methods to protect the interests of all parties bound by various agreements should be included in the regulations. The government's goals are to maximise both private and public interests, with private referring to end-users. In terms of the geothermal sector's overall development during the project, the goal is to increase geothermal power capacity through credible, safe, and efficient development.

ACTION SITUATION AT COLLECTIVE CHOICE LEVEL

According to the analysis of the action situation at the collective choice level, changes in the rules controlling heat distribution between network operators and geothermal developers have been characterised as "not straightforward." The ability of constitutional level interventions to correct legal governance failure at collective choice levels, to provide effective, efficient, legitimate, and lawful thermal infrastructures, is usually accompanied by a broad and abstract legislative form (Ostrom, 2011). The Dutch Heat Act should be studied in order to understand this. This act makes no demands on a public regime or a high or low level of technical sophistication in terms of infrastructure functionality (Tempelman & van den Berg, 2019). As previously stated, the Heat Act was enacted with the goal of permitting a feasible development of residual heat use, with sufficient expenditures to improve sustainability and safeguard heat consumers. A permission is required for large-scale infrastructures with more than 10 users and producing more than 10.000 GJ/year, according to Article 9 of the Heat Act, with the Minister of Economic Affairs as the competent authority. The Heat Act establishes a ‘regulated market’, which is a hybrid institutional system that combines the state’s ‘public hierarchy’ and the ‘competitive market’. Institutional environment, according to (Lammers & Heldeweg, 2019), not only describes but also prescribes a pattern of behaviour that may exist in practise in order to establish normative opportunities for and constraints on acts in collective choice scenarios. The Dutch Heat Act has features of the second type: Alternative regulatory interventions at the constitutional level have an impact on stakeholders’ ability to self-determine the form of instrumentation in legal governance of decision-making that leads to new or upgraded heat infrastructure that includes geothermal energy. With this in mind, we may examine the situation at The Hague more closely. In 2016, a motion had passed demanding that the municipality stick to its own sustainability goals (= 2030 climate neutrality). Previously, 'Guarantee of Origin' certificates were obtained from many sources, including Norwegian hydropower plants: these guarantees are plentiful and do not contribute to the creation of sustainable energy in-house. The potential to encourage local generation using additional sources was taken as the energy contract expired. For the municipality, renewable energy comes primarily from the wind and sun, but it can also come from hydropower and geothermal energy. Eneco had been allocated one of the lots (de Voogt, 2021). They established a plan at the time to provide 100 percent renewable energy from regional sources by 2021. Furthermore, the party aspires to win 10% of the vote in the local elections. The municipality has signed a 5-year deal with Eneco that can be extended up to a maximum of 10 years. Eneco also has more sales certainty as a result of the longer payback time of renewable energy investments. Eneco buys heat from Project Leyweg based on the amount of capacity available.

KEY STAKEHOLDERS

Warmtebron Utrecht, based in the province of Utrecht, has set its goal to examine if geothermal energy is a viable alternative to gas and electricity in the future years (Steinberger, 2019). And whether achieving the climate targets is a safe, feasible, and cheap option. In order to do this, two research projects were launched in 2018: LEAN and Gold. Eleven public and commercial entities are involved in these projects: initiator TNO, coordinator ENGIE, Well Engineering Partners (WEP), IF Technology, the University of Utrecht, the province and Municipality of Utrecht. Warmtebron Utrecht is the name of the collaboration between the two research initiatives (Steffens et al., 2020).

TNO is notably involved in the LEAN project (TNO & Universiteit van Utrecht, 2020). The organization ensures that large data sets containing a diverse range of subsurface data are digitally accessible for planning, policymaking and scientific research, among other things (TNO & Universiteit van Utrecht, 2020). All with the goal of addressing societal challenges and ensuring a long-term future. TNO is a non-profit organization that works on behalf of the government, water boards, municipalities, and other organisations, as well as the business community. BROloket, DINOloket and NLOG are three well-known sites managed by TNO. At the same time, the University of Utrecht is a partner of the LEAN project. The main goal within the partnership is to broaden their knowledge with regard to geothermal heat and to make their campus more sustainable (TNO & Universiteit van Utrecht, 2020).

WEP originated from a merger of two companies from the world of oil and gas extraction (WE-P, 2019). For clients in oil, gas and salt extraction, the office prepares permits, write project plans, purchase materials and manage parties during the drilling phase. Technical officer Geertjan van Og has been involved with the LEAN project since 2017 (Van Og, 2022).

With the LEAN project **Huisman** was in charge of drilling the initial so-called thin hole (Huisman, 2017) - 2,500 metres of measured depth in an almost vertical well using some of Huisman Well Technology's ground-breaking innovations, such as Measured Pressure Drilling (MPD) and Enhance Casing Installation (ECI). Through inventions, Huisman put a major emphasis on boosting the viability and success of geothermal energy, not just in the Netherlands but also internationally (Huisman, 2017).

ENGIE obtained an exploration permission as part of heat source Utrecht in 2019 to search for a suitable heat source (geological target reservoir) in which a geothermal source can be created in a defined search region surrounding Utrecht (Steffens et al., 2020). Hydreco Geomec was acquired by ENGIE in 2020 (ENGIE, 2020). With this transaction, ENGIE has risen to the top of the geothermal energy industry. In order to make the Netherlands CO_2 neutral, ENGIE uses a number of sustainable energy sources, including geothermal heat, heat and cold storage, heat networks, residual heat, and decoupling. Because ENGIE has extensive experience with sustainable energy systems, the best mix for each place is determined in consultation with and for the benefit of the businesses and locals (ENGIE, 2020). The influence on the development, management, and operation of new heat networks and ATES systems in the Netherlands has increased thanks to the combination of Hydreco Geomec's knowledge and ENGIE's strength.

Geothermal energy, according to the **province of Utrecht**, is a sustainable and clean energy source that can be used to replace natural gas (Steffens et al., 2020). However, little is known regarding the availability of geothermal energy in the province of Utrecht. That is why, within the province of Utrecht, the province fosters and supports (financial) research into the application of geothermal energy, including the LEAN research project (Warmtebron Utrecht, 2019a). The presence of adequate geothermal energy layers in the subsoil, as well as the manner in which geothermal energy can be exploited safely and ethically, are the province's key focus areas. The actual utilisation of geothermal energy sources requires a good connection to regional heat demand and investment in heat networks. The most important thing to remember is that local and regional interests must be considered (including drinking water, nature and spatial integration of activities, for example).

The municipalities of Nieuwegein and Utrecht are probable locations for the LEAN research project (Steffens et al., 2020). Both of the municipalities have their own sustainability and energy transition visions and policies. The **municipality of Nieuwegein** wants to be energy neutral by 2040, and the Nieuwegein Energy Neutral 2040 Roadmap is the roadmap for getting there (De digitale Nieuwegein, 2021). Nieuwegein was mostly constructed in the 1970s and 1980s, at the same time as the energy infrastructure. As a result, a major portion of the gas networks will need to be replaced soon. Furthermore, 50% of houses are connected to the district heating system (De digitale Nieuwegein, 2021). This opens up possibilities for making Nieuwegein's heat supply more sustainable on a bigger scale. By 2040, the municipality of Nieuwegein hopes to have recycled all of its essential heat using a combination of sustainable techniques, including geothermal energy. In 2021, the goal will be to see if a geothermal project in Nieuwegein is possible (De digitale Nieuwegein, 2021).The **municipality of Utrecht** believes it is critical to investigate fossil-fuel-based heating options such as natural gas (Steffens et al., 2020). As a result, the municipality of Utrecht is taking part in research into geothermal energy extraction as well as the feasibility of the LEAN research project. The city of Utrecht believes that this research – and the potential fulfilment of the LEAN research project – is a step in the right path toward realising Utrecht's goal of becoming a climate-neutral city. The town has put in place the requirements that geothermal energy be extracted in a socially responsible manner and that the risks be managed. Consider the dangers to drinking water and groundwater, as well as buildings, offices, and natural resources.

Eneco, like the municipalities of Utrecht and Nieuwegein, aspires to reduce CO_2-emissions to zero percent in the future (Eneco, 2018b). Fossil fuels are currently the primary source of heat in heat networks. The heat network in Utrecht and Nieuwegein, which dates from 1923, is the oldest in the Netherlands. Eneco and both municipalities reached an agreement in 2018 to make district heating more sustainable (Eneco, 2018a). Eneco holds two specific visions on sustainability in the province of Utrecht (Eneco, 2018b). Eneco develops its own sources, but it also makes its heat network available to third parties, such as businesses and heat cooperatives. Eneco is also studying how neighbourhoods might be turned natural gas-free in partnership with citizens, in collaboration with neighbourhood initiatives and partners.

EBN was founded as a state-owned corporation to represent social and economic dangers in the Dutch underground (Geothermie Nederland & EBN, 2021). They aim to reduce the risks of geothermal energy projects for people, the environment and nature while also lowering costs through systematic, efficient and sustainable subsurface management. EBN has had a specific position in the LEAN project. In early 2021, the SCAN programme informed the Provincial

Council and the municipal councils of Utrecht, Zeist, and De Bilt about the search area where a research drilling could take place, in order to alleviate some of the existing uncertainties (Van Og, 2022).

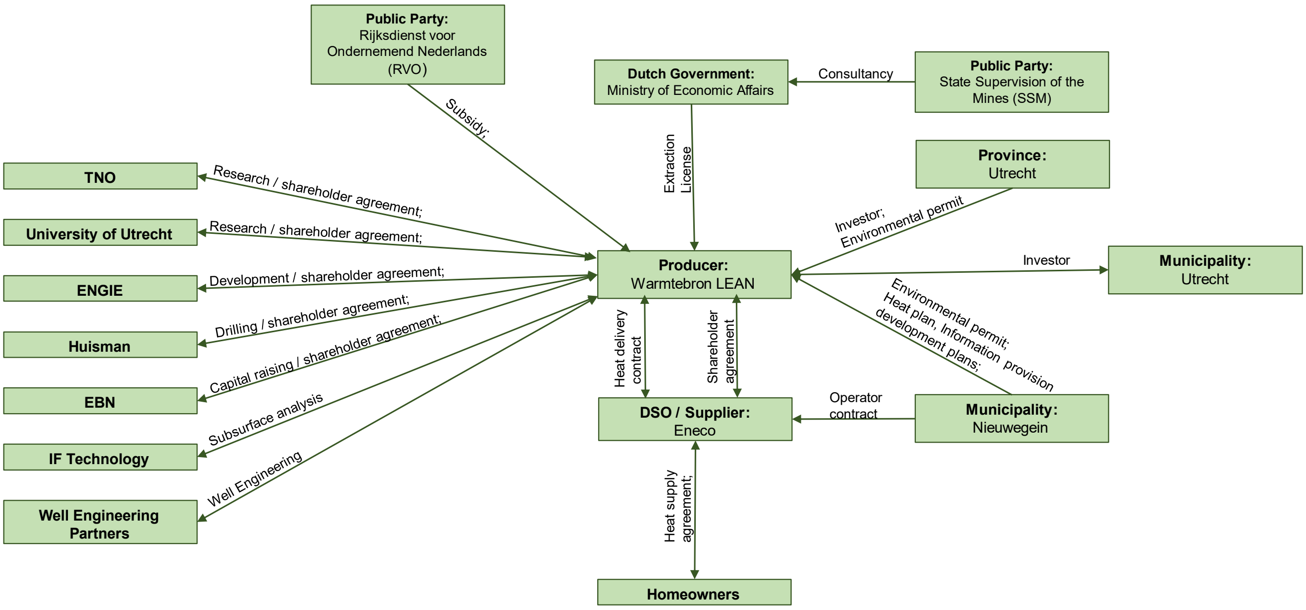

Figure 35: Stakeholder diagram - Project LEAN [simplified]

POLICY & POLITICS

Minister Wiebes stated in 2018 that mining rules and regulations are more aligned with the practise of gas and oil extraction than with the practise of geothermal energy (Wiebes, 2018). Whereas test drilling and actual production can be technically separated in the gas and oil industries, this was not the case with geothermal energy. For numerous technical and financial reasons, the exploration phase of geothermal energy quickly transitions to the extraction or exploitation phase after a short test period. Furthermore, the extracted substance is of a distinct kind. Heat is a local product that can be efficiently transferred and stored to a considerably smaller extent than gas, which is an international commodity that can be easily carried and stored. As a result, it would be more closely linked to direct changes on the topsoil, such as municipal and provincial attempts to make their heat supply and demand more sustainable. That is why the Minister stated in 2018 that a change in protocols was required, which he endorsed in 2020. The adjustment to the licencing system for geothermal energy is one of the most significant improvements in the proposal to update the Mining Act. The suggested improvements would make geothermal project procedures more streamlined and allow mining to begin immediately after a brief test period.

A change in the role of the supervisory authority, State Supervision of Mines, was also included in the plan. In the proposed system, the permit phasing would be altered. In contrast to hydrocarbons, the initial permit for geothermal energy was just a market organisation permit at the entrance – the allotment of search area. It was a permit that allows the holder to make the necessary preparations to apply for a permit for geothermal energy exploration and production, but no drilling or production activities are permitted at this time. In addition, the goal of the Mining Act was to strengthen the interaction with topsoil. As previously stated, geothermal energy extraction and sale is significantly more localised than oil and gas production and sale. This meant that not just for the establishment of a geothermal project, but also for a long-term heat shift within a municipality, cooperation and connections with local subsurface and above-ground operations are critical. That is why, in the case of geothermal energy, the Minister had declared that local and regional authorities would be included in the formal advisory process at all stages of the permit process. Furthermore, subsurface search areas are only assigned if a proposal for the sale of the geothermal energy to be recovered can be filed. This ensures that projects are linked to above-ground demand and that strategic claims on the subsurface are avoided. Finally, the Minister states that geothermal developments are not permitted to interfere with plans already in place by the municipality(s) or province. This establishes a legal connection to the topsoil that is consistent with the visions for the heat transition and Regional Energy Strategies.

In November 2019, the Minister devised a temporary policy framework to meet the above goals while avoiding becoming bogged down in the process (Wiebes, 2020). This meant that until the law was changed, a temporary production licence had to be filed for well before drilling and a temporary extraction plan had to be approved. The temporary production licence will be assessed in much the same way as a regular production licence, with the exception that the duration and size of the production area have not yet been decided for the entire production period. The production licence will be assessed using the criteria set out in Article 9 of the Mining Act, but, unlike previous production licences, it will be valid for a standard period of two years, and the area boundary will not be determined using TNO's 'determination of area boundaries for geothermal energy production licence' memorandum (dated June 5, 2014, reference: AGE 14-10.050) (Samsom et al., 2018). The temporary production licence area is determined by the area sought by the holder of the exploration licence, and in most cases, the requested region is approved. Of course, if the proposed location is within the scope of the applicable exploration permission.

The definitive extraction area will be defined using the TNO process with the follow-up permit. The method for obtaining a temporary production licence is the same as for obtaining a regular production licence. The application for a production licence is submitted to TNO, SodM, and the province for guidance once the holder of an exploration licence has submitted an application and it has been assessed as admissible. The municipality(s) and (the) water board(s) will be involved in the province's advise. Finally, the Mijnraad is enlisted to help. The Mijnraad considers the advise of TNO, SodM, and the province when drafting its recommendations. In addition, the Ministry briefed the House in 2019 about how EBN can be employed in projects aimed at speeding up geothermal energy development. EBN can establish a project portfolio in which expertise and experience can be shared, and EBN can participate in conversations and decision-making as a public partner concerning decisions that impact the project's sustainability and quality by participating in projects with a risk. EBN collects knowledge that assists other projects in the portfolio, and EBN can pool project experiences for cost savings, innovation, public understanding of the subsurface, and policy formulation and incentive tightening guidance. The Mining Act and Regulation control EBN's participation in new geothermal projects as a reciprocal duty that is initially prescribed for 5 years and then assessed. The Mining Scheme specifies the level of participation percentage as well as other restrictions. The Ministry has made a subsidy available to EBN in the form of a subordinated loan of 48 million euros for (required) participation and financing.

Finally, the Ministry updated **the SDE++** geothermal energy system in 2020. There are now categories that reflect the intricacies in business scenarios. A distinct base amount has been added for shallow geothermal energy, for example, because the cost of generating shallow geothermal energy is lower. In order to encourage the use of geothermal energy in the built environment, new categories have been created with a greater base amount but fewer subsidised full load hours. As a result, realising geothermal energy as a source for smaller heat networks, or heat networks in the early stages of growth, should become more appealing.