Geothermal energy as part of the energy transition in the Netherlands

How policy instruments influence the planning and implementation of geothermal energy projects in contemporary energy governance

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COLOPHON

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ABSTRACT

Geothermal energy as a sustainable heat source has the potential to make a significant contribution to the energy transition in the Netherlands. It can meet heating, cooling and electricity demands for the future. In the body of literature regarding energy transition towards renewables, geothermal energy does not receive much attention. In practice, geothermal energy use is increasing, but not yet widely used in the Netherlands. To accelerate the shift towards the use of geothermal energy in its full potential, it is necessary to create a conducive governance context. In this qualitative study, the geographical area of RES region Rotterdam-Den Haag is scrutinized as case. It is the region in the Netherlands where most geothermal energy projects are currently planned. By means of semi-structured interviews and a document analysis it is researched how the contemporary governance setting regarding geothermal developments is influenced by policy instruments, with the aim to learn from the insights. One insight is that established within the paradigm of the heat transition, geothermal projects are highly subject to multi-level interactions. However, the decisive decision-making lies with the national government and geothermal development is therefore not -yet- that decentralized. Based on this study several recommendations are put forward. One of these recommendations is that a mix of *1) legislative/regulatory instruments, 2) economic/fiscal instruments, 3) agreement-based instruments, 4) information/communication based instruments and 5) knowledge and innovation instruments,* should be applied to build knowledge and capacity with regard to geothermal energy planning on multiple levels within the actor network. And lastly, a lesson is that coordination between these levels is required if geothermal energy is to be increasingly applied to the built environment.

Keywords: geothermal energy, policy instruments, energy governance, energy transition, multi-level governance

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List of abbreviations

DMGE	Dutch Masterplan of Geothermal Energy
E.g.	Exempli gratia/ for example
EZK	Ministry of Economic Affairs and Climate
GGA	Global Geothermal Alliance
PJ	PetaJoule
PPP	Public Private Partnership
RES	Regional Energy Strategy(ies)

1. INTRODUCTION

1.1 INCREASING USE OF GEOTHERMAL ENERGY IN THE NETHERLANDS

Geothermal energy is a heat source that has potential to make a significant contribution to the energy transition, and more specifically the heat transition in the Netherlands. As an environmentally-friendly source it can meet heating, cooling and electricity demands for the future (IEA, 2021). Following the recent targets set by the European Union in the policy 2030 Climate and Energy framework, by the year 2030 at least 32% of the energy share should be generated by renewables, including geothermal energy. According to the Dutch Masterplan Geothermal Energy (DMGE) (2018) in the Netherlands the technique has made a promising start in greenhouse horticulture and the next step for the further development of geothermal energy is its application in the built environment. Potentially about 26% of the total heat demand of all Dutch houses and buildings can be met by geothermal energy as part of a collective heating system (DMGE, 2018).

In literature on environmental and energy governance, a shift from centralized towards decentralized governance can be noticed (Zuidema, 2016; Goldthau, 2014). This resonates with the situation in the Netherlands, where energy planning is increasingly regulated at regional government level. At the regional level, the so-called Regional Energy Strategies (RES) exist with regard to energy policy. Within the designated RES regions, the local governments, social partners, network operators, the private sector and where possible local residents, collaborate to prepare regionally supported choices regarding energy transitions (NPRES, 2019). These choices are translated to relevant areas, projects and the implementation and execution of these projects. The Regional Energy Strategies (RES) are an important element in the Dutch Climate Agreement (NPRES, 2019). In several policy documents drawn up by governmental bodies within the RES regions, it is recognized that geothermal energy should be part of energy transitions strategies in the Netherlands (see among others: RES Rotterdam-Den Haag, 2021; RES Groningen, 2021).

Nevertheless, the plans of approach regarding geothermal energy are still not very concrete and policy documents on different government levels actually call for more research. For example, the GGA (Global geothermal alliance) (2016) at an international level states in their action plan as one of their main purposes helping to develop institutional instruments preferable on a regional level. In the DMGE (2018) parties call for an institutional focus on knowledge sharing, actor networks, funding and other incentives. In the RES of energy region Rotterdam-Den Haag it is stated that additional legislation and regulations, policy instruments and knowledge and skills are required to optimally implement local geothermal heat sources in the future (RES Rotterdam-Den Haag, 2021).

As a consequence, despite formulated ambitions and goals, geothermal energy as a sustainable energy source, is still largely untapped. Where other sustainable renewables grown rapidly in recent years, driven by policy support and sharp cost reductions for e.g. solar and wind power, worldwide geothermal energy generation increased an estimated 2% in 2020, falling below average growth of the previous five years (IEA, 2021). These global developments are also reflected in the Netherlands. Compared to wind and solar energy development, the implementation of geothermal energy is not yet on a comparable scale (CBS, n.d.). Thus, in order to achieve set targets upscaling and innovation is required.

1.2 A NEED FOR POLICY TOOLS REGARDING GEOTHERMAL ENERGY

In the body of literature regarding energy transition towards renewables, geothermal energy does not receive much attention. Two studies on the main barriers that hamper the introduction of geothermal energy use, reveal that at a regional level the barriers are institutional, economic, technical and social of nature (Colmenar-Santos et al., 2018; Pan et al., 2018). Furthermore, a study concludes that the actual emergence of this technology is subject to developments in legislation and incentives coming from governments (Petitclerc et al. 2017).

On the contrary, there are studies on the hampering factors and successes of the energy transition in general. For example, several scholars analyzed the success of the energy transition to low carbon and renewable energy systems from the resource potentials, technical and economical perspective (Dominković et al., 2016; Brown et al., 2018; Jacobson et al., 2018). It was found that despite the identified feasible technical solutions, their implementation can only be realized throughout an effective governance mechanism. Hence, the successful implementation of renewable energy sources is dependent on a framework of institutions and instruments on the energy transition. Loorbach et al. (2008) confirm this and add that the energy transition has an emergent character in terms of how the transition issue is formulated in society and what direction is desired. Policy and governance strategies in this context should include structuring and coordinating activities as well as allowing for and creating room for spontaneous and surprising activities (Loorbach et al., 2008). The following manners are offered to accomplish that: formation of new combinations of knowledge, stakeholders and technologies. In addition, Loorbach et al. (2008) state that policy instruments might trigger developments on the micro- and meso-levels and set off new dynamics that encourage the transition towards renewables. In the limited literature on geothermal energy related to social science, there are indications that in this paragraph described enabling factors are lacking or insufficient when it comes to geothermal energy. Besides, compared to the techniques (wind and solar energy) on which traditional energy transition literature is often based, geothermal energy is extremely capital intensive and implementation also requires an thorough risk analysis (Manzella, 2018). Altogether, this makes geothermal energy an interesting topic to study.

Energy planning, as part of environmental governance is already occurring on many levels: the local, the regional, the national and the global. The governance of energy has to be adapted to the changing and transforming energy world (Pastukhova and Westphal, 2020). Within literature on energy governance, there are three dominant trends noticeable: multi-level governance, decentralization and new forms of partnerships (Dobravec et al., 2021; Goldthau, 2014; Sanders et al., 2014). However, geothermal energy is almost not associated with them. Despite the fact that these multi-level governance structures are necessary to enable and facilitate the energy transition on the ground (Dobravec et al., 2021). In order to stimulate the transition towards increased geothermal development and to create a conducive governance environment, certain kinds of pressure is needed that can be given by various government levels, but also market parties. Policy instruments can serve as means to that pressure, since policy instruments are a set of techniques that actors use to give effect to their policies and to effect change (Bemelmans-Videc et al., 1998).

Concluding, the main problem is that despite the formulated ambitions and objectives, there is apparently little knowledge on the governance setting and the type of policy that could actually encourage geothermal developments. Policy instruments could function as catalysts in achieving the outlined ambitions and objectives and in overcoming barriers that hamper the implementation of the renewable source. Considering the ambitions of growth in geothermal energy use, an important focus is firstly on how existing governance (networks) has affected development processes for geothermal energy so far and secondly, how, in the context of contemporary energy governance, geothermal use can be boosted by means of policy instruments.

1.3 RESEARCH OBJECTIVES AND QUESTIONS

The aim of this research is to explore how policy instruments can influence the development of geothermal energy projects in the Netherlands and to see what lessons can be learned from a Dutch 'front-runner' RES region Rotterdam-Den Haag. This is studied from an instrumental perspective and within the context of contemporary trends in energy governance. The Netherlands is chosen because of its ambitious targets regarding geothermal energy, and specifically the geographical area of RES region Rotterdam-Den Haag is chosen as case to study because it is the area where most geothermal projects in the Netherlands are currently implemented. The region therefore has a leading role. Moreover, at the regional level (within the RES), the energy transition and its implementation are now very actively being considered. The main research question of this study is:

How is the planning and development of geothermal energy projects in RES region Rotterdam-Den Haag influenced by policy instruments within the context of contemporary energy governance in the Netherlands?

To support this central question, the following sub-questions have been formulated:

1. What does the exploitation of geothermal energy entail, what are contemporary trends in energy governance, and how can the concept of policy instruments be defined, and subsequently operationalized to contribute to the exploitation of geothermal energy?
2. What are current policy goals that apply to RES region Rotterdam-Den Haag and how are geothermal energy projects in RES region Rotterdam-Den Haag affected by policy instruments?
3. What lessons can be learned from RES region Rotterdam-Den Haag regarding the position of geothermal energy in contemporary energy governance?

1.4 SOCIETAL AND SCIENTIFIC RELEVANCE

Recently the European Commission presented the REPowerEU plan in response to the problems in the global energy market caused by the recent Russian invasion. It is a plan that pursues clean energy production and energy supply from various sources. The plan shows all the more the urgency to accelerate the energy transition. Following the national Climate Agreement of June 2019 (the Dutch elaboration of the international climate agreements of Paris (2015)), in the long term there must be many hundreds of geothermal installations in the Netherlands. The 3 petajoules (PJ) now produced should grow to 50 PJ in 2030 and at least 200 PJ in 2050. The Climate Agreement states that by 2050 we will make full use of sustainable alternatives for energy and heat generation (Rijksoverheid, 2019). In the Netherlands, there is an increased interest in exploitation of geothermal energy (see among others: RES Rotterdam-Den Haag, 2021; RES Groningen, 2021). However, there are still knowledge, institutional and social barriers that prevent geothermal projects from developing (Provoost et al., 2019). The right instruments and governance networks are needed to increase geothermal-based power generation (IEA, 2021). This research will lead to insights in the form of recommendations on policy instruments that influence geothermal energy exploitation, while giving consideration to contemporary energy governance. Moreover, the research will result in recommendations for Dutch governments as to how they can further embed those instruments to stimulate the use of geothermal energy.

Limited amount of research and innovation funds in the energy sector, have led to underdevelopment regarding academic knowledge about geothermal energy in social science (Manzella, 2018). The current literature on geothermal energy is mainly focused on technical aspects. Studies to governance and policy related concepts remain underutilized in the geothermal sector (Manzella, 2018; Sovacool, 2014). Multiple scholars concluded that more insight is needed into the relationship between the transition towards renewables, governance and

institutions (Sovacool, 2014). Manzella (2018) state that instruments and institutions represent key factors for the overall acceptance and implementation of geothermal energy facilities. Thus far, however, a study with an instrumental perspective on geothermal energy project development has not yet been conducted. This research adds to the understanding of especially the concept of policy instruments and provides insights in what should be part of an analytical framework for policy instruments that influence the exploitation of geothermal energy. This analytical framework can be used to study policy instruments for in particular geothermal energy as part of the energy transition in contemporary energy governance.

1.5 READING GUIDE

This thesis consists of five chapters. In this first chapter the research is introduced and the problem statement, research objective and research questions are formulated. In the second chapter, the theoretical basis of the research is laid. This chapter answers the first sub-question and thus explains the concepts geothermal energy exploitation and policy instruments and works towards the operationalization of policy instruments for accelerating geothermal energy exploitation. In chapter 3 the methodology will be elaborated, this includes data collection and data analysis methods. Furthermore, this chapter sets the stage for the geographical area of RES region Rotterdam-Den Haag as the selected case in this research. In chapter 4, the results of the document research and semi-structured interviews are discussed which also answers the second sub-question. Finally, in chapter 5, the research is finalized with the conclusion, lesson drawing on the basis of sub-question 3, recommendations, reflection and suggestions for further research.

2. THEORETICAL FRAMEWORK

This chapter provides an overview of relevant theories, which enables the researcher to operationalize key concepts. Simultaneously, the chapter answers the first sub-question: *"What does the exploitation of geothermal energy entail, what are contemporary trends in energy governance, and how can the concept of policy instruments be defined, and subsequently operationalized to contribute to the exploitation of geothermal energy?".* First, the concept of geothermal energy exploitation is introduced and the complexity of implementing geothermal energy is examined. Subsequently developments in energy transition governance are described. Then, the concept of policy instruments and their necessity is defined and hereafter a literature review is used to create an overview of policy instruments in current academic literature related to the transition towards renewables. This results in an analytical framework for policy instruments influencing the development of renewables that is needed to implement instruments that support the development of geothermal energy.

2.1 GEOTHERMAL ENERGY EXPLOITATION

2.1.1 TECHNICAL FUNCTIONING GEOTHERMAL EXTRACTION

Heat is a form of energy, and geothermal energy is the heat that is stored inside the earth, which when transferred to the surface can be used by humans. Uses for geothermal energy range from its direct use with no transformation, to the generation of electricity using geothermal power plants (Salazar et al., 2017). In geothermal energy, warm water is pumped up from deep layers of the earth (Barbier, 2002). This is done by drilling several wells. Hot water is pumped up from the earth via the production well. The heat of this water is obtained via a heat exchanger. Subsequently, the cooled water goes back into the earth through the injection well (Barbier, 2002). In the Netherlands there are generally 3 types of geothermal energy: Heat and Cold Storage (depth <250 m), shallow geothermal energy (depth <1000 m) and deep geothermal energy (depth > 1500 m) (Hellebrand et al., 2012). The shallow subsurface (50-250m) is used for open thermal storage systems (Oomes, 2012). Figure 1 shows a visualization of the geothermal depths. Although in the Netherlands, geothermal energy is mostly used from a depth of 500 meters, geothermal systems can be used in different soil layers with a wide variety of depths. However, the depth and potential of geothermal energy differs per region and depends on the presence, location and geological properties of suitable soil layers (Wong et al., 2007). The extracted heat is mainly used to heat greenhouses, homes and other buildings and can be used to generate electricity (Hellebrand et al., 2012).

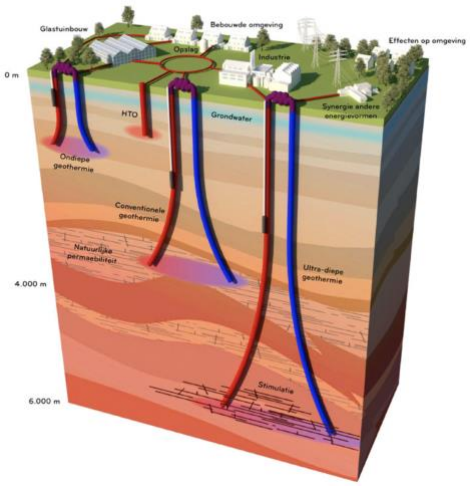

Figure 1: Schematic visualisation of functions in the subsurface according to depth (RHDHV|Nederland, n.d.)

2.1.2 THE COMPLEXITY OF GEOTHERMAL ENERGY IMPLEMENTATION

Previous research reveals several predefined factors that seem to constrain the use of geothermal energy. It is relevant to gain insight into these barriers, dependencies and considerations, as they may be influenced by policy and this research focuses on how policy instruments can facilitate the use of geothermal energy. Pan et al. (2018) already conducted research into the barriers for implementation of geothermal systems around the world. According to their study, the hampering factors can be divided into the categories 'institutional', 'regulatory', 'technological', 'financial' and 'others'. Figure 2 provides an overview of the exact barriers, these barriers remain however rather abstract.

Categories	Barriers
Institutional	• Local authorities' unawareness of geothermal energy system benefits • Land suitability and availability • Cumbersome tender process
Regulatory	• Policy and legal issues • Complicated legal and regulatory bureaucracy • Unclear regulation in environmental impact assessment • Incompatibility and conflict between regulations or acts
Technological	• Lack of expertise within community/city government • Lack of exploration data • Lack of own technologies for drilling, as well as production and O&M of reservoir • Complexity of project and technology/high risk undertaking
Financial	• Low electricity purchasing price • No economic feasibility • High price for water use
Others	• Low social acceptance and public awareness • Lack of partnership with stakeholders/private investors • Tender arrangement • Resistance to change

Figure 2: Potential barriers for establishing geothermal energy plans (Pan et al., 2018, p.26)

In other literature on geothermal energy, factors that are decisive for successful exploitation are described more in depth.

Geological dependencies - The characteristics and requirements with regard to geothermal extraction suggest that not all soil layers in the Dutch subsurface are suitable for geothermal energy. First, a suitable soil layer should be an aquifer. An aquifer is a layer enclosed by soil layers that are impermeable to water (Braak et al., 2001). In the Netherlands there are only aquifers that are suitable for geothermal sources with a low enthalpy. There are no geothermal sources with a high enthalpy (>180°C), such as geysers and steam fields (Wong et al., 2007).

Financial dependencies - For the extraction of geothermal heat, deep drilling is required. This requires a substantial investment (Barbier, 2002). There must be sufficient heat consumers in the vicinity of a geothermal energy installation (e.g. greenhouses or homes) to make the installation profitable (Manzella, 2018). Besides, the initial costs of production and the injection well regarding geothermal energy are relatively high. Once operating, the costs are lower than that of conventional systems (Manzella, 2018). Actually investing in a geothermal plant requires a thorough consideration of costs and benefits.

Environmental considerations - As with all drilling deep into the earth, there is a small chance of earthquakes. Especially around areas where fault lines run and where earthquakes occur due to gas extraction, the risk is significantly higher (Barbier, 2002). Just like drilling for oil and gas, drilling for geothermal energy therefore entails environmental risks. In addition to the risk of earthquakes, pollution of the groundwater or unexpected drilling of oil or gas are potential hazards (Barbier, 2002). In the Netherlands, the State Supervision of Mines checks whether the safety rules are being observed in order to limit these risks.

Social acceptance - Considering the described environmental impacts, social acceptance is a factor of importance. Citizens represent a key stakeholder for governments and energy companies that want to develop geothermal energy facilities and thus the acceptance of the public should be taken into considerations (Contini et al., 2019 in Manzella et al., 2019).

Land-use considerations - Van Kann (2015) states that the space required by geothermal systems above ground is small, but below ground it is large compared to other forms of sustainable energy. Geothermal systems have a high location-dependency, because heat must be applied locally and geothermal energy depends on a specific location with a suitable subsoil. Spatial variables such as distances, building densities and multifunctionality are important to integrate heat networks into regional energy systems in an efficient way (Broersma et al., 2011). The spatial planning of a region is therefore important for the development of heat networks and geothermal systems. In addition, underground spatial planning is also important for geothermal systems, because the subsurface is being used for an increasing amount of different functions. Some functions are difficult to combine or exclude each other because they use the same soil layer (Oomes, 2012). The presence of other functions can therefore influence the integration of a geothermal plant.

Sustainability - The heat from geothermal energy is CO2-free. There is no combustion, as with natural gas and coal, which does release greenhouse gases. However, pumping water from the well and back again costs electricity. As long as this electricity is not completely sustainable, the use of geothermal energy will lead to some CO2 emissions (Barbier, 2002). The construction of the geothermal energy installation also entails CO2 emissions. Furthermore, geothermal sources can last for decades (Ryback, 2003). Due to the cooling of the subsoil, it may be necessary after that period that a new drilling is required to regain sufficient heat.

2.2 GOVERNANCE FOR GEOTHERMAL ENERGY

Understanding how policy instruments can be successful in supporting the planning and implementation of geothermal energy projects requires a general understanding of the governance context in the energy and environmental field. According to De Boer & Zuidema (2015), the current energy transition in the Netherlands, of which geothermal use is an inherent part, is complex. The existing energy system is a web of actors and networks that are connected in a physical, economic, social and institutional way (de Boer & Zuidema, 2015). The different owners and forces of and within the energy network make it more difficult to create changes (de Boer & Zuidema, 2015). Traditional planning and policy approaches, such as command-and-control governance, cannot fully handle this complex web of the energy system (de Roo, 2013). Policy executives and spatial planners must therefore come up with different governing methods. There are several themes among the most important emerging trends that are shaping modern energy governance. According to Lemos and Agrawal (2006) all generate pressure for innovative ways to address issues such as the energy transition (see also more recent literature: Dobravec et al., 2021; Goldthau, 2014; Sanders et al., 2014). In this chapter 2.2., first the concepts of governance and governance networks is defined, then the following three trends are discussed: multi-level governance, energy decentralization and new forms of partnership. Energy governance has relationships with

different trends, developments, shifts and paradigms over time. However, the trends mentioned are often referred to in literature on energy governance and energy policy (see e.g. Lemos and Agrawal, 2006; Dobravec et al., 2021; Goldthau, 2014; Sanders et al., 2014). Besides, they are in line with the ways of governance that are being pursued in the Netherlands for the energy transition. Therefore, these are examined as concepts in this study. The chapter ends with a paragraph on how these governance trends relate to policy and policy instruments regarding geothermal energy.

2.2.1 DEFINING GOVERNANCE

To get a grip on the governance playing field where geothermal energy is a part of, first the concepts of energy governance and governance networks are defined. This research focusses on geothermal energy, which in literature is often related to environmental concerns (Manzella, 2018). Besides, in this study geothermal energy is reflected upon in the context of the energy transition, which is related to environmental interests. Therefore, the specific concept of 'environmental governance' will be used in this study. Environmental governance is: "*synonymous with interventions aiming at changes in environment-related incentives, knowledge, institutions, decision-making, and behaviours"* (Lemos and Agrawal, 2006, p.298). The definition of governance networks used in this study is: *"…more or less stable patterns of social relationships (interactions, cognitions and rules) between mutually dependent public, semi-public and private actors, that arise and build up around complex policy issues or policy programmes"* (Klijn, 2008, p.12*).* This indicates that governance 'the interventions aiming at changes' takes place within governance networks, 'interactions between actors'. There are other definitions of governance, but it is beyond the scope of this study to discuss them in detail. References cited are considered most appropriate for this research.

2.2.2 MULTI-LEVEL GOVERNANCE IN THE ENERGY TRANSITION

In energy governance literature it is argued that energy transition and climate change mitigation achievement can no longer be seen only through top-down activities from a national government. Local and regional governments have a crucial role in delivering public policies relevant to such a transition (Hoppe and Miedema, 2020; Dobravec et al., 2021). The implementation of multi-level governance has therefore become a priority to drive more inclusive local and regional development. Scholars who studied energy transition governance and who take a multi-level governance perspective, state that a shift towards renewable energy use involves activities not only on the national, but also on subnational levels (Loorbach and Rotmans, 2006; Geels, 2021). The multi-scalar character of energy projects adds substantial complexity to environmental and energy governance. An implication is that concerns about the distribution of costs and benefits arise when transboundary problems arise (Hoppe and Miedema, 2020). Therefore, multi-level governance is intended to counter the fragmentation that is characteristic of sectoral-based decision-making or of decision-making that is organised by territorial, social, and political divisions (Hoppe and Miedema, 2020; Lemos and Agrawal, 2006). Increasingly, cross-scale governance mechanisms are being shaped by non-state actors, including NGOs, transnational environmental organisations, intergovernmental and multilateral organisations, market-oriented actors and communities (Lemos and Agrawal, 2006). For geothermal energy this form of governance would entail that implementation of projects is not governed on one level, or on a number of separate levels, but through interaction between these levels.

2.2.3 ENERGY DECENTRALIZATION

A shift towards more democratic political processes throughout the developing world is noticeable. Corresponding to and intertwined with the trend of multi-level governance is the emergence of decentralization.

As described, a more reactive top-down, command and control way was previously used (Zuidema, 2016; Hoppe and Miedema, 2020). However, the power of the central government to develop and implement policies in a top-down manner has decreased, leading to increasingly difficult policymaking structures and processes across subnational, national, and supranational levels of government (Loorbach, 2010). In environmental- policies and planning, decentralized decision-making has become one of the new strategies (Zuidema, 2016; Lemos and Agrawal, 2006). This decentralized setting has facilitated the move towards dependence on higher levels of participation and greater involvement of citizens in processes of governance (Lemos and Agrawal, 2006). Another characteristic of the decentralized setting is a more area-based approach of environmental issues, which generally entails more proactive, integrated and tailor-made methods (Zuidema, 2016).

With regard to the energy transition, decentralization of energy has advantages and disadvantages. Generating and planning energy close to the locations where it is used (which is also the case with geothermal energy) and tailored to the local environment, results in reduced costs, greater affordability and reliability, an easier ability to cope with system failures, and community empowerment that enhances resilience (Ha and Kumar, 2021; Goldthau, 2014). On the contrary, these more local and context focused approaches lead to an increasing number of stakeholders involved, which according to Verweij et al. (2013) contributes to increased complexity. Whenever the amount of interests increases, reaching consensus becomes more challenging. Nevertheless, the decentralized approach seems to fit the development of geothermal energy systems, because, as found in chapter 2.1., successful implementation of geothermal energy plants always depends on the local context.

2.2.4 FORMS OF PARTNERSHIP IN ENERGY GOVERNANCE

As mentioned briefly in section 2.2.2. on multi-level governance, the involvement of private parties in energy governance is becoming increasingly important. Sanders et al. (2014) state that in order to realize the Dutch energy transition, governments are also dependent on the contribution of market parties. Active involvement of businesses or interest groups in policy processes or other developments can lead to input of their *"capital, technical expertise, entrepreneurship and social support"* (Sanders et al., 2014, p.2). In line with this development, new forms of partnerships are emerging within environmental and energy developments. To describe the relationship between the different types of parties and their interactions, the model of Lemos and Agrawal (2006) is used that visualizes the different forms of governance in a 'governance triangle' (see figure 3). Following Lemos and Agrawal (2006), a first form of governance contains a combination of 'state' and 'market', within a public private partnership (PPP). A second form consists of a combination of the 'state' and 'community' that is called 'co management'. A third form consists of a combination of 'community' and 'market', that is called private-social partnerships. The model shows the institutional playing field at a glance; it is a dynamic playing field in which the focus is on different places in the various discussion arenas (Zuidema, 2016).

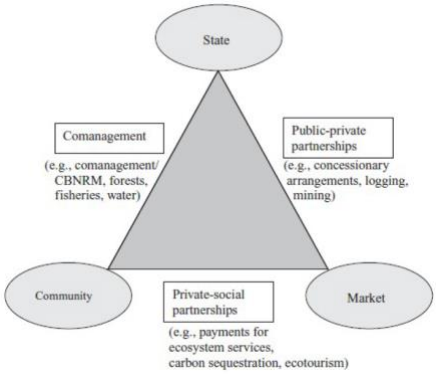

Figure 3: Mechanisms of environmental governance (Lemos and Agrawal, 2006)

The hybrid forms of governance visualized in figure 3 are based upon the notion that no single agent holds the capabilities to address the multiple aspects, interdependencies, and scales of environmental issues and developments. Nevertheless, Rotmans et al. (2001) indicate that government parties play an important role in taking the lead to effect energy transitions. For specifically geothermal energy, Dumas (2018) described that liberalisation of the energy sector and the removal of market barriers should ease the contribution of market parties in the geothermal sector. These developments are interesting for geothermal energy, as they contrast with and thus potentially alleviate the barrier for geothermal energy implementation identified by Pan et al. (2018) (paragraph 2.1.2), namely: a lack of partnerships with private investors and stakeholders.

2.2.5 CONNECTING GOVERNANCE AND POLICY

Resonating with the indication of Rotmans et al. (2001), De Boer and Zuidema (2015) state that energy planning requires a significant role for the state and/ or organisations like the EU to stimulate, enable or constrain other more dynamic and context specific approaches. The government can stimulate the energy transition by formulating policy goals and determining the rules of the game (Kemp and Rotmans, 2009).

A policy goal indicates what is wanted to be achieved. It is the desired situation or desired behaviour. Policy goals can be formulated very abstract, as well as more concrete and can be considered as ambitions or aims (Howlett, 2009). According to Howlett (2009), when policymakers are exploring policy options, they consider not only what to do, but also how to do it. To this end, policymakers utilize a variety of means or tools, known as policy instruments (described more in depth in chapter 2.3). Policy is all about matching policy goals and policy instruments to implement formed policy. Which instruments are used, depends on the nature of the goal or problem and how one considers the problem to be tackled (Howlett, 2009).

Kern and Howlett (2009) describe that the success of policies in the Dutch energy sector depends on how policy goals and means are combined in a consistent, coherent and congruent way. Dumas (2018) researched the policy aspects of geothermal energy from a European perspective and reveals that it remains uncertain whether certain implementations of regulations and other instruments *"can concretely have an impact on the development of geothermal energy as a renewable and efficient source for district heating" (p. 31).* In light of this research, it is therefore interesting to dive deeper into the phenomenon of these tools named 'policy instruments' and how they are organized for- and influence geothermal energy developments.

Concluding, chapter 2.2. revealed that a shift can be noticed from a coordinative governance (government) to a network of actors (governance network). This new pluralistic institutional structure means less government and more governance and the involvement of more actors, between multi-levels of institutions. Policy goals are set on international, national, provincial, regional and local levels and consists of aims and ambitions. Policy instruments function as means to achieve those goals. Hence, the types of policy instruments applied set the tone for how geothermal energy is governed.

2.3 POLICY INSTRUMENTS

In the chapter above, contemporary governance trends affecting the energy transition are scrutinized and it is found that policy goals regarding the energy transition towards renewables can be achieved by use of the right -mix of- policy instruments. Policy instruments can be tailored to support policy goals in order to achieve intended outcomes (Howlett and Rayner, 2018). For this research, this specifically concerns the policy goals set on the different governance levels regarding geothermal energy development. This chapter first defines the concept of policy instruments and then provides a classification of different types of instruments.

2.3.1 DEFINITION AND APPLICATION OF POLICY INSTRUMENTS

In literature, there are several definitions of the terms 'policy instruments' and most of these are based on the assumption that policy instruments are formed by government as a means of implementing policy and influencing the behaviour of citizens and businesses (Elmore, 1987; Salamon, 2002). For instance, Bemelmans-Videc et al. (1998) refer to 'policy instruments' as: *"to be concrete and specified operational forms of intervention by public authority"* (p. 4). In other words, the role that the government sees for itself in society is clearly reflected in the instruments it uses. However, there are also more socio-political definitions that take into account the changing role of government in society. For example, Howlett (2004) defines it as follows: *"techniques of governance that, one way or another, involve the utilization of state authority or its conscious limitation, in order to achieve policy goals*" (p.2). The reference to the concept of 'governance' in the definition of Howlett (2004) indicates that policy is developed in a more interactive way in an increasingly complex society. Taking into account the earlier described trends in energy governance, the definition of Howlett (2004) is more fitting and will be used in this study. Additionally, following Lascoumes and Le Galès (2007), policy instruments are considered as instruments that can govern interactions and behaviours of actors in order to achieve a predefined outcome. By forming these interaction processes, policy instruments can have significant impacts on the results of implementation and are in that sense a form of power (Bressers and O'Toole, 2005; Le Galès, 2010).

A wide set of policy instrument can be selected to implement policy or steer on a certain outcome, based on deliberations concerning effectiveness and efficiency (Salamon, 2002). Policy instruments are frequently described in their ideal form, but in practice many hybrids exist and they change over time (Le Galès, 2010). A coherent set of goals in combination with a consistent mix of instruments is necessary to achieve the best results (Howlett and Rayner, 2018).

2.3.2 CLASSIFICATION OF POLICY INSTRUMENTS FOR CONTEMPORARY ENERGY POLICY

Similar to the changing definition, in literature the classification of policy instruments is also subject to change. Bemelmans-Videc et al. (1998) classify policy instruments in a tri-fold scheme of: regulations (the stick), economic means (the carrot), and information (the sermon). While Howlett (2000) distinguishes substantive instruments, being the command-and-control type of instruments, and procedural instruments, aimed at guiding and steering policy processes.

However, the shift in governance from hierarchy to networks and markets, and from top-down towards a decentralized setting, contributed to the rise of a second generation of policy instruments (De Bruijn and Ten Heuvelhof, 2007). As described in chapter 2.2. these shifts are noticeable in energy governance as well. A multi-actor playing field requires other tools and skills than the conventional ones, such as more multi-lateral

instruments (De Bruijn and Ten Heuvelhof, 2007). Considering the barriers of geothermal energy exploitation regarding the lack of knowledge, upcoming multi-level governance, energy decentralization and new forms of partnership (see chapters 2.1. and 2.2.), policy instruments should focus on interdependency of actors as well. In addition, research reveals that sharing knowledge is an important driver for innovations on renewable energy and more efficient energy planning (del Río and Kiefer, 2022; Maxwell, 2009). Hence, in the context of the energy transition and trends in energy governance, policy instruments should stimulate interaction, i.e. transfer resources such as knowledge and cross horizontal and vertical boundaries.

In this research a categorization of instruments will be used that is based on commonly distinguished typologies in more recent literature (Lascoumes and Le Galès, 2007; Leshinsky and Legacy, 2015; Juerges and Hansjürgens, 2018): *1) legislative/regulatory instruments, 2) economic/fiscal instruments, 3) agreement based instruments, 4) information/communication based instruments.* Based on the knowledge gained on recent trends and shifts in governance, another category is distinguished: *5) knowledge and innovation instruments*.

The first two categories concern the more command-and-control type of instruments, where government resources are directly used to direct desired behavior (Lascoumes and Le Galès, 2007). The last three categories contain instruments that steer indirectly and are based on interactions between different actors (Lascoumes and Le Galès, 2007).

2.4 Operationalizing policy instruments for the energy transition

To learn how policy instruments can be operationalized to encourage the transition towards increased geothermal energy use, a literature review was conducted. For this literature review, articles on policy instruments for renewable energy or for the energy transition have been selected, since there is still little literature on what policy instruments specifically stimulate implementation of geothermal projects. The aim of the literature review was to get a better understanding of the concept policy instruments and to make the step towards operationalization of policy instruments after having classified different types of policy instruments in chapter 2.3.

2.4.1 Legislative and regulatory instruments

Legislative and regulatory instruments are laws and regulations that a government entity imposes. Their main feature is that a public authority sets obligatory requirements, which in cases of refusal will be followed by sanctions. The requirements can either forbid certain behaviour and be prohibitive or require a certain behaviour and be prescriptive (Lascoumes and Le Galès, 2007). These can be imposed very strictly in a command and control manner. However, a shift in focus could be noticed from strict, towards looser prescriptions e.g. corporate or governmental carefulness or process rules. There are several reasons that motivate the use of legislative and regulatory instruments. One of these is that they have the ability to force stakeholders to act in accordance with the authority; free collaboration is thus not necessarily required (Leshinsky and Legacy, 2015). Furthermore, they are the same for every actor and protect these actors from inconsistent governmental decisions. Besides, they contribute to improving the predictability of governments (Lascoumes and Le Galès, 2007).

Various studies focusing on policy instruments that promote renewable energy implementation emphasize that these kind of instruments are essential (Park, 2015; Yi and Feiock, 2014). An important instrument named in several studies is a Renewable portfolio standard (RPS) (Park, 2015; Carley et al. 2016; Yi and Feiock, 2014; Baldwin and Tang, 2021). RPSs have been used widely to promote renewable energy at the national level and, in

some cases, sub-national level and is a regulation that requires increased production of energy from renewable energy sources, such as wind, solar, biomass and geothermal. Other legislative and regulatory instruments that either stimulate or regulate renewable energy generation mentioned by those scholars are standards, laws and rules, monitoring and auditing.

In literature on geothermal energy, laws and regulations are considered as barriers and limiting for geothermal development (see e.g. Yasukawa, 2018 in Manzella et al., 2019). However, discussion on which specific regulatory framework would be stimulating often remains superficial.

2.4.2 ECONOMIC AND FISCAL INSTRUMENTS

With economic and fiscal instruments, the government tries to steer by means of financial incentives. These are instruments that financially reward desirable behavior and tax undesirable behaviour. The government thus influences activities through a financial consequence (Lascoumes and Le Galès, 2007). Hence, economic and fiscal instruments are based on a government that influences market mechanisms. Several tools are often described in literature that are used for this purpose within the energy transition and for stimulating development of renewables: subsidies and loans (Park, 2015; Enzensberger et al., 2002). Loans and subsidies can be provided to not only help with overcoming high capital costs, but also to reduce overall costs for renewable energy development (Enzenberger al., 2002). Government loans or loan guarantees can additionally be used for a more long-term approach (Enzenberger et al., 2002) as well as taxbased incentives (Park, 2015).

Under the category of subsidies, feed-in tariffs have been known to be a superior tool to incite renewable energy production and technological diversity, by lowering risks for investors (Enzensberger et al., 2002; Fouquet, 2013; Blazquez et al., 2018; Carley et al., 2016). In literature on specifically geothermal energy, Dumas (2018) stated the feed-in tariff as an attractive financial incentive for a geothermal project developer as it encourages investments. It is thus recognized that financial support is of great importance, since the initial costs of geothermal projects are relatively high (Dumas, 2018). In addition, operating aid is also considered needed for some geothermal energy projects, which can be achieved with, for example, subsidies and loans (Dumas, 2018).

2.4.3 AGREEMENT-BASED INSTRUMENTS

Agreement-based instruments are considered here as instruments in which the government and/or involved actors cooperatively and voluntarily decide to act in a specific way (Lascoumes and Le Galès, 2007). These instruments usually arise from networks that share an agenda, where often both public and private parties are involved (Lascoumes and Le Galès, 2007). In literature on policy instruments stimulating renewable energy development, instruments that are mentioned and fall under this category are: public-private agreements, stakeholder partnerships, or agreements between stakeholders (Park, 2015; Enzensberger et al., 2002; Falcone et al., 2019). The agreements made between parties (government, private or otherwise) are often laid down in a covenant code or agreement.

In literature on geothermal energy, agreement-based instruments are not explicitly touched. However, the right partnerships and the rise of consortia are multiple times considered as important to promote geothermal energy as an alternative to fossil fuels and also to get projects off the ground (Ejderyan et al., 2018 and Contini et al., 2019 in Manzella et al., 2019).

2.4.4 INFORMATION AND COMMUNICATIVE INSTRUMENTS

Information and communicative instruments are used with the aim of disseminating information among certain actors. It specifically concerns one-way communication aimed at enticing people to change their behavior or to inform them (Lascoumes and Le Galès, 2007). Information and communication tools have the characteristic of being able to reach a wide audience through the use of media, but can also be used in a more targeted way through for example targeted programs (Lascoumes and Le Galès, 2007). People can make the decision to ignore these type of instruments, which makes these instruments voluntary. A consequence is that disseminated information does not perse lead to compliance (Lascoumes and Le Galès, 2007). Additionally, those parties who are not interested may be more difficult to reach because they are not necessarily looking for information.

Literature on stimulating factors for renewables and the energy transition, reveals public information campaigns, one way professional training and targeted educational programs to reach a specific audience as instruments relating to communication and information provision (Falcone et al., 2019; Park, 2015). The importance of social acceptance regarding geothermal energy has been increasingly discussed in studies (see e.g.: Ratio et al., 2019 and Luketina and Parson, 2019 in Manzella et al., 2019). Looking at the characteristics of information and communicative instruments, precisely these instruments can play a role in promoting social acceptance. Countries as New Zealand and the Philippines, where geothermal energy is already far developed, identify information campaigns, and trust building activities as useful resources aimed at involving citizen's perspective (Contini et al., 2019 in Manzella et al., 2019).

2.4.5 KNOWLEDGE AND INNOVATION INSTRUMENTS

Knowledge based instruments are not specifically mentioned as a category in the well-known literature on policy instruments (e.g. Howlett or Lascoumes and Le Galès). However, there are studies that emphasize that knowledge sharing is of importance for innovations and future developments in the energy transition and, accordingly, that it requires interactions between actors with different backgrounds for knowledge development and diffusion (e.g. Carlsson et al. 2002; Kemp, 2010). In line with these insights, knowledge and innovation based instruments are in this research considered as the jointly gatherings of participating actors, online communities and other platforms. These moments are aimed at increasing their knowledge through involvement in social learning, in which knowledge includes both information as well as ability to act.

Examples of such instruments used or recommended in the energy transition are communities to exchange best practice, living labs or workshops (Park, 2015; Kemp, 2010; Juerges and Hansjürgens, 2018). A benefit of these instruments is the limited resistance on the side of the involved actors and that the instruments can cope with situations that are complex and dynamic (Juerges and Hansjürgens, 2018).

2.4.6 OPERATIONALIZATION

In order to create research transparency and increase the quality of the results, descriptions of the main concepts and variables have been defined (Sarantakos, 1993). Based on the literature presented in paragraphs 2.3 and 2.4, table 1 shows the concepts, the variables as well as indicators that further operationalize these variables.

	Variable	Indicators	Source
Policy instruments	Regulatory and legislative instruments	- Standards, laws and rules - Monitoring/ auditing - Renewable portfolio standards	Yi and Feiock (2014); Park (2015); Carley et al., 2016); Baldwin and Tang (2021)

	Economic and fiscal instruments	- Subsidies - Loans	Fouquet (2013); Enzensberger et al. (2002); Blazquez et al. (2018); Carley et al., 2016); Park (2015); Dumas (2018)
	Agreement-based instruments	- Public-private agreements - Stakeholder partnerships/ agreements	Enzensberger et al. (2002); Falcone et al. (2019); Park (2015); Ejderyan et al., 2018 and Contini et al., 2019 in Manzella et al., 2019
	Information and communicative instruments	- Public information campaigns - Professional training	Falcone et al. (2019); Park (2015); Ratio et al., 2019; Luketina and Parson, 2019 in Manzella et al., 2019
	Knowledge and innovation instruments	- Communities of practice - Living labs - Workshops	Park (2015); Kemp (2010); Juerges and Hansjürgens, 2018

Table 1: Operational framework

2.5 CONCEPTUAL MODEL

Based on the collected theories, a conceptual model has been created (figure 4). The conceptual model visualizes the relations between the different concepts and the expected cause-effect relationships. The hampering setting for the development of geothermal energy projects requires governance in order to move towards a stimulating environment for geothermal energy development. Contemporary energy governance is subject to following trends: multi-level governance, energy decentralization, new forms of partnership emerging. These trends form the context in which geothermal developments are governed. Governance as explained in this theoretical chapter is very much about the 'interaction between actors'; which is the overlapping aspect of the 3 trends. Policy instruments can shape those interactions and the governance context. As Howlett (2004) defined, policy instruments are the techniques of governance and in that regard they influence how geothermal energy is governed. Hence, in governing the transition towards increased development of geothermal energy, policy instruments can be used as tools and catalysts to help govern (e.g. execute policies and achieve set goals and ambitions) geothermal energy. The concept 'policy instruments' is for this research subdivided into multiple categories: 1) *legislative/regulatory instruments, 2) economic/fiscal instruments, 3) agreement-based instruments, 4) information/communication based instruments, 5) knowledge and innovation instruments*.

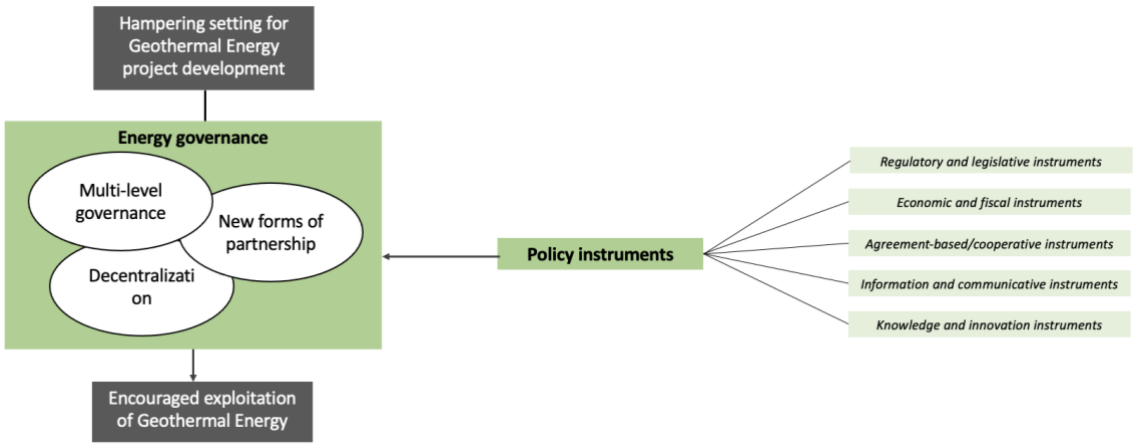

Figure 4: Conceptual model (Author, 2022)

3. METHODOLOGY

This chapter focuses on the methods used to collect the data for this research. On the basis of this chapter it becomes clear how the sub-questions and ultimately the main question have been answered. To achieve these goals a well-structured research design is needed to produce convincing and meaningful results (Clifford et al. 2016). The chapter is divided into four sub-chapters consisting of; Introduction to the strategy, the literature review conducted, the case study conducted (specifications and methods) and the research ethics. It elaborates on how the data was collected and why the methods in question were chosen. In addition, it is discusses how the collected data has been analysed.

3.1 INTRODUCTION TO RESEARCH STRATEGY

For this explorative study a qualitatively driven approach was used. A qualitative study is based on obtaining qualitative data collected using qualitative research methods. Conducting a qualitative research is a very suitable research strategy to analyze a complex spatial phenomenon within a certain context (Baxter & Jack, 2008). While a quantitative study examines various variables and mutual relationships, a qualitative study observes a spatial phenomenon as a whole (Swanborn, 2010). Within this research, the planning and implementation of geothermal energy projects is regarded as such a spatial phenomenon. Applying one or more research method(s) within a qualitative research is very suitable for obtaining in-depth information about a spatial phenomenon (Clifford et al., 2016). Qualitative research methods are applied to investigate meanings and values with an emphasis on gaining quality, depth and understanding different relationships (Clifford et al., 2016). Besides, qualitative data collection methods are particularly suitable for examining social and institutional processes (Longhurst, 2016). Hence, this strategy of research is not only about establishing a particular problem or relationship, but also how the problem or relationship in question can be positively influenced. The described characteristics of a qualitative strategy are in line and fitting with the aim of this research; to investigate the influence (relationship) of policy instruments on the development of geothermal projects in the context of contemporary energy governance.

Specifically, this research makes use of a case study. A case study is a detailed, in depth examination of a single example within its real-world context (Flyvbjerg, 2011). For this study, geographical RES region Rotterdam-Den Haag was chosen as case (further elaborated in 3.3). Case studies are suitable for answering 'how' or 'why' questions, and for exploratory studies (Baxter and Jack, 2008). Which makes it a fitting strategy for answering the main research question of this study: "*How is the planning and development of geothermal energy projects in RES region Rotterdam-Den Haag influenced by policy instruments within the context of contemporary energy governance in the Netherlands?".* Swanborn (2010) indicates that studying a case should not be seen as a separate method; a case is a design framework to which multiple research methods can be applied. Thus, within the case study used as a strategy, several research methods are applied.

In total, three qualitative methods were used for collecting data in this study: 1) a literature research, and -within the case study approach- 2) a document analysis and 3) semi-structured interviews. The study thus makes use of triangulation of research methods, which according to Clifford et al. (2016) strengthens the validity of research outcomes. The literature review serves to collect appropriate literature to gain insights on the topic of this study (Clifford et al., 2016). The process consisting of different research methods, research questions and data collection strategies is visible in figure 5. The different methods are discussed in depth in paragraphs 3.2 and 3.3. Appendix I provides an overview of the methodology.

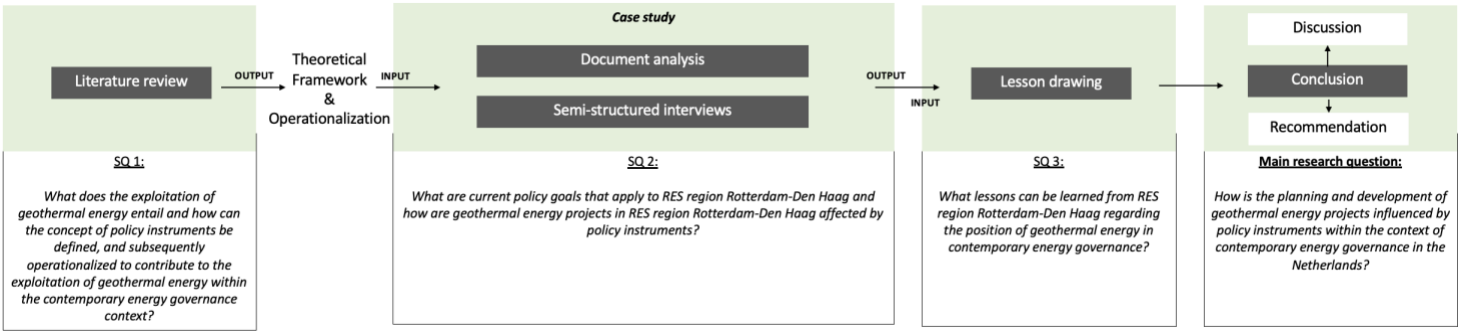

Figure 5: Research process related to research questions (Author, 2022)

3.2 LITERATURE REVIEW

The literature research is important for the formation of the theoretical framework (Clifford et al., 2016) and was used to find the current status of the debate. Healey and Healey (2010) state that reading about a topic helps to broaden your image and refine your ideas. The literature research was conducted to describe the concept of geothermal energy project development and its complexity, to study the contemporary governance context of energy developments and lastly to define the concept of policy instruments and their operationalization for renewables in order to form an analytical framework for policy instruments encouraging the use of geothermal energy. Ultimately, it helped answering the theoretical sub-question that was formulated: *"What does the exploitation of geothermal energy entail, what are contemporary trends in energy governance, and how can the concept of policy instruments be defined, and subsequently operationalized to contribute to the exploitation of geothermal energy?".* The literature review resulted in a framework that helped to sharpen the focus of the research (Clifford et al., 2016) and it functioned as input and guideline for the empirical research to further develop the analytical framework and to study policy instruments used in the RES region Rotterdam-Den Haag.

The theoretical framework is largely built up on the basis of literature research, in which scientific English articles were used. Relevant academic papers were found by making use of following search engines: SmartCat, Scopus and Google Scholar. The following key-words were used individually and in several combinations to set a scope and to filter the academic literature:

"geothermal energy" "energy transition" "policy instruments" "policy tools" "energy policy" "renewables" "energy governance" "environmental governance".

Articles were selected on the basis of their relevance (e.g. articles on specific western or EU countries), number of citations, publication year and overall quality.

3.3 CASE STUDY: GEOGRAPHICAL RES REGION ROTTERDAM-DEN HAAG

In order to answer the second research question "*What are current policy goals that apply to RES region Rotterdam-Den Haag and how are geothermal energy projects in RES region Rotterdam-Den Haag affected by policy instruments?"* a case study approach was used. A case study is considered an in-depth exploration from multiple angles, which involves looking at a particular spatial phenomenon from different points of view (Swanborn, 2010). The aim of the case study was to test the operational framework created in chapter 2 by means of a document research and semi-structured interviews. In this chapter, first the case selection is elaborated upon, then the different research methods are discussed, followed by description of the data analysis.

3.3.1 CASE SELECTION AND DESCRIPTION

The selected case for this approach is the RES region Rotterdam-Den Haag shown in figure 7. RES stands for "Regional Energy Strategy". On 28 June 2019, the government published the Climate Agreement: the Dutch elaboration of the international climate agreements of Paris (2015). One of the agreements in the Climate Agreement is that 30 energy regions in the Netherlands will investigate where and how sustainable electricity can be generated and which heat sources can be used so that districts and buildings can switch off from natural gas. In a RES each energy region describes its own choices. The case of this study, RES Region Rotterdam-Den Haag is one of those regions. RES Rotterdam-Den Haag is a collaboration of 23 municipalities, 4 water boards and the province of Zuid-Holland. Together they have described a strategy (RES 1.0) and in that sense, the RES regions are actually policy-related collaborations between authorities. However, in this study the region is considered more as a geographical area. The case has been selected by 'means of information' (Flyvbjerg, 2011). Most geothermal projects in the Netherlands are currently located within the geographical boundaries of the region (see figure 6), which makes the region a Dutch frontrunner and thus an interesting case to research. According to Flyvbjerg (2011) a valid way of selecting a case is selecting one that has a maximum form of a variable. In the light of this research that variable would be 'geothermal energy development' in the Netherlands. This study focuses on a RES region, however, the region is influenced by policy goals at various levels from international to local. That is why data will also be collected from these different levels. There are 23 municipalities, the 2 largest municipalities will be included in the data collection because they either already have a specific policy on geothermal energy or already have specific contact persons for geothermal energy.

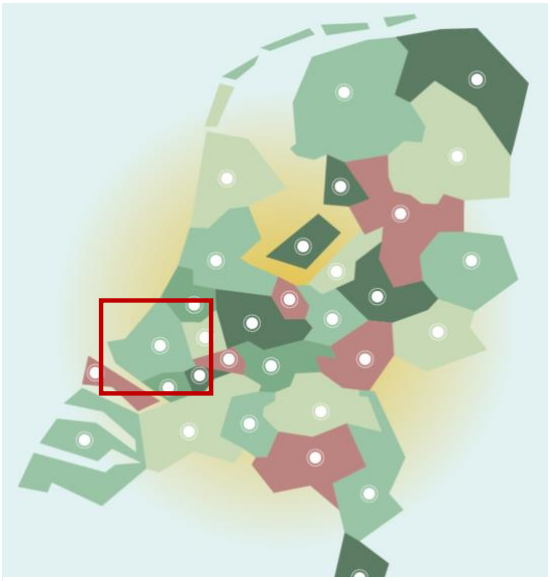

Figure 6: Case - RES region Rotterdam-Den Haag (Regionale Energiestrategie Rotterdam-Den Haag, 2021)

Figure 7: Overview development of geothermal projects in the Netherlands (geothermie.nl, n.d.)

3.3.2 DOCUMENT RESEARCH

A document analysis is a procedure in which documents from a specific research area are analyzed and assessed (Bowen, 2009). Through a document analysis, a researcher obtains understanding, insights, meanings and knowledge about a particular topic, within a particular context (Bowen, 2009). Accordingly, a document analysis can contribute to the gathering of information about the case area of this research. In a document analysis it is important that the researcher takes a very critical role. The reason for taking a critical role is due to the fact that documents are often drafted, modified and subsequently published by third parties (Yin, 2014). It often happens that documents are presented from a certain point of view (Bowen, 2009).

For this study, documents from formal energy policy and geothermal energy were scrutinized, for the main purpose of getting insights into current policy goals, governance processes and the relating instruments regarding geothermal development. The approach was to identify and analyze current documents that had (or intend to have) a strategic, tactical or operational importance for the exploitation of geothermal energy in the geographical area of RES-region Rotterdam-Den Haag. The secondary data mostly consisted of policies and other governmental documents. Taking into account the multi-level governance perspective (as described in chapter 2.2), policies created at different levels of authority and governments could be of influence on geothermal energy development in the case area. Therefore, the following wide array of Dutch search terms were used in Google and on government websites to find appropriate documents (in brackets is the English translation):

- Europees geothermie beleid [European geothermal energy policy]
- Beleid geothermie Nederland [Policy geothermal energy in the Netherlands]
- Regionale energie strategie Rotterdam-Den Haag [Regional Energy strategy Rotterdam-The Hague]
- Geothermie beleid Zuid-Holland [Geothermal energy policy South-Holland]
- Duurzaam energie beleid Zuid-Holland [Renewable energy policy South-Holland]
- Warmte transitie Visie (2 gemeenten in RES regio Rotterdam-Den Haag) [Heat transition vision + (*2 municipalities within RES region Rotterdam-The Hague)]*
- Geothermie + (2 gemeenten in RES regio Rotterdam-Den Haag) [Geothermal energy + (*2 municipalities within RES region Rotterdam-The Hague)]*

The collection of the secondary data was done before the collection of the primary data. In this way, the researcher was prepared and aware when conducting the interviews. However, if certain (not yet selected) documents came up during the interviews, they were also considered relevant for the analysis. Table 2 below shows the analysed documents per governance layer and the type of information that has been found.

Level	Title document and author	Document type	Publication date
European	RES Directive 2018/2001 – European Union	Legal framework	2018
	REPowerEU Plan – European commission	Strategy plan and ambitions	May 2022
National	Masterplan Aardwarmte in Nederland – EnergieBeheerNederland, GeothermieNL, DAGO	Goals and ambitions regarding geothermal energy	May 2018
	Klimaatakkoord - Dutch Cabinet	Programs, goals and ambitions	June 2019
	Beleidsbrief Geothermie - Ministry of Economic affairs and Climate	Reinforcement measures	February 2018
	Beleidsbrief Voortgang Geothermie - Ministry of Economic affairs and Climate	Policy goals and instruments	September 2021
	Beleidsbrief Stimulering duurzame energieproductie – Ministry of Economic affairs and Climate	Policy goals and instruments	March 2019

Provincial	Potentieel Geothermie - Province of Zuid-Holland	Goals and ambitions regarding geothermal energy	November 2016
	Visie Aardwarmte - Province of Zuid-Holland	Goals and ambitions regarding geothermal energy	March 2019
	Warmteplan Anders Verwarmen - Province of Zuid-Holland and Geothermal branche	Vision document	February 2017
Regional	RES Rotterdam-Den Haag 1.0 – consortium of government parties within region	Goals and ambitions regarding energy	July 2021
Municipal	Transitievisie Warmte Den Haag (concept) – Municipality Den Haag	Goals and ambitions regarding energy	February 2022 - Concept version
	Transitievisie Warmte Rotterdam – Municipality Rotterdam	Goals and ambitions regarding energy	December 2021

Table 2: Overview of analyzed documents

3.3.3 SEMI-STRUCTURED INTERVIEWS

Subsequently to the document collection, interviews were held. Interviews can be conducted in different ways. During a structured interview, the interviewer follows a prepared questionnaire (Longhurst, 2016). Semi-structured interviews are more flexible; the semi-structured nature of an interview allows the researcher to follow a predetermined direction on the one hand, and to still allow for flexibility in addressing issues on the other (Longhurst, 2016). This gives the participant the freedom to clarify his own insights. For this research and specifically for answering sub-question 2, semi-structured interviews are seen as the most suitable data collection method because the knowledge of the interviewee is unknown in advance (Longhurst, 2016).

To conduct an effective interview that allows for targeted data collection and comparison, sufficient structure is needed (Clifford et al., 2016). Therefore an interview guide was developed that has been used as a guideline for the interviews (see Appendix B). In this interview guide the main concepts discussed in chapter 2.2. and all aspects in the operational framework (table 1) can be found: *multi-level governance, decentralization, new forms of partnership* and 1) *legislative/regulatory instruments, 2) economic/fiscal instruments, 3) agreement-based instruments, 4) information/communication based instruments, 5) knowledge and innovation instruments*. The aim of the interviews was to get an insight in the current governance structure, state (barriers and enabling circumstances), aims, and instruments regarding geothermal development in the case of RES region Rotterdam-Den Haag and to investigate how the aspects found in the literature relate to the participants experiences in practice.

Selecting fitting interviewees is an essential part in conducting semi-structured interviews (Clifford et al., 2016). Interviewees are often selected based on their experience within the research topic or area (Longhurst, 2016). Due to the certain connection of a participant with the subject, the conversation is immediately conducted at a desired level (Longhurst, 2016). This was also desired in this study; the aim of this qualitative method is to create an in-depth understanding of organisational or individual experiences regarding geothermal energy. For this research, interviewees were approached via e-mail or phone. The first interviewees were found through desk research, e.g. on the general pages of the RES region Rotterdam-Den Haag and via the general geothermal branch organisation, and were so-called cold callers (Longhurst, 2016). Some of the interviewees were referred to by others, this is called snowballing (Longhurst, 2016). All interviewees are experts in the (policy) field of geothermal energy and/or involved in geothermal energy projects in RES region Rotterdam-Den Haag. According to Clifford et al. (2016), combining different perspectives strengthens the validity of research outcomes. Therefore, parties on different (government) levels were interviewed as well as market parties, so that different views could be

gathered. The amount of interviews held, was determined by the moment that the researcher did not obtain any new information, i.e. data saturation (Longhurst, 2016). Table 3 provides an overview of the interviewees, their organization, the interview dates and the used platform.

Identifier	Organization	Level	Date interview	Medium interview
R1	Province of Zuid-Holland	Provincial	29-04-2022	Google Meet
R2	State Supervision of Mines (SodM)	National	13-05-2022	Microsoft Teams
R3	Sector association GeothermieNL	National	13-05-2022	Google Meet
R4	Municipality of Rotterdam	Municipal	27-05-2022	Microsoft Teams
R5	TNO – Organisation for applied scientific research	National/ Local	31-05-2022	Google Meet
R6	EBN B.V. – State owned company	National/ Local	31-05-2022	Google Meet
R7	Municipality of Den Haag	Municipal	24-05-2022	Google Meet

Table 3: Overview of interviewed participants

3.3.4 DATA ANALYSIS

Producing convincing and meaningful results requires systematic analysis and interpretation of the collected data (Cope, 2010). In this regard, several steps were undertaken. As described, the documents were selected and read before the interviews took place, however the analysis of both the documents and the interviews took place within the same time frame. Firstly, for the analysis of the documents in table 2, a table was used to order relevant quotations, successively linked to page number and gained information (Appendix C). Then, the semi-structured interviews were recorded and transcribed. The interview transcripts and the document quotations are analysed by coding the data using the Atlas.ti software. Coding is labelling fragments of text on the basis of categories that are related to the research and it is a way of evaluating and organizing data in order to be able to interpretate the text (Cope, 2010). There are two types of coding; deductive and inductive coding (Cope, 2010). The transcripts and document quotations were both deductively coded by means of the coding scheme in Appendix D. These deductive codes were created beforehand on the basis of theoretical framework in chapter 2 and the operationalization in table 1. Inductive codes were generated during the analysis and are additional aspects that were not considered before conducting the interviews. The overview of codes that have been used and obtained during coding is included in Appendix D.

3.4 ETHICAL CONSIDERATIONS

According to Clifford et al. (2016), confidentiality and privacy are two important parts of ethics. Besides, awareness of ethical issues is an inherent part of a valid research design (Clifford et al., 2016). To guarantee this, the following ethical factors have been taken into account in this study. Firstly, it has been communicated in advance with the interviewee that the data generated from the interview will only be used for this study and therefore has no further purposes. Furthermore, Clifford et al. (2016, p. 111) describes that *"participants will remain anonymous, unless they desire otherwise*". Therefore, permission to record the interview was asked in advance as well as whether interviewees would prefer to remain anonymous, would prefer to be quoted by the

name of their organization or did not object to being quoted in this research by their name. In addition, interviewees were made aware of other options at the beginning of the interview; for example, interviewees can withdraw from the interview at any time, change their answers or withdraw their answers altogether. Also, presenting the study is an example of thorough research (Clifford et al., 2016). Therefore, afterwards a copy of the transcript was sent to the interviewees if they wished so. Mentioned ethical aspects are included in an informed consent form (Appendix E), which the participants signed before conducting the interview. Lastly, the researcher made sure the data was digitally encrypted using a password so that no one could access the data.

The interviews were taken by the researcher as a master student Environmental and Infrastructure Planning at the University of Groningen and independently of any other organizations. Completely objective research is virtually impossible (Clifford, et al., 2016). The position and background of the researcher always influences the way in which research is conducted and how results are interpreted. To limit this, it was always tried to take a neutral position towards the opinions, views and claims that were put forward by respondents during the interviews. An attempt was also made to keep the questions in the interviews as neutral as possible and not to be suggestive in order to influence answers. These factors contribute to valuing the respondents (O'Leary, 2004).

4. RES region Rotterdam-Den Haag: towards a stimulating environment for geothermal energy development

The aim of this chapter is to set out the results of the collected data and to get in-depth knowledge of the geothermal energy project developments in the geographical area of RES region Rotterdam-Den Haag in its governance and policy context. However, the RES region is influenced by policy goals at various levels from international to local. That is why gathered data from these different levels will also be described. The following question is intended to be answered in this chapter: *"What are current policy goals that apply to RES region Rotterdam-Den Haag and how are geothermal energy projects in RES region Rotterdam-Den Haag affected by policy instruments?".* First, chapter 4.1 discusses the current geothermal situation, the set policy goals that affect the case area and the network of actors. Then, chapter 4.2 describes in a concrete way the results with regard to the policy instruments that are of influence on geothermal energy development in the case area. Chapter 4.3 discusses the governance setting in a more abstract and reflective way. At the end of every chapter/ paragraph a short reflection on the results is provided.

4.1 RES region Rotterdam-Den Haag: current status, policy goals and actors

4.1.1 Current status of geothermal energy projects

The case area RES region Rotterdam-Den Haag is the area where most geothermal projects are currently implemented in the Netherlands. Currently 12 projects are running, and 10 projects are in development (RES Rotterdam-Den Haag, 2021). The first operational geothermal project in the region dates from 2007. Since then, geothermal energy has developed steadily, mainly in greenhouse horticulture and only sparsely in the built environment. 6 geothermal projects in the case area are focused on the built environment, two of which are already in production. Furthermore, the techniques of the geothermal projects currently focus on heat and not on electricity (R1; RES Rotterdam-Den Haag, 2021).

Thus, geothermal energy is already used in the (horticulture) industry and now also increasingly applied to the built environment. However, where the application to industry usually proceeds without too many problems, geothermal application to the built environment turns out to be more complex (which will also become apparent within this chapter of results). Nevertheless, the application to the built environment is becoming increasingly important, in the context of the energy transition, but also in the present time: developments in Europe come with the insight that it is important to become less dependent on the energy supplies of other countries. These developments show all the more the urgency to accelerate geothermal developments applied to the built environment.

4.1.2 Policy goals on geothermal energy

As was found in theoretical chapter 2, the government can stimulate the energy transition by formulating policy goals (Kemp and Rotmans, 2009). On different levels of authority, policy goals are formulated that apply to the case region. The broader aims, with regard to geothermal energy development are presented here:

→ European Union (EU) policy goals

The EU Directive 2018/2011 stipulates that the share of renewable energy in the entire Union must amount to 32% of the total gross final energy consumption by 2030 (p. L328/83). Within formal EU legislation, heat from shallow geothermal energy has been approved as renewable energy source in the European Renewable Energy Directive (2018). In addition, in line with the reflection in 4.1.1., the European Commission has also set new targets in response to the Russian invasion in the form of the document REPowerEU Plan (2022). With this plan, the Committee broadly sets targets concerning cost-effective acceleration of geothermal energy and on encouragement of member states in the production of renewable energy and licensing.

→National policy goals - Netherlands

In the national Climate Agreement (2019) it is recognized that geothermal energy is potentially one of the largest sustainable heat sources in the Netherlands. In doing so, it relies heavily on the 'Geothermal Master Plan in the Netherlands' published in May 2018 by the geothermal sector (represented by Platform Geothermal (now GeothermieNL), DAGO, Stichting Warmtenetwerk, and EBN) and emphasizes its importance as follows:

"The geothermal sector has already committed to scaling up geothermal energy in both greenhouse horticulture and the built environment. The sector is committed to further cost reduction, developing a (geothermal) heat proposition with heat companies, broadening the base and further professionalizing the sector across the entire value chain and ensuring a local and regional social dialogue about geothermal energy, in the context of the energy transition" **(p. 150-151)**

Both the government and the sector explicitly express targets of 15PJ for 2030 and 110PJ (government) and 250PJ (sector) for heat produced by geothermal energy for 2050 (Beleidsbrief Geothermie, 2018; Geothermal Master Plan, 2018). In addition, the national aim is to realize 35 additional projects in the period up to and including 2030 (Rijksoverheid, 2019). The potential of geothermal energy has thus been acknowledged and what stands out is that the acceleration of geothermal energy in specifically the built environment is a national policy intention in the context of the heat transition. Furthermore, it is noticeable that at a national level targets are set, but that little policy is pursued specifically on geothermal energy and the role of geothermal energy within the subsurface. Lastly, what is striking is that in the Dutch geothermal sector, there is a clear sector lobby that has jointly drawn up the Geothermal Master Plan and that the national government also relies on this sector lobby in their policy. However, the national government and the sector are setting slightly different targets for the year 2050.

→ Provincial policy goals – province of Zuid-Holland

The province of Zuid-Holland shares its ambition to be climate neutral by 2050 in various policy documents. The province explicitly shares the aim to have the energy supply completely CO2 neutral for the built environment by 2035, and greenhouse horticulture completely CO2 neutral by 2050 (Provincie Zuid-Holland, 2017, p. 16). The provincial government wants to be completely independent from natural gas and foresees a huge task ahead to heat the built environment, greenhouse horticulture and industry in a sustainable manner. It is indicated that geothermal energy can play a major role in this. However, in order to achieve 25-40 PJ of geothermal energy in 2040, they state that a vision and an action plan is needed so that the development of geothermal energy in the province of Zuid-Holland can be accelerated and scaled up in a safe and responsible manner (Provincie Zuid-Holland, 2019, p.1).

→ Regional policy goals – RES region Rotterdam-Den Haag

In the Climate Agreement, the Netherlands is divided into thirty Regional Energy Strategies (RES) regions (Kempenaar et al., 2020). Because local authorities more easily give room for initiatives to experiment, the

central government has opted to divide the national energy transition policy into 30 regional transitions. Within the framework of climate legislation and the realization of the energy generation target of 35TWh, each region is free to form its own process and to give substance to the national targets (Kempenaar et al., 2020; Wood and Baker, 2020). The RES Rotterdam-Den Haag document (2021) clearly indicates that the goal is to make geothermal energy part of the heat transition. Although no exact numbers are stated, the geothermal potential for the region is estimated at 23 to 33 PJ (RES Rotterdam-Den Haag, 2021). The RES also mentions the broad ambition to focus on the available residual and geothermal heat and, in particular, a future-proof energy mix (p. 26). As far as regional policy is concerned, it seems that the goals and ambitions on geothermal energy are still quite abstract.

→ Municipal policy goals – municipality of Rotterdam and municipality of Den Haag

On municipal level, each municipality creates a heat transition vision. According to the Climate Agreement, municipalities are the directors of the heat transition for the built environment. Therefore, in a heat transition vision, a municipality describes the (local) source strategy for all districts for a heat supply without natural gas, of which geothermal energy can be a part. The two interrogated municipalities within the case region are Rotterdam and Den Haag. The interviewee of the municipality of Rotterdam (R4) states that the municipality has not yet formulated concrete policy goals with regard to geothermal energy, but they are well advanced in exploratory processes. In their Heat Transition Vision they describe the importance of a diversified resource strategy for a reliable and resilient heat system. Rotterdam can use residual heat from the ports as the main heat source, but will also focus on geothermal energy (Municipality of Rotterdam, 2021). The Municipality of Den Haag describes in their draft Transition Vision Heat (2022) that they aim for a climate neutral city and municipality by 2030. In Den Haag located at the Leyweg, the first Dutch geothermal source that is connected to the built environment is developed. Besides, more geothermal sources are being developed in Den Haag. It is feasible in large parts of the city to connect buildings to sustainable sources for heating, including geothermal energy. In other parts of the city, it is not yet clear which heat option is a good fit and concrete goals with regard to geothermal energy have yet to be set (Gemeente Den Haag, 2022). It could be stated that The Hague is further ahead with geothermal developments than Rotterdam.

Reflecting on results in 4.1.2

The policy goal analysis confirms that in the Netherlands we have been sailing on the compass of the Climate Agreement (2019) for several years now. Geothermal energy plays an important role in the palette of alternative sustainable energy sources. The reason is simple: it produces relatively low CO2 emissions. That is why the Climate Agreement (2019) addresses the need to intensify the use of geothermal energy in our country in various places. When asked what the biggest enabling factor is for geothermal developments, most interviewees stated that it is the climate crisis that is manifesting itself more and more and is forcing the world and thus the Netherlands into an energy transition, which is reflected in the following quote by the geothermal sector association:

"We agreed to get rid of natural gas in the Netherlands and have set targets for 2030 and 2050 in the context of the energy transition. We don't really have that much as an alternative to heat. For the collective side, you have either electrification or a collective heat network to which geothermal energy can be connected. And geothermal energy can provide constant temperatures all year round." **(R3)**

Furthermore, it can be deduced from the policy goals scan that the development of geothermal energy in the case area does not only take place within the broader paradigm of the energy transition, but more specifically within that of the heat transition. The findings on formal policy goals indicate that geothermal energy is indeed under attention at different scales of government as well as of private parties; goals have been formulated.

However, these goals remain fairly abstract and are mainly set at an (inter)national level. At the local level, the Heat Transition Visions now give rise to a clearer directing role for the municipalities. However, there is still little coordination and concretization between the regional and local levels.

4.1.3 ACTORS: THEIR INTERESTS AND INFLUENCE IN THE GOVERNANCE NETWORK

Based on the document research, the conducted interviews and specifically information derived from the geothermal sector association, following table 4 is developed that provides an overview of actors active in the governance network regarding geothermal energy in the case area. It concerns the actors that in a certain way -can- influence geothermal developments in the RES region Rotterdam-Den Haag.

Actor type	Actor	Interest and/or influence regarding geothermal energy
National state	Ministry of Economic affairs and Climate (EZK)	Develops policy and grants permits regarding geothermal energy.
	Ministries relating to Internal affairs, Infrastructure and Water	Regulate the coordination of spatial planning, agriculture and nature, and form policy.
	State Supervision of Mines (SodM)	Monitors compliance with the Mining Act, human safety and protection of the environment when using the subsurface e.g. with geothermal energy.
	Energie Beheer Nederland (EBN)	Participates (financially) as a partner in geothermal energy production and actively supports the development of geothermal energy. EBN is committed to making optimal use of the potential of the Dutch subsurface.
	Rijksdienst voor Ondernemend Nederland (RVO)	Shares knowledge, supports innovation and provides subsidies. E.g. via the SDE++
	De Mijnraad	Advises the Minister of Economic Affairs and Climate Policy on the granting of geothermal heat permits.
Provincial government	Province of Zuid-Holland	- Offer support in integrating projects into the environment, reserve the necessary space in spatial plans in good time. - Provide advice to the Ministry of Economic Affairs and Climate on the granting of exploration- and production permits (in accordance with Article 16 of the Mining Act).
Municipal government	Municipalities: Albrandswaard, Barendrecht, Brielle, Capelle aan den IJssel, Delft, Den Haag, Hellevoetsluis, Krimpen aan den Ijssel, Lansingerland, Leidschendam, Voorburg, Maassluis, Midden-Delfland, Nissewaard, Pijnacker-Nootdorp, Ridderkerk, Rijswijk, Rotterdam, Schiedam, Vlaardingen, Westland, Westvoorne, Wassenaar, Zoetermeer	- Coordinate spatial and environmental policy and permit granting with the Ministry of Economic Affairs and Climate (in accordance with the General Provisions Environmental Law Act) - Are involved by provinces in advice on local conditions for exploration and production licences. - Are asked by the Ministry of Economic Affairs and Climate for advice on environmental permits. - Provide the 'Heat Transition Vision' before the end of 2021 as part of the Regional Energy Strategy. - Provide support in fitting projects into the environment and reserve the necessary space in spatial plans in a timely manner. - Local authorities can be shareholders in renewable energy projects, such as
Regional	Water boards: Hoogheemraadschap van Delfland, Hoogheemraadschap Schieland en de Krimpenerwaard, Waterschap Hollandse Delta	Enforce environmental and water legislation, including using the 'water test'.
Other parties	Citizens	Local residents may notice something of geothermal energy activities in their immediate environment. They are potential stakeholders and can put forward their views in environmental permit procedures. Local residents can be heat consumers if the geothermal energy is used to heat their homes.

	Drinking water companies	Their interest is clean drinking water and the companies want to guard against the potential pollution of drinking water when geothermal drilling is executed in water extraction areas.
Private parties (business interest)	Geothermal operators	Develop, built and manage geothermal energy projcts
	Heat- or energy companies	Exploit heat networks
	Heat demanders	Heat consumers: e.g. the entrepreneurs in greenhouse horticulture and users of offices or homes.
	Financial providers	E.g. banks, provide capital for geothermal energy projects.
	Insurance companies	Insure project risks.
Interest groups	Geothermie Nederland (NL)	Is the sector association for geothermal energy. It unites all companies and organizations with a business interest in the geothermal sector and promotes the application of geothermal energy.
	Interprovinciaal Overleg (IPO)	Represents the interests of the twelve provinces.
	Vereniging Nederlandse Gemeenten (VNG)	Represents all Dutch municipalities.
	Unie van Waterschappen	Represents all Dutch water boards
	Land- en Tuinbouw Organisatie Nederland (LTO)	Is an entrepreneurs and employers' organization for arable farmers and horticulturists and shares knowledge in the field of making greenhouse horticulture more sustainable
Knowledge institutes	TNO Geologische Dienst	Advises the Ministry of Economic Affairs and Climate Policy, RVO and State Supervision of Mines (SodM).
	Het Planbureau voor de Leefomgeving	As a national institute, it advises on policy analyzes such as advice on the Sustainable Energy Subsidy Scheme (SDE) and future perspectives for sustainable energy

Table 4: Overview of actors in the field of geothermal energy in RES region Rotterdam-Den Haag

Reflecting on results in 4.1.3

The overview of actors and the belonging information imply that the responsibilities regarding geothermal energy lie mainly at the national level, which also becomes clear from the analysis of the instruments described in the next chapter. Furthermore, there are a lot of actors. A large part of them is connected in a more indirect way. This can lead to a noteworthy ratio in interest/influence. For example, the municipal government does have many interests, but they have little formal influence in the current governance setting regarding geothermal energy.

4.2 POLICY INSTRUMENTS FOR GEOTHERMAL ENERGY DEVELOPMENT IN RES REGION ROTTERDAM-DEN HAAG

This chapter describes the findings for each category of policy instruments that are potentially influencing geothermal energy developments in the case region RES Rotterdam-Den Haag. A reflection on the results and key observations with regard to policy instruments are summarized at the end of this chapter in 4.2.6.

4.2.1 LEGISLATIVE AND REGULATORY INSTRUMENTS

Based on the operational framework in table 1, legislative and regulatory instruments that could be of influence to renewable energy development are 1) standards, laws and rules, 2) monitoring/ auditing and 3) renewable portfolio standards.

Standards, laws and rules

The Mining Act - is the leading legislation and applies if geothermal heat is extracted from a depth of more than 500 meters below the earth's surface. It is prohibited to detect or extract geothermal energy without the

permission of the Minister of Economic Affairs and Climate Policy (EZK), the Ministry of EZK is therefore the competent authority. EZK submits 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 on geothermal energy and advises EZK on 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 permit structure prescribed by the current Mining Act for the extraction of geothermal energy is identical to that for the extraction of oil and gas: first an exploration permit is granted, then a production permit is issued and the extraction must take place in accordance with a production plan approved by the minister. However, experience has shown that the current regulatory system does not sufficiently match the specific characteristics of geothermal energy; it is now known that the entire life course of a geothermal project is very different from a project for oil or gas (R2; R3; R6). One difference is, for example, that geothermal energy causes little or no pressure difference in the subsurface, while gas extraction does.

Another critical point of the current Mining Legislation that the interviewees unanimously mention is that the permitting processes are very long, which has a delaying influence on geothermal developments; not only in the RES region Rotterdam-Den Haag, but throughout the Netherlands. The geothermal consultant of TNO (R5) explains about the permit process:

"Now we first receive a request for advice from the EZK, then SodM, then the mining damage technical committee, then local authorities and finally the Mining Council. And everyone has to wait for each other. That is not an ideal process and they want to allow it to run more simultaneously in the future and also to shorten advice periods. It is also useful if EZK is working on capacity, that there is enough manpower to write decisions and permits. The problem is certainly not only due to the slow process, but also that permit applications are not always of very good quality." **(R5)**

The quote shows that the delaying aspect is not only due to the long assessment and advice processes. The operators (the initiators of a geothermal project) do not always deliver the right information, resulting in an permit application that still has to be adjusted, which results in a delay.

The Mining Act is currently being revised and the permits system is being adjusted to speed up the procedures. An average geothermal project now takes about 8 years from exploration till production. Both interviewees from the municipalities (R4; R7) and also the sector association (R3) explicitly state that if we continue at this pace, the set objectives (see paragraph 4.1.) will not be achieved. With the forthcoming Mining Act, it is intended that the geothermal 'planning till production process' can be completed within 5 years. The aim of these amendments to the Mining Act are thus that the permits and the governance part are more specifically geared towards geothermal energy activities (R5).

The Heat Law/ Collective heat law - The Heat Act contains rules about the supply of heat. 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 (R6). The law is currently under review and will change to the Collective heat law. Several interviewees mention that this forthcoming law will be a key piece of legislation in accelerating geothermal energy (R2; R6). Because it is a future goal to also connect the built environment more to geothermal energy in the case region, many heat networks will also have to be developed. R2 states about this aspect:

"The Collective heat law is being delayed, while that is really a key piece of legislation to accelerate geothermal energy use; you really need to have arranged your heat network first, before you consider what you are going to feed that network with, for example with geothermal energy." **(R2)**

A question that will be addressed when drafting the new Collective heat law is whether all heat pipelines and -infrastructure should be in the hands of a public body (which now is not the case) and whether that will support the acceleration of the heat transition (R7). In the heat transition vision, the municipality will indicate where it thinks heat networks are a good alternative, and if so, in what form. When realizing a heat network, the municipality will have to issue a permit.

WABO/Environmental Act - The WABO applies to the above-ground aspects of the geothermal energy installation. These are in particular: the extraction site, the buildings, the environment of the extraction site. Before starting a seismic survey or drilling a well, the operator must have an environmental permit. The operator requests this at the Ministry of EZK. Because geothermal energy is a mining activity, the national government is also the competent authority for this permit. The forthcoming Environmental Act will bundle and modernize the laws for the physical living environment. However, the Mining Act – which will be amended – will, however, continue to exist as a separate legal framework.

Monitoring/ Auditing

According to the Mining Act, SodM is a legal supervisor for geothermal projects. In this role, they are essentially a legally defined instrument that can affect the development of a geothermal project. What they say in the following quotation confirms that:

"For SodM, the starting point always remains 'risks', and how will you ensure that these risks can be controlled. This control element is reflected in the law, for example in the form of standards: e.g. noise standards in residential areas within the environmental permit. We monitor this during the project." **(R2)**

Thus, when certain standards are not met in any phase of a geothermal project, SodM can use their authority to set a geothermal project on hold and in that way affect the development.

Renewable portfolio standards

As mentioned in chapter 4.1. much of our National legislation is linked to European legislation. In order to stimulate the heat transition, the EU formed some official directives that could be seen as renewable portfolio standards:

- Energy Efficiency Directive (EED): aimed at reduction of greenhouse gas emissions by at least 55% by 2030
- Renewable Energy Directive (RED): aimed at deploying 32% renewable energy by 2030

R3 and R5 specifically stated that although the development of geothermal projects is not directly affected by these directives, they do help create a conducive climate for geothermal development by requiring countries to produce a minimum share of renewable energy. Furthermore, the overarching Dutch RES Program exists. This program supports the RES regions in making the RESs by developing and sharing knowledge, providing process support and facilitating a learning community. In this program, however, little is said about specific geothermal energy.

4.2.2 ECONOMIC AND FISCAL INSTRUMENTS

As can be seen in the operational framework in table 1, economic and fiscal instruments that could be of influence to renewable energy developments are 1) subsidies and 2) loans.

Many interviewees explain that the development of geothermal projects involves high and risky investments. The complexity of working in the deep subsurface makes drilling expensive, depending on the depth, the costs are between 6 and 8 million euros and there is a risk that a suitable layer with warm water will not be found. Several instruments are addressed that reduce described costs.

Subsidies

The most important financial instrument that initiators of a geothermal project can claim is the Incentive Scheme for Sustainable Energy Production (SDE++) scheme, which is a feed-in tariff. All interviewees stated that for geothermal projects the SDE++ is per definition needed and without subsidy so far projects have not been profitable. However, some barriers related to the SDE++ are also addressed. As the sector association explains:

"The SDE is actually an operating subsidy; the moment you supply, you receive money for your supplied heat. The costs that you incur for a geothermal project before it produces are high. You can only recover the costs when you supply heat and from then on the costs are often no longer a problem. The problem really lies with getting the investment costs covered." **(R3)**

Furthermore, it appears from the interviews that the SDE++ is now very focused on the geothermal application among horticulturists and not yet well on the built environment. The sector association, TNO and the municipalities explain that geothermal energy now needs a different type of instrument; because more and more built environment projects will soon be launched, in which the heat network and the heat infrastructure often still have to be developed. That part also needs to be subsidized or co-developed by the government (R3; R5; R4; R7). In addition, the heat supply/demand factors also differs; horticulturists have a constant demand for heat throughout the year and they can also produce and thus receive money constantly. However, in the built environment there is a lot less demand for heat in the summer, so there is less purchase that is paid for. R5 explains:

The operator receives SDE++ funds per generated megawatt per year. If you produce little in the summer, you will receive a lot less money. And that's a problem; in fact, the subsidy scheme should be adapted for projects aimed at the built environment. That the subsidy scheme fits better with the trend in heat demand. **(R5)**

Loans

In addition to the fact that initiators often borrow a sum of money from the bank to complete the business case for a geothermal project, there is also a specific instrument that was an extra stimulus for development in the case region. This is how the interviewee of the Municipality of Den Haag explains the Energiefonds Den Haag (ED):

"We [the municipality of Den Haag] have set up a fund called Energiefonds Den Haag and that has proved to be a very successful instrument. Projects that qualify for a loan do not use fossil fuels and are aimed at reducing CO2 emissions, including geothermal projects. It is not a subsidy, but really an investment aid that can fill the gap in the availability of finance. In any case, the ED fund has helped advance the first geothermal project in Den Haag." **(R7)**

Hence, with this additional funding source, the geothermal project aimed at the built environment within Den Haag could get off the ground.

Additional instruments

Additional financial instruments influencing the development of geothermal energy projects that came up in both the document analysis and during the interviews are the following:

Insurance **–** The majority of interviewees identified the Covering risks for geothermal energy scheme (RNES) as a "convenient" insurance mechanism. With the RNES, an initiator insures himself against the financial risks of a mis-drilling. If a drilling has a disappointing result, compensation can be obtained, for which a premium is paid in advance. However, interviewees from the municipality of Den Haag (R7) and from TNO (R5) state that due to the amount of knowledge about the subsurface in the case area (due to the region's history with oil and gas drilling), the RNES is not of great added value there. This is shown with the following statement:

"Many geothermal projects have already been completed in the RES region of Rotterdam-Den Haag, and they already have a lot of data from the subsurface there, the uncertainty of the subsurface is thus relatively limited. To participate in the RNES scheme you have to pay a premium that is relatively high and sometimes too much if the uncertainty is relatively low. In that region there is therefore no real claim to the RNES because it is not worth it." **(R5)**

Investing party **–** What is relatively new is that EBN is now firmly involved in geothermal projects. In the document from EZK dated 21 March 2019 (p.3), the minister discusses the (financial) risk profile of geothermal projects and indicates that he is prepared to use EBN's knowledge and experience and that they are obliged to join each geothermal project as a party. In line with this, it is stated that from 1 January (with the entry into force of the new Mining Act) EBN will be obliged to participate in geothermal projects with a maximum size of 40 percent on a risk-bearing basis. Most interviewees indicate that they expect that the mandatory participation of EBN will be beneficial for geothermal projects, not only to reduce financial barriers, but also to limit risks. However, the influence of EBN as instrument on specifically geothermal projects in the case region cannot be described yet.

4.2.3 AGREEMENT-BASED INSTRUMENTS

Agreement-based instruments that could affect geothermal energy development are according to the operationalization in table 1: 1) public-private agreements and 2) stakeholder partnerships/ agreements.

Public-private agreements

As described earlier, the relatively small Dutch geothermal sector has a relatively large network of actors (paragraph 4.1). The interviews indicate that within the sector the importance of tight agreements between the public side and the private parties for developing geothermal projects is recognized. The interviewee of the municipality of Den Haag, located within the case region, describes the added value of a mix of public and private parties in the following quote:

"The geothermal energy in Den Haag started with a collaboration between 3 housing corporations, EON, Eneco and the municipality of Den Haag. This consortium signed a joint contract stating that everyone had to do their part. The housing associations were going to build the houses, Eneco was going to install the heat network and

all of us were drilling. Then the housing crisis came, the houses were never built. The project went bankrupt, but was picked up again a few years later, resulting in the first geothermal energy project connected to the built environment in the Netherlands." **(R7)**

Stakeholder partnerships/ agreements

Furthermore, several interviewees mention the two sector-wide agreements that have been formed into standards. The first concerns the 'Industrial Standard for a Sustainable Well Design': the well in a geothermal installation must be double-walled in accordance with the standard, previously these were single-walled, but corrosion sometimes caused them to leak, resulting in potentially polluted drinking water (R1; R2; R3; R5). This caused geothermal production to come to a standstill because maintenance and replacement of the well can take a long time. Now that hardly happens (R2). The standard has been imposed by the sector in consultation with the Ministry of EZK, SodM, partnerships, provinces, 'actually the entire geothermal chain' (R3). SodM monitors when industry standards are being made and assesses whether they also fit within the legislative framework.

Another sector-wide agreement to which the sector is committed is the code of conduct 'Environmental involvement in geothermal energy projects'. It has been agreed within the sector to deal with the environment in a certain way and to also involve the environment in activities that the operators of geothermal heat locations do: they must inform what the project entails, how they are doing it and when. The interviewee from the sector association explains:

"Everyone can determine the form themselves, but we have agreed that if you want to develop a geothermal project, you involve the stakeholders at an early stage; preferably already in your investigation phase, that you make a new stakeholder analysis for each phase your project enters and see which parties are important to involve and why, and on the basis of that the form has also been developed, which is most suitable and appropriate for the target group; for example workshops." **(R3)**

Hence, this code of conduct therefore actively implements the care for local residents in the vicinity of geothermal projects not only for geothermal developments in the case area, but throughout the Netherlands. Not only during construction, but also during the entire extraction. The standard is part of the further professionalization of the sector.

4.2.4 INFORMATION AND COMMUNICATIVE INSTRUMENTS

Based on the operational framework in table 1, information and communicative instruments that could be of influence to renewable energy are 1) Public information campaigns and 2) professional training.

Public information campaigns

To comply with the code of conduct 'Environmental involvement in geothermal energy projects', described in the previous section, public information campaigns are more specific tools to use in that regard. The interviewees indicate that geothermal energy is currently relatively unknown to the general public, but that they expect that scaling up will ensure that it will become more widely known and therefore creating permanent support is essential. SodM explicitly states that at the moment geothermal energy still has a positive image, but that they know from experiences that that can change quickly: if risks become explicit or if stakeholders are not properly involved in geothermal energy projects. Each interviewee agrees that it is essential that information, safety and risk management with geothermal energy are of such a high level that public opinion remains positive about

geothermal energy. Most interviewees believe that the responsibility for this rests in any case with the operator, i.e. the executor. However, both municipalities interviewed also see such information sharing as their task, from their position they are in contact with residents or groups and they must also safeguard the public interest from their role as municipality (R4, R7). Following quotes from the municipal interviewees endorse the importance of public information sharing and engagement. Respectively the interviewees of the municipality of Rotterdam and the municipality of Den Haag state:

"The adjacent municipality of Westland [located in the case area], organized an information evening when residents were very worried when they heard about a geothermal project; they were against the project. In the end, after that evening, you saw that many people were enthusiastic and they even said that they also wanted a geothermal source. So you can see that with a little information provision, people can see that something is not that bad as it seems." **(R4)**

"During a project that concerns the environment, you have to communicate in any case. This turned out to be crucial in the geothermal project on the Leyweg [located in the case area]. When the drilling started, a wall of sea containers had been erected to prevent noise nuisance from the drilling. However, the wall aroused some mistrust among local residents. The director decided to completely open everything up, so that people could come and look. There even was an open day, which brought about a turnaround; the environment didn't think it was so bad anymore and they rallied behind the project." **(R7)**

Professional training

In addition to an increased flow of information to citizens, the importance of informing professional and governmental parties is also addressed. It emerged from the interviews that the involvement of smaller municipalities -which also have to draw up a heat transition vision, of which geothermal energy can be a part- is experienced as more difficult. This resonates with the occurrence described in section 4.1.3. of a lack of knowledge and capacity, especially among decentralized smaller authorities. The geothermal projects are now mainly realized in areas where many oil and gas projects have already been carried out, such as in the case area. In these areas, people from municipalities and provinces already have experience with projects that concern the subsurface. The amount of geothermal projects outside that region increases, but local authorities often do not know what to advise. EZK has now arranged that for every geothermal project on which advice must be written, a session is organized by EZK, where advisors TNO and SodM are present to tell the local authorities about the project and what they can advise. Hence, that gives the local authorities a direction.

Although professional training is already given to a limited extent, the interviewees did indicate that there is still room for improvement. The TNO advisor elaborates:

"We think that something can still be done to provide information to local authorities, for example by designing certain programs that can help them gain knowledge about geothermal energy in an accessible way if necessary." **(R5)**

The sector association also emphasizes the need for a specific instrument for municipalities to get help with the energy transition and, more specifically, the heat transition. Help in how they can complete their heat transition as well as possible, both in terms of process and technology. The following quote describes this need:

"Geothermal energy is an inherent part of the heat transition. For decentralized governments, which have to draw up the energy visions, it is important to know how you arrive at geothermal production; from the initial planning to the actual supply of heat. To properly understand that process, how it works and when you can

expect what, together with what you need in terms of technology and choices, you need an instrument that is currently not there." **(R3)**

The parties interviewed are unanimous about the fact that EBN, as a state party that will always operate as one of the initiators in the future (under the new Mining Act), has a role to provide information to decentralized governments or market parties.

4.2.5 KNOWLEDGE AND INNOVATION INSTRUMENTS

Based on the operationalization in table 1 the following knowledge and innovation instruments can affect geothermal energy developments: 1) communities of practice, 2) living labs and 3) workshops.

Every interviewee recognizes the importance of knowledge and innovation instruments for geothermal development. SodM shows with a practical example why these instruments are relevant:

"Not so long ago there was an incident in Naaldwijk [located within the case region] in which the geothermal installation was partially destroyed and a large gas cloud ignited. We are currently seeing plans being made for geothermal energy in the built environment throughout the Netherlands. To this end, we can and must learn from all the knowledge and experience gained in recent years, in particular from the factors that went wrong. So also the incident in Naaldwijk. We [SodM] consider it important that this knowledge sharing takes place sufficiently to prevent incidents like this in the future." **(R2)**

Communities of practice

In the interviews and in the document analysis (Ministry of EZK, 2018, p.5) the sector association GeothermieNL is mentioned as a prominent party when it comes to knowledge sharing. Although it is not an instrument set up by the government, the sector association GeothermieNL is a non-profit party with many members from the geothermal sector. In addition to developing the previously described industry standards (section 4.2.3.), the aim of the party is that the members (consisting of operators, consultancies, research institutes, local authorities) jointly tackle the challenges in the geothermal sector with GeothermieNL as a central connector for advocacy, knowledge building, innovation, support creation, information provision and meeting (R3). GeothermieNL is in this way an umbrella organizaton of a group of parties (a community of practice) that share the same concern.

Living labs

In the Rijswijk Center for Sustainable Geo-energy (RCSG) field lab, located in the case region, TNO, together with companies and universities, develops, tests and validates new well designs, sensor technology, new drilling techniques and materials to accelerate the further development of geothermal energy. This is in the former Shell lab, which TNO has transformed into an innovation lab with support from the Ministry of EZKEBN, the province of Zuid-Holland and the municipality of Rijswijk. The TNO advisor (R5) and the province (R1) say that research is being done here into innovations in the field of value chain optimization and increasing effectiveness, such as coordinating geothermal energy with other heat and energy sources and making maximum use of heat cascading. The projects are diverse and are organized programmatically to facilitate knowledge sharing to accelerate innovation.

Workshops

This heading 'workshops' has great similarities with the earlier described informative tools under the heading 'professional training'. However, the focus here is on the equal input of parties and on joint learning and promotion of knowledge and innovation. According to the municipality of Rotterdam (located in the case region),

such sessions are organized on a local scale, initiated by the developers. The following quote from the interviewee of the Rotterdam municipality shows this using a practical example:

"There are plans for geothermal energy projects in particular areas and the initiating market parties Shell Geothermie and Eneco have set up their own learning sessions in order to get the municipalities where the geothermal projects will take place, Rotterdam and Capelle, also 'up to speed'. These sessions provide the opportunity for all parties to discuss logical locations for the projects and to jointly decide on this. In principle, the creation of knowledge through workshops on a local scale is therefore taken up by the operators." **(R4)**

Additional instruments

EBN **-** EBN has been given a clear role in participating in new geothermal projects through the proposed amendments to the Mining Act (see also 4.1.2). This is apparent from letters to parliament from the Ministry of EZK (2019, p. 3) and from the interviews. EBN's participation is expected to ensure the professionalization of the geothermal sector and improve projects by disseminating and securing knowledge in new projects in which EBN participates. The interviewee from the province explains:

"EBN, now on a voluntary basis, but later on a mandatory basis, focuses on collecting useful information for a geothermal project that they can then use in subsequent projects. Previously, it was often the case that a horticulturist had drilled and shared the knowledge at annual gardeners' meetings. Now, with EBN as a professional party, this can be done more expertly; the amount of information released during a drilling can be collected in an adequate way and then transferred again for reuse in subsequent projects." **(R1)**

SCAN-program **–** Every interviewee states that the main reason that the RES region Rotterdam-Den Haag is the front running geothermal region in the Netherlands is that a lot of data is already available about the subsurface. This has worked extremely beneficial when carrying out targeted drilling and finding a decent water-bearing layer. For areas where this data is not yet available, the Ministry of EZK has set up the SCAN program (Seismic Campaign for Geothermal Energy in the Netherlands). With the SCAN program as instrument, EBN and TNO are determining the potential of geothermal energy in places where little is known about the subsurface. It provides useful insights into the potential of the Dutch subsurface for geothermal energy. However, as described, this instrument was not necessarily of extra value for the case region.

Periodic reports – In addition to the fact that SodM has a supervisory and advisory role as a party and can thus be regarded as an instrument itself (paragraph 4.2.1.), SodM also writes periodic reports aimed at sharing knowledge and making recommendations. These reports, with themes such as 'a state of the sector', an 'evaluation of the state of the sector' or a 'supervision signal', are produced through interviews with experts from the sector and are thus jointly developed for the purpose of knowledge sharing and innovation. SodM explains:

"As a supervisory and advisory party, we hear a lot within the sector and that provides knowledge and insights. We combine this knowledge from time to time in the form of a report and we return that report to the Ministry of EZK as a reflection, or to the industry and operators. These are real insights into what needs to be improved or where things can be improved." **(R2)**

4.2.6 REFLECTING ON POLICY INSTRUMENTS AND KEY OBSERVATIONS

As described in the theory in chapter 2, but what also emerges in this chapter in 4.1, is that the governance network regarding geothermal energy consists of government parties, market parties, research institutes and

other parties. In addition, the theory in chapter 2 showed that policy instruments in contemporary energy governance do not necessarily have to be initiated and shaped by government parties alone. In line with this, the results show that the Ministry of EZK and the local authorities have a number of instruments in place and that the sector has also united and formed instruments.

Furthermore, the difference in complexity of geothermal applications in the built environment compared to industry is noticeable. The correct application of policy instruments can be a solution to remove barriers to geothermal energy application in the built environment. For example the SDE++ is not yet fully focused on applications of geothermal energy in the built environment and that also applies to the collective heat law.

With regard to agreement-based instruments, it is noticeable that the stakeholder partnerships and agreements are very focused on technological aspects in the form of 'industry standards', which is foremost the perspective that parties within the sector still take. While other forms of agreements that are more focused on the organizational aspect are pretty much missing. In view of the shortcomings in the governance of geothermal energy (chapter 4.3.), these would be of great added value. The fact that stakeholders within the sector still have a mainly technical perspective can also be deduced from the findings regarding knowledge and innovation instruments. For example, the SodM hints that as an advisory party, it often looks at the risks associated with geothermal projects and they manage the exchange of knowledge on the risks. This is of course very important, but the technical risks are usually not the barriers where projects aimed at the built environment get stuck. That is the organizational or the resistance of the environment. However, there are still very few guidelines for environmental management with regard to geothermal projects.

An interesting finding described under the heading 'workshops', is that private parties (Shell and Eneco) are initiators in organizing meetings to consider how and where geothermal developments can take place within the municipality in the future. Such developments are a result of a lack of strategic thinking about organizational issues at government level. The result is that private parties run into this and then take action themselves. This implies that there is actually something missing in how geothermal energy is organized/ governed now.

A final point for reflection is that the future Environmental and Planning Act focuses mainly on the economic planning issue and grants permits to companies to start working on, for example, a geothermal project in a certain area. The Environment and Planning Act focuses on the physical environment and the proper design of the living environment. Participation and seeking support are essential and mandatory themes within the Environment and Planning Act. However, the Mining Act does not contain such an obligation. Only later in the process, when a company actually starts drilling for geothermal energy, an environmental law permit is required. But with the first permit that is required to investigate whether there is, for example, geothermal energy in the subsurface, it is not yet mandatory to involve the environment. While involving the environment and creating support are factors that every interviewee attaches great importance to with an eye to the future.

To summarize the analysis of chapter 4.2., the key observations are described in table 5 below.

Key observations

		Weaknesses	Strengths
Policy instruments	Regulatory and legislative instruments	- Current regulatory system (the Mining Act) does not sufficiently match the specific characteristics of geothermal energy. - Long permit procedures within the Mining Legislation, which have a delaying effect. - Operators/ initiators don't always provide the asked information in permits requests, which has a delaying effect.	- Change is on the way: revision of the mining law and permit system expected in 2023.

		- Creating support is not yet included in current legislation	
	Economic and fiscal instruments	- Subsidies are not yet sharply focused on geothermal projects aimed at the built environment. - RNES insurance is little used due to high premium.	- EBN as a state party and co-financier provides extra finance and confidence in the environment. - Separate municipal fund in The Hague has provided additional financial support for geothermal development in the case region.
	Agreement-based instruments	- Stakeholder partnerships and agreements are very focused on technological aspects and industry standards, while the other forms of agreements that deal more with the organizational aspect are missing.	- Consortium of parties are developing sector-wide agreements aimed at: safety and involvement of the environment. This contribute to further professionalization of the sector.
	Information and communicative instruments	- Public information provision is not widely applied yet, which sometimes results in dissatisfaction among local residents. - Training and campaigns aimed at informing professionals are done very sparsely, despite the fact that there is a demand for more geothermal knowledge among local authorities.	- Where information provision is applied in forms of open days or information sessions, this helps creating support for geothermal energy.
	Knowledge and innovation instruments	- Private parties take initiatives to share knowledge in the field of strategic and planning choices with regard to geothermal energy. While it is precisely the government that is responsible for the heat transition and the public interest.	- EBN as a state party participant in every geothermal project, with the aim of sharing knowledge. - Sector association as 'umbrella party' provides a community of practice. - Instruments aimed at sector innovations: e.g. RCSG lab.

Table 5: Summary data analysis results on policy instruments

4.3 Discussion: Characteristics of geothermal energy governance in the case region

This chapter describes on the basis of the governance concepts from the theoretical framework: multi-level governance, decentralization and forms of partnership, the results with regard to stimulating conditions and complexities in governing geothermal energy development in RES region Rotterdam-The Hague. It is therefore already a discussion of the results. It at the same time links the governance observations to the analysis of the policy instruments in the previous chapter.

Multi-level governance

In theoretical chapter 2 it was concluded that for geothermal energy multi-level governance would imply that implementation of projects is not governed on one level, or on a number of separate levels, but through interaction between these levels (Lemos and Agrawal, 2006; Loorbach and Rotmans, 2006; Geels, 2021). From the different policy goals that have been set at different scale levels, a certain interaction between these levels also seems to be traceable when it comes to geothermal development in the case region. The scrutinized policy documents at municipal level (the heat transition visions of the municipalities of The Hague and Rotterdam), are a 'mandatory' product that is part of the policy at the regional level (the RES Rotterdam-The Hague). In these RESs, national agreements from the Climate Agreement are put into practice, which in turn are achieved through set goals at international and EU level. Although interactions seem to exist, these interactions resemble a kind of 'top-down' approach: higher levels of government have imposed decentralized levels to also shape policies related to the energy or heat transition. The important role for the state is clearly shown with these results.

However, the interviews show that the governance setting is not as black and white as the presence of a 'top-down' approach. As the actor analysis showed, the governance playing field with regard to geothermal energy concerns a large network of actors, in which, according to the interviewees, there are certainly interactions. This becomes apparent from the following quote.

"In geothermal projects, we work with local partners, the municipalities, initiators, companies, drinking water companies. In order to actually obtain the correct permit at the policy level, there are collaboration, controlling or advisory processes between parties such as TNO (a department that advises on the subsurface), SodM (the supervisor who advises), the municipalities, provinces and water boards that advise. And then the national government, the ministry of EZK, which is the competent authority and takes a final decision regarding the granting of permits for the geothermal project." **(R1)**

The central government is thus responsible for permits regarding geothermal energy. However, several interviewees noted that the permit process is very complex and opaque for municipalities and provinces. In addition, local authorities and citizens have relatively little influence on the granting of permits. Municipalities have hardly any influence, except for an advisory vote and one formal moment at which a so-called "Declaration of no objection" is issued for a location (R1; R4; R7). There is not much interaction with the national government during geothermal project development, according to the interviewee of the municipality of Rotterdam:

"During geothermal developments, we do not really have contact with the Ministry of EZK. At the time of application for a permit, it goes through all levels of government in a certain way; the application is sent to the EZK, who request advice from the provinces, municipalities and other parties. Other than that, we don't really have any contact." **(R4)**

From what has been described above, it appears that contact is mainly maintained through formal channels; through the permit procedure. According to the interviewees, this limited contact has several consequences, described under the heading 'decentralization'.

Decentralization

In the theoretical chapter it was found that a decentralized setting contains a more area-based approach of environmental issues, which generally details more proactive, integrated and tailor-made methods (Zuidema, 2016). At the municipal level, heat transition visions are made in which a municipality can determine locally whether they want to include geothermal energy in their energy strategy. The governing of geothermal projects therefore seems to have characteristics of decentralization. However, it appears that decentralized governments are not involved during the entire process, as was noticed in the previous 'multi-level governance section'; there is limited contact between decentralized governments and the national levels during permit processes. Although, this contact is considered as needed. The interviewee from the municipality of Rotterdam explain why they consider involvement in a large part of the process important:

"It is quite difficult for the municipalities to manage geothermal projects, which is not necessary per se, but what is important to us is that it fits within the transition vision for heat and other policy documents." **(R4)**

This statement touches on the previously described directing role of municipalities in drafting and implementing the heat transition visions and also their role in looking after the public interest.

The importance of involvement of decentralized governments also appears at a provincial level, as the province of Zuid-Holland says:

"The subject matter of geothermal projects and the permit process is generally experienced as complicated. That is why it is good that the Haaglanden Environmental Agency within our province has thoroughly studied the subject of geothermal energy and the meetings we have with them contribute to knowledge sharing." **(R1)**

What also emerges from the quotation above is that de province of Zuid-Holland even uses the knowledge of the Haaglanden Environmental service to assess and give advice on the geothermal project documents which need to be assessed. The quotation shows the importance of understanding and awareness that the local and regional authorities need to fulfill their advisory role. However, apparently the province itself does not have the knowledge that is needed for this role. Policy instruments related to information provision and knowledge could fill the identified knowledge gap here.

Although, geothermal energy permit processes and the formal decision-making is not arranged decentralized, the decentralized authorities are involved in an advisory role. However, sometimes complexities occur in this regard. The interviewees of the municipalities, the province and TNO, all state that municipalities do not always have enough knowledge and capacity in-house to adequately fulfill their advisory and supporting role. For example, R6 says:

"The energy transition is largely the responsibility of the municipalities, but especially for smaller municipalities where you have 1 policy officer who deals with many different subjects, geothermal being one of them, it is difficult to advise on technical aspects of geothermal energy." **(R6)**

While the larger municipalities located in the case region, the municipalities of The Hague and Rotterdam already have a strong focus on geothermal energy, some small municipalities do not always have sufficient knowledge and resources to specifically delve into geothermal energy. The overarching RES does not by definition provide a solution for this, as is apparent from the following quote:

"When developing the RES Rotterdam-The Hague, it was said that we should all work together and exchange heat in the context of the energy transition. That is not actually happening with geothermal energy yet, there will also have to be a link in that area with neighboring municipalities, because then you can weigh up where geothermal energy would fit best in a bigger picture and exchange knowledge and expertise." **(R4)**

Nevertheless, the interviewees agree that the involvement of the municipality requires great attention because the heat transition is very much in the hands of the municipality and it is expected that this will increase in the future, because they will also more often fulfill a role as initiator of a geothermal project connected to the built environment. As stated by SodM:

"We notice that more and more municipalities are considering geothermal energy as a heat source. Municipalities will in the future be initiators of a heat network to which geothermal energy can be connected as a source. They will play an important role in the decision whether or not to develop geothermal energy projects within a municipality." **(R2)**

The results described above regarding the lack of knowledge and capacity in provinces and municipalities are by no means remarkable in the sense that the policy instrument analysis also revealed that information provision and knowledge sharing aimed at the professional of the local authorities is very sparsely done and there are no standard guidelines for this yet. The barriers all concern access to knowledge and it is remarkable that the RES has not yet provided a solution for the provision of this, since specifically the RES is aimed at jointly providing an

energy strategy for the bigger picture. Another, improved approach of the RES may actually offer a solution for bundling and providing knowledge and capacity as an instrument.

Forms of partnership

The main theoretical finding regarding the 'new forms of partnership' trend in contemporary energy governance was the more active participation of market parties in policy and other processes and that Dutch governments also depend on this to bring about the energy transition (Sanders et al., 2014). This participation of market parties is reflected in the development of geothermal projects in the RES region Rotterdam-The Hague. As described, geothermal projects in the case region have mostly been initiatives in recent years by horticulturalists who provide their companies with geothermal heat. In addition to horticultural companies, (energy) companies that have geothermal energy as their main activity are now also entering the geothermal sector. These companies realize multiple geothermal systems (portfolio approach) and bring mining knowledge and experience with them. It emerged from the interviews that there is clearly increased expertise in this area, risk management and safety and compliance with legislation and regulations. This makes a dichotomy visible between horticultural companies with the extraction of geothermal energy as a secondary activity and (energy) companies that have geothermal energy as their main activity or have experience in mining. Reflecting on the emergence of these experienced operators, this seems to be an opportunity for the application of geothermal energy to the built environment. Interviewee of TNO says about this:

"The first systems were developed in Westland [located in the case area]. At first these were initiated by individual horticulturists and since about 5 years we have seen that larger players are entering the market. A consortia of market parties also developed the first built environment project [located in the case area]. Their goal is to develop multiple systems over a larger area: that is called portfolio operating. That is the step you see now; from the infancy to the deployment of acceleration." **(R5)**

Nevertheless, the development of geothermal energy in the built environment is currently only taking place on a limited scale. The interviews show that this is because in the current situation there are too many uncertainties and risks to realize geothermal projects in the built environment. The development process has many question marks regarding the development of the heat chain, legislation and regulations, permits, geology and subsurface, subsidization and financing, support and sales to get up to speed (R3). Furthermore, the interviewees emphasize the enormous differences: a small number of large-scale heat consumers in a closed system (in greenhouse horticulture) versus the integration of one or more sources in a complete energy chain, including base, medium and peak load sources, kilometers of distribution network, storage, and thousands or tens of thousands of smaller customers (in the built environment). And the main complexity is that geothermal energy in the built environment depends on the presence of a large-scale heat demand with a distribution network (R3; R6).
Reflecting on the complexities in this paragraph, these 'question marks' actually expose the lack of policy instruments that might alleviate and/or remove the barriers experienced in geothermal developments for the built environment.

Due to the complexities and the social interface, municipalities are also involved in the permit applications needed for geothermal development, which is apparent from the following quote from the municipality of The Hague:

"We have a party within the municipality of The Hague that has a geothermal exploration permit, that is Haagse Aardwarmte B.V. That is a party that we actually have a meeting with every week. This partly concerns the state of affairs, but also the development of new sources. For example, we are currently working on a subsidy application, that requires lots of coordination with the heat supplier. What is difficult is that there are

no heat networks yet, so parties are in a competitive position there. As a municipality, we are looking at how we can fold it in such a way that there is a feasible business case for every initiator, but that the public interest is also represented." **(R7)**

The dependence on the local heat demand means that there is no national market for geothermal energy and that the local demand is leading in the establishment of a healthy business case for a geothermal project. For heat consumers such as homes or utility buildings, but also projects with glasshouse horticultural customers consisting of several companies, this requires extra coordination to organize sufficient customers for a geothermal installation, and often the construction of a new or larger heat network. The need for extra coordination to organize a heat network that is required here, is a recurring aspect; in the policy instruments analysis we saw that instruments that focus on organizational aspects are missing. Hence, there is still a gap to be filled here, for example by offering instruments in the form of formal guidelines on how to deal with the organizational aspect.

The costs and social acceptance of the heat networks and especially the building of and drilling required for these networks play an important role (R4; R7). Initiators therefore involve municipalities in a private process as a public party in the extraction of geothermal energy. This puts municipalities in a position in which, on the one hand, they can expect clarity from initiators, and on the other hand, they are also expected to take a position in the debate and weigh up public interests. As soon as it becomes publicly known that the search area for a geothermal drilling falls within the municipality's own boundaries, a dynamic is created in which residents ask the municipality many questions and express their concerns (R7). Here, too, a gap can be recognized that policy instruments can fill: as the policy instruments analysis showed, there is still little public information provision and, according to the current mining law, the public does not yet have to be included in geothermal developments. While it does appear here that the public does have concerns and is going to ask questions. Instruments through which the general public is already taken at the front would be valuable here.

Reflecting on results in 4.3.

This chapter, which examines the governance aspects of geothermal development at a somewhat more abstract level, shows that many parties are involved in realizing a geothermal project: at project level you have the initiators and their applications are assessed through a policy process wherein advice is sought from multiple levels of government and authorities. At a decentralized level (both municipal and provincial), it is decided whether a geothermal project fits in with the energy strategy, but the actual decision-making process regarding the permits required for a geothermal project, the competent authority, rests with the Ministry of EZK, i.e. at national level. In this regard, the development of geothermal projects is less decentralized than might be expected from the theoretical framework. The main governance barriers and gaps identified in this chapter, are put in table 6. Since policy instruments are the technique of governance (Howlett, 2004), policy instruments that are now lacking or not sufficient yet, are proposed in table 6 to enlighten the identified gaps.

Identified governance barrier	Possible instrument type to enlighten the barrier	Concise suggestion
Decentralized authorities have difficulty with the complex and opaque permit procedures, while they do have an advisory role	- Information and communication instruments - Regulatory and legislative instruments	- Deploying parties with knowledge, for example as the province deployed the environmental agency Haaglanden. Such a party could be accessible to all local authorities. - Clarifying the permit procedures within the Mining Act in collaboration with the actors in the network
(Especially smaller) decentralized governments do not always have the	- Information and communication instruments	As an overarching collaboration network, the RES region as an entity able to

knowledge and capacity needed to fulfil their advisory role	- Knowledge and innovation instruments	coordinate information sharing by, for example, giving courses or by bringing the right people/organizations into contact.
Little interaction between governmental layers during geothermal developments - while the local authorities do have an interest in involvement at the front, because of their coordinating role in drawing up and implementing the heat transition visions (municipality) and also for their role in monitoring the public interest (municipality and province)	- Agreement-based instruments - Information and communication instruments - Knowledge and innovation instruments	Arranging periodic meetings during the course of a geothermal project so that each party can inform about their knowledge and regularly declare and monitor their interests.
Built environment application only on a limited scale because considered more complex to govern (more parties involved, larger scale, need for heat network)	- Information and communication instruments	Focus on creating understanding among the relevant actors regarding the complexities of applying geothermal energy to the built environment. For example, by drawing up a teaching program (within the RES, by the sector organization, or by the national government) in which periodic information sessions and interactive workshops (where relevant parties join) steer towards joint learning about the application of geothermal energy to the built environment.
Involvement of citizens and the environment is not yet governed with a clear responsibility	- Information and communication - Agreement-based instruments - Regulatory and legislative	- Agree with the sector (in a covenant code) to inform and involve those directly involved at an early stage in the planning phase of a project, e.g. by means of workshops. - Include mandatory consultation of the general public in an early stage of exploration in the Mining Act

Table 6: Identified governance barriers linked to proposed policy instruments

5. CONCLUSION AND DISCUSSION

The previous chapter presented the results of the interviews and the document analysis. These results have been discussed and analyzed, resulting in information that allows us to draw conclusions and answer the sub and main questions. In section 5.1, first an answer to the theoretical sub-question 1 is shortly given, then an answer to the empirical sub-question 2 is discussed in connection to the theory, starting with a part on specifically policy instruments and followed by a section on policy goals and governance. Section 5.1 ends with answering the main question and providing a conclusion. In section 5.2, generic lessons are drawn and recommendations are made on the basis of sub-question 3. Finally, 5.3 reflects on the theoretical and practical contribution of the research, on the methodology used and the research process, and ends with a section on suggestions for future research.

5.1 CONCLUSION: POLICY INSTRUMENTS AFFECTING- AND THE GOVERNANCE CONCERNING GEOTHERMAL ENERGY DEVELOPMENTS

5.1.1 ANSWERING SQ 1

What does the exploitation of geothermal energy entail, what are contemporary trends in energy governance, and how can the concept of policy instruments be defined, and subsequently operationalized to contribute to the exploitation of geothermal energy

In the theoretical framework, it was found that contemporary energy governance is subject to following trends: multi-level governance, energy decentralization, new forms of partnership emerging. These trends form the context in which geothermal developments are governed. Governance as explained in the theoretical chapter is very much about the 'interaction between actors'; which is the overlapping aspect of the 3 trends. Policy instruments can shape those interactions and the governance context. In the conceptual framework, 5 types of policy instruments are distinguished: 1) legislative/regulatory instruments, 2) economic/fiscal instruments, 3) agreement based instruments, 4) information/communication based instruments, 5) knowledge and innovation instruments. The policy instruments are operationalized (table 1), resulting in a framework of policy instruments that influence the way geothermal energy is governed hence is exploited.

5.1.2 ANSWERING SQ 2

What are current policy goals that apply to RES region Rotterdam-Den Haag and how are geothermal energy projects in RES region Rotterdam-Den Haag affected by policy instruments?

How policy instruments affect geothermal developments in the case region

The specific instruments and their influence on geothermal developments in the case region are already set out in the previous chapter 4.2. The strengths and weaknesses of the instruments are provided in table 5. Following section, describes the answer to the sub-question in a more broader perspective.

In literature on regulatory and legislative instruments it was found that these type of instruments are essential in developing and promoting renewable energy (Park, 2015; Yi and Feiock, 2014). It was also concluded that for specifically geothermal energy, laws and regulations can be considered barriers and limiting for geothermal development (see e.g. Yasukawa, 2018 in Manzella et al., 2019). Both statements, are pretty much highlighted

in the case region. Although a legislative framework is indeed experienced as necessary, the results show that the national Dutch legislative framework regarding geothermal energy is not experienced as sufficient. The leading Mining Act is mostly focused on oil and gas and the system does not match the specific characteristics of geothermal energy.

With regard to financial instruments, subsidies and loans were identified as means to overcome high capital costs of geothermal projects (Park, 2015; Enzensberger et al., 2002). This resonates with the findings from the case study, which show that geothermal developments within the area cannot yet take place without subsidies and loans. However, there is some nuance to this statement. Dumas (2018) stated that financial support is of great importance because of the initial costs of geothermal energy. But, from the subsidy provided by the National government (the SDE++) funds are only paid when a geothermal energy project actually produces. The high initial costs must be provided by the initiator himself. For geothermal projects, this has often resulted in loose business cases. For this reason, the municipality of The Hague provided a separate municipal fund to cover he initial costs, which ultimately had a stimulating effect and resulted in the first built environment project of geothermal energy in the Netherlands.

Agreement-based instruments focus on actors cooperatively and voluntarily deciding to act in a specific way (Lascoumes and Le Galès, 2007). As the results on the case area show, there are joint agreements in the geothermal sector, which are laid down in industry standards, which have a primary technical focus. Ejderyan et al. (2018) and Contini et al. (2019) argued that these kinds of instruments are needed to get geothermal projects of the ground. This is not clearly evident from the results, however it can be concluded that the technical industry standards are beneficial for the lifespan of geothermal projects. What is not explicitly stated in the theory, but what the interviewees agreed upon, is that sectoral agreements aimed at social factors (e.g. involving the environment) should also have a place in current geothermal governance. This is becoming all the more important, especially due to increasing geothermal applications in the built environment. The effect of such instruments is expected to have a supportive effect.

Information and communicative type of instruments were in literature considered as important for informing people (Lascoumes and Le Galès, 2007) and for geothermal energy specifically for involving citizens' perspectives (Contini et al., 2019). However, it turned out that such instruments are not yet widely used in the case region. The lack of such instruments (e.g. campaigns, professional training) was mainly felt by professionals from local authorities: training and campaigns aimed at informing these professionals are done very sparsely, despite the fact that there is a demand for more geothermal knowledge among local authorities because of their advisory role in permit processes and coordinating role in the heat transition. Hence, there is a gap to be filled here. On the contrary, there are examples within the case area with regards to information provision to citizens (in the form of open days and presentations) that led to eventual acceptance of a planned geothermal project. This positive effect is in line with what Contini et al. (2019) argued, namely that trust building activities and information provision are useful instruments for promoting social acceptance regarding geothermal energy.

Based on knowledge gained in theory, the extra typology ‘knowledge and innovation instruments’ was created, since studies on energy transition emphasized that knowledge sharing and innovating is important for future developments (Carlsson et al. 2002; Kemp, 2010). In the conceptual framework these instruments were operationalized as 'communities of practice', 'living labs' and 'workshops', thus gatherings aimed at actors coming together and sharing knowledge. Results tell us that this type of instrument are definitely present: private parties take initiatives to share knowledge in the field of strategic and planning choices, there are labs aimed for testing technical innovations and there is a sector association that provides a community of practice. In addition, extra instruments were induced aimed at sharing knowledge and innovating the professionality of the

geothermal sector: the SCAN program, the periodic reports of the SodM and EBN as state party that is responsible for incorporating the lessons learned from a project to other projects.

In conclusion to the sub-question, policy instruments influence the development of geothermal energy in a way that is experienced either as an impediment, as a foothold or as a stimulus. The theory in chapter 2 stated that a mix of types of instruments usually is applied in order to implement policy and reach policy goals (Le Galès, 2010; Howlett and Rayner, 2018). With regard to the case area, it can be seen that indeed a mix of instruments is applied and used in governing geothermal developments. The mix of instruments that are now of main influence on geothermal project developments mainly consists of legislative and financial instruments. And although it is recognized that the instruments that are based on involvement of the environment (informing) and the coordination of knowledge sharing and collaboration (agreements, knowledge sharing, communication) are of emergent importance, these are still somewhat underexposed.
Lastly, it can be noticed that the type of policy instruments formed and applied, contribute to how geothermal projects are governed in the case region. In that sense the policy instruments are, as was already stated in the literature the techniques of governance (Howlett, 2004), that can govern interactions of actors (Lascoumes and Le Galès, 2007), which is further discussed below.

Policy goals and governance

The government can stimulate the energy transition by formulating policy goals and determining the rules of the game (Kemp and Rotmans, 2009). The policy goals that affect the case area are described in chapter 4.1.2. Goals are set at every government level (municipal, regional, provincial, national and international), but these stay rather abstract and little policy is pursued on geothermal energy specifically. While it was described in the theoretical framework that precision with regard to geothermal energy is important, because you cannot all use the same subsoil layer or spot and expect that this will always go well (Oomes, 2012). Nevertheless, formation of these policy goals reveal the existence of interactions. These interactions resemble a kind of 'top-down' approach: the national government levels have imposed on decentralized levels (the province of Zuid-Holland, RES and the municipalities of Rotterdam and The Hague) to also shape policy. In literature, it was argued that energy planning requires a significant role for the state and/or organizations like the EU to stimulate or enable the energy transition (Rotmans et al., 2001; De Boer and Zuidema, 2015). The significant role for the state is clearly presented within the case region.

In literature it was also found that traditional planning and policy approaches, such as top-down governance, cannot fully handle the complex web of the energy system (de Roo, 2013). The complexity of the governance structures with regard to geothermal development in the case region is briefly outlined here. An important observation from the results is that the governance of geothermal energy for the built environment is a lot more complex than for its application in industry. One of the reasons for the slow start of geothermal energy developments in the built environment within the case region, which is also responsible for a number of risks in the development of geothermal energy, is the lack of sufficient collective heat demand. Besides, although Regional Energy Strategies (at regional level) and Heat Transition Visions (by the municipalities) are formed, these are almost insufficiently elaborated and rarely offer concrete tools for development. In literature it was found that local and regional governments have a crucial role in delivering public policies relevant to the energy transition (Hoppe and Miedema, 2020; Dobravec et al., 2021). This is in line with the findings on the case region; the named strategy and vision indeed give rise to a clearer directing role for the decentralized level. However, one of the main observations in this research is: there is still little coordination and concretization between these different governance levels. In the permit processes for geothermal energy projects the national government is

the competent authority and the decentralized governments have an advisory role, but the decentralized authorities in the case region indicate that mutual coordination is often lacking.

Within the Heat Transition Vision the municipalities within RES Rotterdam-Den Haag can determine locally whether they want to include geothermal energy in their energy strategy. This resonates with what was deduced from literature; a decentralized setting contains a more area-based approach of environmental issues, which generally details more proactive, integrated and tailor-made methods (Zuidema, 2016). However, only in the future, under the new Mining Act, will municipal advice become more important. Under the new Mining Act, one of the most important considerations will be how the geothermal project fits within the regional strategy of local authorities to initiate the energy transition. Right now, partly because of the lacking coordination, some parties involved have a knowledge gap. There is a need for mutual coordination and despite the fact that the RES and the RES regions are set up to coordinate the energy transition, it is experienced that the RES lacks any coordinating role in geothermal energy.

In conclusion, the results show that the existing policy instruments (e.g. the current Mining Act and belonging permit procedure) do work within the boundaries of current energy governance, since geothermal projects are actually getting off the ground. However, there are a lot of complexities and with an eye to the future and the expected increasing development of geothermal energy in the built environment, the governance will have to be formed into a more flexible and appropriate network with more efficient interactions for which policy instruments can serve as means.

5.1.3 ANSWERING THE MAIN QUESTION AND CONCLUSION

How is the planning and development of geothermal energy projects in RES region Rotterdam-Den Haag influenced by policy instruments within the context of contemporary energy governance in the Netherlands?

The answering of the sub-questions leads us to answering the main question. The RES regions have been formed as a collaborative entity to support local and regional authorities in making regional energy strategies in the context of the energy and heat transition. The geographical delineation of a RES region is influenced by policy goals at various levels from international to local. With regard to contemporary energy governance of influence on the case region, it can be concluded that policy on geothermal energy is still very abstract. There are policy instruments that are highly conducive and needed for the development of geothermal projects (e.g. subsidies). However, the lifting of geothermal energy to the larger scale; an increased and frequent application of geothermal energy to the built environment and its governance, is still complex. The factors in the governance of geothermal projects that were found to be complex resonated with absent or inappropriate policy instruments in that regard (e.g. the lack of coordination between several government levels resonates with the observation of little informative and communicative instruments that can improve this coordination).

It is recognized that it is difficult for municipalities to govern complex geothermal energy projects, while they are largely responsible for the planning and implementation of the heat transition. What strikes is that weak capacity on the local level, a lack of awareness for national intentions among subnational authorities and vice versa as well as a gap between national planning and local implementation due to a lack of consultation during policy formulation, are all governance and policy related obstacles that hamper the development of geothermal energy. In light of this study, that focuses on where policy instruments can enhance implementation of geothermal systems and thus where they can alleviate the -governance- barriers that currently hinder that implementation, this is relevant. The power to form and deploy policy instruments often rests with the authorities (Howlett, 2009).

Furthermore, authorities are a fundamental part of the governance network and of policy creation (Howlett, 2009). Therefore, a significant main barrier as the unawareness among the decentralized governments in the case region, has to be resolved first -by means of policy instruments- before these authorities can form instruments that alleviate the other barriers regarding geothermal energy development. A directing role must be clearly designated. It is precisely here that policy instruments - the techniques that bring about actions, stimulate interactions, and provide frameworks and guidance - can and must be applied. As stated, RES regions are established for the purpose of collaboration; considered as instruments the established RES regions will be a good designated entity to take on the coordinative role. Collectively, the choices in these instruments influence the way in which geothermal energy is governed and consequently form the energy governance.

Lastly, in the theoretical framework, the study by Pan et al. (2018) was cited, who had already researched the barriers for establishing geothermal energy projects (figure 2). However, it was established that the barriers mentioned by Pan et al (2018) remained rather abstract: the study mentioned, among other things, 'policy and legal issues' and 'lack of partnerships'. This research shows that these barriers are indeed experienced in the investigated case area. However, the empirical research has led to a more concrete formulation of some barriers: e.g. how a lack of partnerships mainly concerns the collaboration between different levels of government, which should be coordinated better. These insights are a contribution to the literature on geothermal energy.

5.2 LESSONS AND RECOMMENDATIONS

SQ3: What lessons can be learned from RES region Rotterdam-Den Haag regarding the position of geothermal energy in contemporary energy governance?

Based on this research, this section draws generic lessons on the position of geothermal energy in contemporary energy governance and provides recommendations on how policy instruments can stimulate governance regarding geothermal energy to develop a conducive environment for RES regions throughout the Netherlands.

Lessons

The results teach us that for most governments geothermal energy is still relatively new. Knowledge is required in order to obtain an image, form an opinion and ultimately make decisions as a local or regional government. Knowledge that is currently not always self-evident, transparent and understandable. This research shows that almost all levels of government in the Netherlands are confronted with issues surrounding this new form of energy. With the increasing contribution of local and regional authorities, especially the municipality, it is also important that they are involved and have sufficient knowledge and capacity. In addition, there is a need for stronger coordination between the levels of government, so that the interests of lower governments are better served. In addition, it appears that the implementation of geothermal energy in the built environment is not feasible without public support. New knowledge and insights develop quickly, but they also raise questions. In these times, this no longer requires a top-down, but rather transparency and cooperation. Finally, we learn that despite many actors involved in geothermal processes, geothermal does not yet have its own place in the policy domain: see, for example, the Mining legislation (mainly aimed at oil and gas) and the subsidy scheme (not yet appropriate for application to the built environment).

Recommendations

Based on the generic lessons, recommendations are made here below to the entire network of actors regarding geothermal energy in the Netherlands.

Designate a coordinator for achieving the necessary interaction between different layers of government

The coordination between the different levels of government needs improvement, both in planning and implementation. It is clear that the national government, while granting the permit, is failing to further facilitate the process. Involving local and regional authorities in particular can offer a solution here. However, the position of these authorities within the geothermal sector is often not clear. Knowledge sharing and knowledge transfer are seen as essential with regard to the position of local and regional authorities and are seen as essential for a proper interpretation of the roles and tasks. A informative/ communicative/ agreement-based policy instrument that would be appropriate here is a more efficient use of the RES as phenomenon to come together and coordinate policies and strategies regarding geothermal energy.

Create support in the environment

Due to the alleged risks of geothermal energy, stakeholders are not always unanimous about a project to come, this can be exacerbated if stakeholders are not properly involved in geothermal energy projects. Creating permanent support among stakeholders through environmental management is therefore important, especially with an expected increasing number of projects aimed at the built environment. The following instruments can be used for this purpose: 1) The legal inclusion of mandatory environmental management already in the exploration phase of a project, 2) The development and elaboration of communication tools, aimed at various social target groups, with attention to: what is geothermal energy, what are the benefits, what are the risks, who are involved. With regard to this subject, again cooperation between central government, local authorities and private stakeholders is essential to properly design environmental management, in terms of content when setting up and implementing the various matters, but also in communication to citizens.

5.3 REFLECTION

5.3.1 CONTRIBUTION TO PLANNING THEORY AND PRACTICE

First of all, the subject of this study is established within the context of the HARNESS project. Therefore, the work contributes to the project "*Harnessing the heat below our feet: Promises, pitfalls and spatialization of geothermal energy as a decarbonization strategy*" funded by FORMAS (Swedish Research Council, Project no: 2020-00825).

Furthermore, this research contributes to the understanding of the governance of geothermal projects in practice and the influence of the different policy instruments on the planning and development of geothermal energy. The contemporary governance trends that were proposed as a handle in this research have been deducted from contemporary theories in environmental and energy governance. Policy instruments applicable within the energy transition have been operationalized for geothermal energy (table 1). This formed a theoretical framework that was then applied to a case.

The research has a very explorative approach, because relatively little research has been done into the institutional, policy and governance context of geothermal energy. The research complements the research field of geothermal planning and provides insight into the influence of concepts such as multi-level governance, decentralization, and new forms of partnership, on the governing of geothermal energy as well as the influence of policy instruments on the development of geothermal projects. The findings of this study provide more insight into the current complexities of governance structures regarding geothermal energy in specifically the RES region of Rotterdam-The Hague, though at the same time focuses on the interactions between all (government) levels. The insights can contribute to stimulating geothermal energy governance in the RES region Rotterdam-The Hague.

5.3.2 RESEARCH PROCESS

This research is the result of a months-long process of interpreting, interviewing, transcribing, analysing, writing, revising and a lot of video calling. I look back on the past few months as a very instructive and interesting time, despite the fact that some factors have turned out differently than I had originally expected.

Like any research, this study has its strengths and limitations. An experienced complex factor during the research was that the fact that the geothermal sector was/is subject to a lot of changes during the time span of data collection. There are developments at every level of government, new laws are on the way, the subsidy scheme is being adjusted, the general urgency to get rid of gas has accelerated due to international developments. This means that the data collection of the study may have been a snapshot, which can be deduced from the results; where the sector experiences implications with regard to, e.g. fiscal instruments, the interviewees indicated that in some cases these instruments are already reviewed. Yet, because so much is in motion, the recommendations of this study are now relevant.

In this research, a single case study was chosen: geothermal Dutch frontrunner RES region Rotterdam-Den Haag. Yet, a comparative research might also have been appropriate, as this would have allowed a comparison between the case region and another RES region with significantly less geothermal project. That could have provided insights into fundamental differences. However, the delineation of the geographical area of the RES region Rotterdam-The Hague was very valuable; because of this delineation, a case could be scrutinized where geothermal projects have already been implemented. Hence, a place where experiences and information could usually be found.

With regard to the interviews; Unfortunately, it was not possible to interview the Ministry of Economic Affairs, although they are the competent authority regarding geothermal projects and shape national geothermal policy. This aspect is reflected in the results chapter, where the complexities of governance are often described from the perspective of local authorities and local parties. However, interviews were held with a stated-owned party as well as parties that function as legal advisors to EZK, still resulting in interesting insights at a national level.
The interview number turned out to be sufficient for the exploratory study; during the last interviews, fewer and fewer new themes emerged and all the statements made by the interviewees fell within the themes that had already been suggested by others. The respondents were always asked whether they had anything to add to the interview, to which the answer was almost always negative. It thus seems that the interviewees had told everything they wanted and could say. Furthermore, it is good to note that the interviewees showed great interest in this research. This shows that the connections between the topics of geothermal energy, governance and policy are relevant and that there is a need for knowledge in this area. However, it should be noted that the interviewees could have a certain bias, since they are often consultants in the field of geothermal energy. Finally, the limitation of the document analysis is that things may have been presented too rosy and negative aspects may have been omitted from the analyzed plans. In addition, there is also a possibility that the interviewees consciously or unconsciously make things look too rosy, in that respect the saturation that occurred after a few interviews is also a valuable fact.

5.3.3 SUGGESTIONS FOR FURTHER RESEARCH

This research has a very strong explorative approach and is therefore also a first indication of how geothermal energy is currently being governed, where there are gaps in this governance and how policy instruments can remedy these gaps. There is still a lot of room for further research.

A first suggestion is to investigate another geographical RES region in which geothermal projects have already taken place, in order to make better generalizations and test the operational framework. These studies can then be compared with each other and the different cases can learn from each other. It will also be valuable to do a comparative study, in order to be able to compare with a region where less geothermal projects are being developed. Furthermore, this study showed that the application of geothermal energy in the built environment still has many complexities. A suggestion is therefore to specifically focus on one geothermal case applied to the built environment and scrutinize and analyse the governance aspects, specific experienced barriers and facilitators in order to start learning. Finally, the data collection revealed that various policy instruments and institutional frameworks are being revised and adapted at the time of writing. It will be of added value if these have been in place for a considerable time, to do the research again to compare the results and conclusions.

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APPENDICES

APPENDIX A – METHODOLOGICAL APPROACH

Research question	Information to gather	Moment of collection	Method/ source	Documentation method	Data analysis
Main research question: *How is the planning and development of geothermal energy projects in RES region Rotterdam-Den Haag influenced by policy instruments within the context of contemporary energy governance in the Netherlands?*					
SQ1: *What does the exploitation of geothermal energy entail, what are contemporary trends in energy governance, and how can the concept of policy instruments be defined, and subsequently operationalized to contribute to the exploitation of geothermal energy?*	- Insights in contemporary position of geothermal energy in the energy transition and energy governance - Literature on barriers and drivers of successful geothermal exploitation - Definition and operationalization of policy instruments	Writing of theoretical framework from week 4, onwards	Academic literature review. Search engines: Scopus, Google Scholar, SmartCat	In the theoretical framework of the thesis. - E.g. conceptual model - Operationalization of policy instruments for exploiting geothermal energy	Reading literature and documents and critically comparing and discussing the findings.
SQ2: *What are current policy goals that apply to RES region Rotterdam-Den Haag and how are geothermal energy projects in RES region Rotterdam-Den Haag affected by policy instruments?*	- Aims and ambitions regarding geothermal energy - Experiences and insights on the policy instruments influencing geothermal energy development in the Rotterdam-Den Haag RES-region - Governance with regard to geothermal energy. Will provide information on current context: possibilities and barriers,	Data collection SQ2: In week 10-22	- Review energy policy documents - Interview relevant experts → semi-structured interviews	- Describe information gathering in thesis chapter 'Methodology' - Interview recordings and transcripts will be archived on a password secured cloud. - The results are discussed in thesis chapter 'Results'	- Policy documents analysed with deductive code tree (based on operationalisation) and inductive coding - Interviews analysed same way and by means of coding system in ATLAS.TI

	decision-making.				
SQ3: *What lessons can be learned from RES region Rotterdam-Den Haag regarding the position of geothermal energy in contemporary energy governance?*	- Generalisations on policy instruments for geothermal energy development and exploitation	Analysing data: In week 21-22	Previous gathered information: - Theoretical framework - Coded (policy) documents - Coded interview transcripts	- Drawn lessons will be documented in thesis chapters 'results' and 'conclusion'	Critically discussing findings and formulate an interpretation based on academic literature and empirical data.

APPENDIX B – INTERVIEW GUIDE

Context interview

Bedankt dat u wilt meehelpen aan het onderzoek door mee te doen aan dit interview. Het doel van dit interview is om inzicht te krijgen in de stremmende en bevorderlijke beleids- en governance condities voor de implementatie van geothermie projecten en om te onderzoeken welke beleidsinstrumenten positief kunnen bijdragen aan de -versnelde- exploitatie van geothermie in Nederlandse energie regio's. Ik zag dat [naam instantie/bedrijf/partij] ook werkzaamheden heeft/betrokken is in de geothermiesector in het geografisch gebied van RES-regio Rotterdam-Den Haag, dat is de focus regio in mijn onderzoek. Dit onderzoek doe ik voor mijn masterscriptie van de studie Environmental & Infrastructure Planning aan de Rijksuniversiteit Groningen. Alles wat u in dit interview benoemt zal alleen gebruikt worden voor het onderzoek. U heeft al het online toestemmingsformulier ingevuld en u gaat ermee akkoord dat er een audio-opname van het interview wordt gemaakt. Het interview zal ongeveer een uur duren. Heeft u nog vragen voordat we beginnen aan het interview? Dan beginnen we eerst met een aantal algemene openingsvragen.

Introductie

- Zou u uzelf willen voorstellen? (functie, werkzaamheden)
    - Wat is uw rol binnen (het beleidsveld van) de geothermie sector?

Governance context geothermie

- Zou u kunnen ingaan op de -in uw optiek- huidige status van de geothermie ontwikkelingen in het casus gebied?
    - Wat zijn ervaren barrières bij de ontwikkeling van projecten?
    - Wat zijn ervaren bevorderlijke omstandigheden bij de ontwikkeling van projecten?
- Wat zijn de huidige doelen en ambities met betrekking tot geothermie in het case gebied?
- (*Multilevel governance)* In hoeverre is er interactie en samenwerking tussen verschillende overheidslagen bij geothermie projecten? Hoe ervaart u deze interactie?
- (*Decentralization)* Waar (welke partij/overheidslagen) gebeurt de -doorslaggevende- besluitvorming betreffende daadwerkelijk uitvoering van geothermieprojecten doorgaans?
- (*Forms of partnership)* Met wie wordt er wanneer en op welke manier regelmatig samengewerkt door uw organisatie?

Op basis van literatuur onderzoek zijn beleidsinstrumenten -als middel om de energietransitie/hernieuwbare energie te stimuleren- onderverdeeld in 5 categorieën: *1) wet-/regelgevingsinstrumenten, 2) economische/fiscale instrumenten, 3) op overeenkomsten gebaseerde/samenwerkingsinstrumenten, 4) informatie/ op communicatie gebaseerde instrumenten, 5) kennis- en innovatie-instrumenten.* Ik zal nu graag per typologie dieper ingaan op hoe beleid heeft bijgedragen aan de ontwikkeling van geothermie projecten en welke actoren daarbij een leidende rol speelden.

Beleidsinstrumenten

Legislative/regulatory instruments

- Welke wet- en regelgeving is/zijn van invloed op de geothermie ontwikkelingen? (zoals…*geef indien nodig voorbeelden uit literatuur)*
    - Werken deze bevorderlijk of juist niet bij het behalen van ambities en doelen op het gebied van geothermie?
- Is er behoefte aan meer ondersteunende wet- of regelgeving? Waarom?

Economic/fiscal instruments

- Welke economische en fiscale instrumenten zijn van invloed op de geothermie ontwikkelingen? (zoals…*geef indien nodig voorbeelden uit literatuur: e.g. subsidies: SDE++)*
    - Werken deze bevorderlijk of juist niet bij het behalen van ambities en doelen op het gebied van geothermie?
- Is er behoefte aan andere ondersteunende economische en fiscale stimulansen? Waarom?

Agreement-based instruments

- Bestaan er bepaalde verbanden/samenwerkingen tussen partijen op vrijwillige basis beruste overeenkomsten en afspraken in de geothermie sector? (zoals…*geef voorbeelden uit literatuur: e.g. convenanten, afspraken, publiek private samenwerkingen)*
    - Werken deze bevorderlijk of juist niet bij het behalen van ambities en doelen op het gebied van geothermie?
- Is er behoefte aan meer op overeenkomsten gebaseerde/samenwerkingsinstrumenten? Waarom?

Information/communication based instruments

- Wat is het belang van de inzet van informatie en communicatie voor geothermie ontwikkelingen?
    - Welke instrumenten worden daarvoor gebruikt? (zoals…*geef voorbeelden uit literatuur: e.g. publieke informatie campagnes)*
    - Werken deze bevorderlijk of juist niet bij het behalen van ambities en doelen op het gebied van geothermie?
- Is er behoefte aan meer op informatie en communicatie gebaseerde instrumenten? Waarom?

Knowledge and innovation instruments

- Zijn er bepaalde initiatieven -wellicht geïnitieerd door meerdere partijen- in de geothermie sector die als doel hebben te sturen op kennisdeling en het bevorderen van innovatie, welke zijn dat? (e.g.: workshoppen, het dele van goede ervaringen, uitwisseling tussen meerdere partijen)
    - Werken deze bevorderlijk of juist niet bij het behalen van ambities en doelen op het gebied van geothermie?
- Is er behoefte aan meer kennis- en innovatie-instrumenten? Waarom?

Afsluitend

- Waarom is denkt u binnen de geografische RES regio Rotterdam-Den Haag al meer aandacht voor geothermie dan in andere regio's in Nederland?
- Wat zijn volgens u lessen die geleerd kunnen worden van al uitgevoerde (of juist (nog) niet doorgevoerde) geothermie projecten? (lessen voor de toekomst)
- Wilt u nog wat toevoegen aan het interview?
- Kent u nog andere personen die bereid zouden zijn om mee te werken aan dit onderzoek?
- Wilt u een exemplaar van de uiteindelijke scriptie ontvangen?

Hartelijk dank voor het interview.

APPENDIX C – DOCUMENT ANALYSIS

Document	Page	Text quote	Gathered information
RES Directive 2018/2001 – European Union	L328/83	Member States should take additional measures in the event that the share of renewable energy at Union level does not meet the Union trajectory towards the renewable energy target of at least 32 %.	Set target/ aim/ ambition
REPowerEU Plan – European commission	7	De Europese Unie moet ernaar streven de huidige inzet van afzonderlijke warmtepompen te verdubbelen, met als resultaat in de komende vijf jaar in totaal 10 miljoen installaties. De lidstaten kunnen de inzet en integratie van grootschalige warmtepompen, aardwarmte en thermische zonne-energie op kosteneffectieve wijze versnellen door: - de ontwikkeling en modernisering van stadsverwarmingssystemen die fossiele brandstoffen voor particuliere verwarming kunnen vervangen; - schone gemeentelijke verwarming, vooral in dichtbevolkte gebieden en steden; - de exploitatie van industriële warmte wanneer deze beschikbaar is.	Aim/ ambition
	12	Om het tekort aan vaardigheden aan te pakken, zal de Commissie: - belanghebbenden bij de productie van hernieuwbare energie (zon, wind, aardwarmte, biomassa, warmtepompen enz.) en vergunningverlenende instanties stimuleren om een grootschalig partnerschap voor vaardigheden op te zetten in het kader van het pact voor vaardigheden	Aim/ ambition
Masterplan Aardwarmte in Nederland – EBN, GeothermieNL, DAGO	31	Om de juiste stappen te zetten om deze vraag te leveren, hebben we een ambitie gesteld voor 2030 (50 PJ) en voor 2050 (200+ PJ). Om dit te bereiken is het onder andere nodig de ondergrond te verkennen, de bovengrondse vraag structureel in kaart te brengen en het ondergronds aanbod optimaal te benutten (bijvoorbeeld door middel van cascadering tussen de verschillende eindgebruikers).	Aim/ ambition
	150-151	De geothermiesector heeft zich via het Masterplan reeds gecommitteerd aan een opschaling van geothermie in zowel de glastuinbouw als de gebouwde omgeving. De sector zet zich daarbij in voor verdere kostenreductie, het ontwikkelen van een (aard)warmte propositie met warmtebedrijven, het verbreden van de basis en het verder professionaliseren van de sector over de gehele waardeketen en het zorgen voor een lokaal en regionaal maatschappelijke dialoog over aardwarmte in de context van de energietransitie.	Aim/ ambition
Klimaatakkoord – Dutch Cabinet	147	Bestaande en nieuwe geothermiebronnen en andere lokale warmtebronnen worden stapsgewijs in een warmte distributienet aan elkaar gekoppeld en verbonden met de (rest)warmtesystemen vanuit de Rotterdamse haven en de gebouwde omgeving in Westland en Midden Delfland	Aim
	151	De Rijksoverheid intensiveert de inzet op geothermie gericht op het wegnemen van knelpunten in de wet- en regelgeving en door uitvoering van een missiegedreven kennis- en innovatieprogramma gericht op risicobeheersing in de exploitatiefase, professionalisering van de sector, bevordering van standaardisatie, kennis van de ondergrond (seismiek) en een kostenreductie van 50 %. Ook handhaaft de Rijksoverheid de RNES garantieregeling en de SDE+-regeling voor deze techniek	Aim
	151	Streven is de realisatie van 35 extra projecten in de periode t/m 2030.	Ambition
Beleidsbrief Geothermie – Ministry of Economic affairs and Climate (2018)	4	Het potentieel van de ondiepe en ultradiepe ondergrond is nog moeilijker in te schatten. UDG wordt in Nederland namelijk nog niet toegepast en er zijn op deze diepte weinig data beschikbaar uit olie- en gasexploratie. Binnen de Green Deal ultra diepe geothermie zal een aantal consortia samen met Energiebeheer Nederland (EBN) het geothermiepotentieel van de diepere aardlagen verder gaan onderzoeken middels een geïntegreerd exploratie-programma. Ik heb uw Kamer hierover op 19 juni 2017 (Kamerstuk 33043, nr. 72) geïnformeerd.	Instruments
	5	Stichting Platform Geothermie (SPG) opgericht, een non-profit organisatie die de toepassing van geothermie bevordert. Leden	Instruments

		van het platform zijn initiatiefnemers en opdrachtnemers van geothermieprojecten, maar ook diverse decentrale overheden, kennisinstellingen en energiebedrijven. Vanuit de sector wordt, in nauwe samenwerking met mijn ministerie, ook nagedacht over de vormgeving van de publiekscommunicatie. Daarmee speelt SPG een belangrijke rol bij het versnellen van de ontwikkelingen in de geothermiesector. Om de bijdrage van SPG, bijvoorbeeld waar het gaat om kennisontwikkeling, ook in de toekomst te bestendigen bekijk ik of een overheidsbijdrage aan SPG daarbij behulpzaam kan zijn.	
	6	De operators hebben zich in 2014 verenigd in de brancheorganisatie DAGO (Dutch Association Geothermal Operators) met onder meer als doel om kennis, kunde en ervaring uit te wisselen en gericht te komen tot innovatie.	Instruments
	7	Voor een versnelling van de groei van het aantal geothermieprojecten is ook een belangrijke rol weggelegd voor de decentrale overheden. Zij hebben taken bij de advisering over de vergunningverlening in het kader van de Mijnbouwwet en zijn leidend in het omgevingsbeleid op regionale en lokale schaal. In dat kader ontwikkelen decentrale overheden een visie op het benutten en beschermen van de ondergrond en een visie op de lokale en regionale invulling van de energietransitie. Dat proces is nog volop in ontwikkeling. Daarnaast spelen de decentrale overheden een belangrijke rol in het creëren van draagvlak onder de bevolking bij de energietransitie. Een groot aantal heeft ambities op het gebied van geothermie, maar beschikt nog over onvoldoende kennis en ervaring om hun rol goed te kunnen spelen.	Governance/ instruments
	6	De Regeling Nationale EZ Subsidies (RNES) Aardwarmte ondervangt het risico bij een boring. De regeling werkt als een verzekering met een marktconforme premie: levert de boring teleurstellende resultaten op, dan keert de regeling tot 85% van de gemaakte boorkosten uit. Een belangrijke eis voor deelname is dat het productievermogen waarop de garantie wordt geboden met relatief veel zekerheid (90%) wordt ingeschat	Instruments
	17	De Mijnbouwwet is gericht op de opsporing en winning van delfstoffen, aardwarmte en de opslag van stoffen in de bodem. De vergunningenstructuur die de huidige Mijnbouwwet voor de winning van aardwarmte voorschrijft, is identiek aan die voor de winning van delfstoffen: eerst wordt een opsporingsvergunning verleend, vervolgens een winningsvergunning en de winning moet plaatsvinden volgens een door mij goedgekeurd winningsplan. Aangezien de opsporing en winning van aardwarmte in technische zin veel gelijkenissen vertoont met de opsporing en winning van delfstoffen, leek dit in eerste instantie een logische aanpak. Toch leert de ervaring met de eerste geothermieprojecten dat de huidige reguleringssystematiek onvoldoende aansluit bij de specifieke kenmerken van geothermie.	Instruments
	19	• Continuïteit van kennis en ervaring; • Vergroten kennis van de ondergrond; • Innovatie.	Policy goals
Beleidsbrief Voortgang Geohtermie – Ministry of Economic affairs and Climate (2021)	1	Met deze wetswijziging [Mijnbouwwet] introduceer ik een eigenstandige methode van regulering en vergunningensystematiek voor geothermie. Snelle inwerkingtreding van deze wetswijziging is zowel vanuit het oogpunt van versterking als versnelling van groot belang en ook de sector wacht hier met veel smart op. Om te voorkomen dat een geothermieproject na de boring lange tijd stil komt te liggen is, tot inwerkingtreding van de wetswijziging voor geothermie, een tijdelijk beleidskader van toepassing dat zoveel mogelijk aansluit bij de nieuwe systematiek.	Policy goals and instruments
	1	Door het ministerie van Economische Zaken en Klimaat (EZK) gefinancierde Seismische Campagne Aardwarmte Nederland (SCAN) programma, genomen. Hiermee wordt de geschiktheid van de Nederlandse ondergrond voor geothermie in beeld gebracht. Daarnaast zijn er extra categorieën voor geothermie aangebracht in de Stimuleringsregeling duurzame energieproductie (SDE), is er mede op basis van de Kennis & Innovatie Roadmap Aardwarmte (KIRA) expliciete ruimte voor innovatie op het gebied van geothermie in de meerjarige missie	Instruments

		gedreven innovatie programma's (MMIP's). Ook wordt de risicodragende deelname van Energie Beheer Nederland (EBN) in geothermie projecten geëffectueerd. Deze heeft als doel om de leercurve binnen projecten, en de overdracht van kennis en ervaring tussen projecten te vergroten, om zo bij te dragen aan de versnelling van betere geothermie projecten.	
	2	Tot slot is met ondersteuning van EZK door TNO, de provincie Zuid-Holland, de gemeente Rijswijk en EBN, het testcentrum 'Rijswijk Centre for Sustainable Geo-energy (RCSG)' opgezet.	Instrument
Beleidsbrief Stimulering duurzame energieproductie – Ministry of Economic affairs and Climate (2019)	3	Om EBN risicodragend te laten deelnemen, moet EBN een wettelijke taak krijgen op het gebied van geothermie. Dit wordt geregeld via een wijziging van de Mijnbouwwet. Die zal op zijn vroegst in 2020 in werking kunnen treden. Tot die tijd kan de Minister van EZK op grond van de Mijnbouwwet EBN toestemming geven om zich met de genoemde geothermie-activiteiten bezig te houden. Vooruitlopend op deze wijziging van de Mijnbouwwet, zal ik EBN op grond van artikel 82, derde lid, van de Mijnbouwwet, dan ook toestemming geven om zich bezig te mogen houden met activiteiten die gericht zijn op geothermie. Totdat de Mijnbouwwet hiervoor is gewijzigd (eind 2020) kan dit op vrijwillige basis, wat betekent dat het aan de initiatiefnemer is om EBN te verzoeken deel te nemen.	Instrument
Potentieel Geothermie – Province of Zuid-Holland	5	De provincie wil bijdragen om het hoge potentieel van aardwarmte in Zuid-Holland zo duurzaam en efficiënt mogelijk te benutten. Hierbij heeft ze de ambitie om in 2020 9 petajoule (PJ) aan duurzame warmte te leveren, waarvan uit geothermie 5 – 7 PJ.	Ambition
Visie Aardwarmte – Province of Zuid-Holland	1	De provincie Zuid-Holland heeft de ambitie om in 2050 klimaatneutraal te zijn. Daarnaast gaan we van het aardgas af; een enorme opgave ligt voor ons om de gebouwde omgeving, de glastuinbouw en de industrie anders te verwarmen.	Ambition
	1	Hierin is echter ondiepe en ultradiepe aardwarmte nog niet meegenomen, maar bekend is dat de potentie hiermee omhoog zal gaan. Om te komen tot 25-40 PJ aan aardwarmte in 2040 is er een visie en een plan van aanpak nodig zodat de ontwikkeling van aardwarmte in Zuid-Holland op een veilige en verantwoorde manier kan versnellen en opschalen.	Ambition
Warmteplan Anders Verwarmen – Province of Zuid-Holland and Geothermal branche	16	**Domein** / **Ambitie** Gebouwde omgeving: Energievoorziening in 2035 CO_2-neutraal. Industrie: Herontwerp van industriële processen d.m.v. innovatie. Glastuinbouw: In 2050 is de gehele glastuinbouw CO_2-neutraal. Productie van Duurzame Energie: Elke kansrijke innovatie wordt toegepast.	Ambition
RES Rotterdam-Den Haag 1.0 – consortium of government parties within region	40	We willen de warmtevraag verkleinen door woningen en gebouwen te isoleren en we willen optimaal gebruikmaken van de regionaal beschikbare warmte. De aanleg van een regionaal warmtetransportnet maakt het lokaal uitrollen van warmtenetten mogelijk, ook op plekken waar onvoldoende lokale warmte beschikbaar is. Door gebruik te maken van industriële restwarmte voorkomen we dat energie wordt 'weggegooid'. Zo vergroten we de energie-efficiëntie. Het op grotere schaal inzetten op warmtenetten maakt ook de inzet van geothermie makkelijker. Warmteprojecten worden alleen gerealiseerd als de publieke belangen (betaalbaarheid, rechtvaardigheid, betrouwbaarheid, duurzaamheid en vertrouwen) zijn geborgd	Ambition
Transitievisie Warmte Den Haag (concept) – Municipality Den Haag	13	De aarde onder Den Haag bevat warmte in diepe aardlagen, oftewel aardwarmte. Uit de ondiepe aardlagen is ook warmte te halen, oftewel WKO. In stadsdeel Zuidwest aan de Leyweg is al een eerste aardwarmtebron en er worden meer aardwarmtebronnen ontwikkeld. In het Westland zijn veel aardwarmtebronnen voor agricultuur in kassen die mogelijk warmte aan Den Haag kunnen leveren	Ambition
	10	We streven naar een klimaatneutrale stad in 2030. Het is in grote delen van de stad haalbaar om gebouwen op duurzame bronnen voor verwarming aan te sluiten of de besluiten daarover te hebben genomen. In andere delen van de stad is nu nog niet duidelijk welke warmteoptie goed past.	Ambition
Transitievisie Warmte Rotterdam – Municipality Rotterdam	13	Ook geothermie is in de Rotterdamse regio voldoende in potentie aanwezig. Dat is belangrijk, want voor een robuust en betrouwbaar warmtesysteem is het belangrijk om meerdere bronnen te gebruiken voor de voeding van warmtenetten.	Insight

APPENDIX D – CODE BOOK

Code Group	Code	Sub-categories	Inductive/ deductive
Policy goal	Ambition		
	Aim		
Governance structures	Multi-level governance		
	Decentralization		
	Forms of partnerships		
Policy Instruments	Regulatory and legislative instruments	Standards, laws and rules	Deductive
		Monitoring/ Auditing	Deductive
		Renewable portfolio standards	Deductive
	Economic and fiscal instruments	Subsidies	Deductive
		Loans	Deductive
		Insurances	Inductive
		Investing parties: state owned party EBN	Inductive
	Agreement-based instruments	Public-private agreements	Deductive
		Stakeholder partnerships/ agreements	Deductive
	Information and communicative instruments	Public information campaigns	Deductive
		Professional training	Deductive
	Knowledge and innovation instruments	Communities of practice	Deductive
		Living labs	Deductive
		Workshops	Deductive
		State owned party to enhance knowledge sharing	Inductive
		National Seismic research (SCAN)	Inductive
		Periodic reportss	Inductive

APPENDIX E – INFORMED CONSENT FORM

Geachte deelnemer,

Allereerst, bedankt voor het deelnemen aan mijn onderzoek. Dit onderzoek richt zich op het bestuderen en inzichtelijk maken van welke beleidsinstrumenten kunnen bijdragen aan de -versnelde- exploitatie van geothermie in Nederlandse energie regio's. Voordat het interview begint, zou ik u graag willen wijzen op de volgende informatie.

- Uw privacy is en blijft maximaal beschermd. Er wordt op geen enkele wijze vertrouwelijke informatie of persoonsgegevens van of over u naar buiten gebracht, waardoor iemand u zal kunnen herkennen. Om uw privacy te waarborgen in de publicaties van dit onderzoek zal een pseudoniem in de vorm van de functie die u bekleedt en/of de organisatie waarvoor u werkt worden gebruikt, bijvoorbeeld 'beleidsadviseur energie bij de gemeente .....'.
- Tenzij hier expliciet toestemming voor is gegeven zal er geen persoonlijke informatie gedeeld worden in het onderzoek, zoals geslacht of leeftijd.
- U kun uiteraard op elk moment het interview stoppen. Ook kan u een vraag niet beantwoorden, als u dat niet wil.
- Mocht u hier behoefte aan hebben, dan kan er een kopie van het interview worden opgestuurd, en kunt u hier nog aanpassingen aan maken.
- Van het interview zal een audio-opname worden gemaakt, zodat het gesprek later kan worden uitgewerkt. Dit transcript wordt vervolgens gebruikt in de data analyse.
- De informatie die u geeft in het interview zal alleen worden gebruikt voor dit onderzoek, dat uiteindelijk wordt gepubliceerd op de online scriptiedatabase van de Rijksuniversiteit Groningen. Deze website is openbaar toegankelijk. De volledige uitwerking van het interview zal niet openbaar toegankelijk zijn. Verder kunnen de resultaten gebruikt worden voor een presentatie die wordt gegeven tijdens de Graduation Research Day.

Als deelnemer heeft u de volgende rechten:

- Stop of pauzeer de opname of het interview op elk moment
- Een vraag niet beantwoorden
- Zoveel vragen stellen over het interview als u wilt
- De onderzoeker vragen om het interview of delen hiervan te verwijderen tot publicatie

Kruis de volgende punten aan indien u ermee akkoord gaat:

Ik ben me bewust van mijn rechten en geef toestemming om het interview op te nemen: JA ☐
Ik geef toestemming tot gebruik van (geanonimiseerde) citaten in de thesis: JA ☐

Mijn naam: _____

Handtekening: _____