The strategic investment decision

Developing a framework to assess strategic investment options in the geothermal industry in the Netherlands

MSc thesis Lilian Maat
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Preface

This report is the end result of my Master Systems Engineering, Policy Analysis and Management (SEPAM) at Delft University of Technology (TU Delft). The research is conducted in collaboration with TAQA Energy B.V, who sponsored this research and, therefore, provided me with the opportunity to combine this research with an internship.

As a SEPAM student you are regularly challenged to quickly find your way in a new field of study, often in complex socio-technical systems with a multi-actor setting. After six months of hard work I must admit that this project was the biggest challenge faced up to now. Without much knowledge on either strategy or the geothermal industry I started this journey. After my kick-off meeting I immediately jumped into the field by accomplishing many interviews in the geothermal industry. It was great to experience the willingness from all interviewees to tell me everything about geothermal energy, the projects and their successes and failures. Even though it was a hassle to get to the right place sometimes, it provided me to become acquainted with the sector very quickly and I am very grateful for the open and interesting conversations I had with all of my interviewees.

After these empirical experiences, I focused on theory. It was an incremental journey to get to the right definitions and examples. I truly enjoyed this and discovered that I am really interested in the theories I used. I am convinced that these strategy related theories will prove to be of value in my professional career. However, without the help and support of many people, my theoretical understanding and the resulting report would not have become what it is now. First of all, I would like to thank my graduation committee from the TU Delft: Rob Stikkelman, for providing me with lots of ideas and being honest with me when needed; Aad Correljé, for the theoretical advice and ideas at any time and any location; and Paulien Herder, for the constructive feedback and availability for questions when needed. Second, I would also like to thank all people at TAQA who participated in the evaluation workshop and supported me during the research, and especially Bas Froon who was my external supervisor. You made me focus on the key message of my research and helped me to get this message across. I really enjoyed my time at TAQA, mainly because of the friendly working atmosphere. Last but not least, I would like to thank family, friends and all others who helped me during the last six months, either academically or at times I needed distraction. I truly appreciated it.

Unfortunately, an end to my student life has come with this report. It was a great pleasure to study in Delft and I would like to thank everyone for this fantastic experience.

Lilian,
August 2013
Executive summary

Research problem
Deep geothermal energy gained more and more attention in the Netherlands over the past few years. It is a renewable energy source with limited air emissions and it can provide reliable base-load power. Since 2007 eight installations were built and more than hundred exploration permits were approved by the Dutch authorities. Many energy firms are looking for new business opportunities and might also see the potential of the geothermal industry. However, the geothermal industry is a nascent market in an early stage of formation. It is not clear which activities are present in the geothermal industry and what investment options are available for energy firms. Will it be beneficial to combine these activities or is it better to specialize in only one activity? Moreover, there are large differences between geothermal energy and other renewable and non-renewable sources of energy. For example, the application of geothermal energy is often direct and on a decentralized level, like houses or greenhouses, and firms do not know if these characteristics fit their strategy. Do they have the resource and capabilities, like technological equipment, knowledge, experience and relations to perform activities in the geothermal industry?

Several theories provide an explanation for the strategic investment decisions made by firms to perform activities in an industry. Transaction cost theory argues that a firm’s strategic investment decision is driven by efficiency, to minimize transaction costs between firms. In contrast, the resource-based view argues that this decision is based on the resources and capabilities a firm possesses in order to gain a competitive advantage. The third theory, named resource dependence theory, argues that investment decisions are driven by power, in order to minimize dependence and maximize organizational autonomy. Empirical research shows that transaction cost theory is most useful in markets with stable industry structures. The resource-based view fits well in dynamic competitive environments with high technological uncertainty. Resource dependence is most relevant in oligopolistic and ambiguous markets. However, which of the theories is important when assessing strategic investments in the geothermal industry? The theories poorly explain the factors that underlie a firm’s decision to execute certain activities in a nascent market that is in an early stage of formation, while clarity of role and purpose is crucial for survival in a new market.

This research addresses these issues. Should energy firms invest in the geothermal industry and if so, what strategic investment options are available and which should they choose? Therefore, the main research question of this research is as follows:

*How can energy firms be supported in assessing strategic investment options in the geothermal industry in the Netherlands?*

Research approach
Theory shows three different views on how to assess strategic investment options: transaction cost theory, the resource-based view and resource dependence theory. They might function in addition to each other. Therefore, criteria from all theories are taken into account in this research. A theoretical framework is constructed in which characteristics of all three theories are combined. This framework is a starting point for the strategic investment framework that can be used by a firm to compare and assess different strategic investment options, so to help them in their decision-making process.

Next, this theoretical framework is applied to the geothermal industry by using a case study and evaluated at TAQA Energy B.V. (TAQA). Ten interviews are carried out to find out what strategic investment options are available in the geothermal industry and if the theoretical criteria are of importance in this industry. At TAQA an evaluation workshop is held to discuss the importance of all
theoretical criteria and a survey is done to test if the framework is able to do what it is aimed for. With these empirical findings the strategic investment framework is developed.

**Empirical findings**

The case study shows that every strategic investment option has two dimensions: the stage of integration and the breadth of integration. The stage of integration is the step in the value chain in which the firm is active, depicted by the blue and yellow boxes in Figure 1-a. As shown, there are two value chains in the geothermal industry: the heat value chain and the power value chain. The breadth of integration dimension encompasses the activities within a step of the value chain, as depicted by the purple boxes. This includes four activities: investing, operating, project management and retail. Every activity could be performed solely or in combination with other activities.

![Figure 1-a: Overview of activities that can be performed in the geothermal industry](image)

At this moment, geothermal facilities in the Netherlands only supply heat. The case study shows that firms in the heat value chain choose for highly integrated strategic investment options. More specifically, they choose to invest and operate in as many steps as possible in the value chain. This is mainly caused by the high level of dependence between the activities in the value chain. Because the heat loss during transportation is high, suppliers of heat are depending on local demand. In combination with high fixed up-front investments local monopolies arise with only one supplier and a small number of consumers. No competitive market exists. Besides, there is a low level of trust between firms and they fear for opportunistic behaviour of partner(s). Therefore, firms try to integrate as many activities as possible.

However, firms do often not possess the resources to perform all activities. Even though these resources are not present, they still choose to perform these activities. Over the years, the regulations on required resources have become stricter and at this moment no horticulturist or municipality can receive a permit to produce heat. Only experienced (oil and gas) firms have the required resources. Unfortunately, these firms are reluctant to invest.

The high level of resource dependence and required resources hampers the development of geothermal heat projects in the Netherlands. Geothermal power is not affected by high levels of resource dependence. However, this technology is still in development, but might become an important renewable alternative for fossil fuels in the future.
In contrast to the geothermal industry that is driven by resource dependence, the resource-based view is of importance when strategic investment options are assessed by TAQA. The evaluation workshop shows that resource overlap between the resources required for an activity and those owned by the firm is the most important criterion when making strategic investment decisions. Strategic investment options that require resources possessed by the firm are chosen because in that way higher rents can be achieved.

As the strategic investment framework will be used by energy firms that consider entering the geothermal industry, resource dependence and resource-based criteria are both included.

**The strategic investment framework**

The strategic investment framework developed in this research is shown in Figure 1-b. The framework consists of three rings that the user must go through from the outer ring towards the inner circle.

![Figure 1-b: The strategic investment framework](image_url)

The outer ring concerns the selection of strategic investment options as the total number of options is too large to take into account. The selection of activities is based on firm preferences. Then, three paths can be chosen. The firm can choose to assess a strategic investment option based on:

- External and internal criteria
- Only relational criteria
- All three types of criteria

Internal criteria look inside the firm. Does the firm have the required resources, for example in terms of technical knowledge, equipment or management skills, to perform the activities included in the strategic investment option? And if not, is the firm able to acquire these resources through learning? External criteria deal with the environment of the firm. Is there a large chance of environmental changes, for example regulatory changes or an economic crisis, when choosing this strategic investment option? Are the activities included in the strategic investment option that depend on other activities in order to succeed? Relational criteria look at the sensitivity of the partner when choosing a strategic investment option.
option, in case a partner is involved. Is there a high level of trust between the firm and the partner(s) in this strategic investment option? Is there a large chance on unexpected behaviour? And is the firm able to learn from the partner(s)? For the relational criteria, knowledge on the relationship with partner firm(s) is necessary. Note that the relational criteria have to be scored for each partner. If all these criteria are defined, the inner circle can be entered in which the criteria are scored on their performance level. The performance level is measured in rent and risk. What is the chance that a strategic investment option will deliver high rents to the firm? And what are the risks accompanying this strategic investment option? These risk and rent levels will be displayed with the use of colours. Green stands for a chance on high rent or low risk and red stands for a high level of risk or low rent. The output of the framework is an overview of the different strategic investment options scored on every criterion. These scores are displayed with use of a scorecard shown in Table 1-a.

<table>
<thead>
<tr>
<th>External criteria - risk</th>
<th>Resource dependence</th>
<th>Environmental uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal criteria - rent</td>
<td>Physical resources</td>
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<td>Learning</td>
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<td>Relational criteria – rent and risk</td>
<td>Learning</td>
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<td></td>
<td>Trust</td>
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<tr>
<td></td>
<td>Behavioural uncertainty</td>
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</table>

Table 1-a: Scorecard assessment framework

Conclusion

This research connects practice—the geothermal industry, which is still immature, very cooperative and under development—with the theoretical concepts from transactions cost theory, the resource-based view and resource dependence theory. The strategic investment framework is the result of the research and answers the main research question: How can we support energy firms to assess strategic investment options in the geothermal industry in the Netherlands? It is concluded that the strategic investment decision is depending on several factors and that different factors are important in different firms and environments. It appeared that resources are especially important in competitive markets, in which TAQA is currently active, while resource dependence is important when firms do not directly compete, which is the case in the geothermal industry. Transaction cost theory might be important in mature markets and did not prove to be of high value for the geothermal industry or for TAQA. The framework includes criteria resulting from all three theories in order to support firms in assessing strategic investment options in different environments.
Recommendations for the strategic investment framework

The framework developed in this research is based on theory and empirical findings. However, it has not been extensively tested in practice yet. To be able to use the framework in practice, testing is needed to enlarge reliability and validity of the framework. When the framework is tested by energy firms in the geothermal industry and appears to be valid, it may be possible to apply the framework to other firms and other industries. This way, it is possible to discover the framework’s applicability in a broader environment and it might be possible to develop a general assessment framework for firms’ strategic investment options.

Recommendations for future theoretical work

The assessment criteria are based on the three theoretical views. These are not always competing. In some situations, criteria reinforce each other. For example, the impact of environmental uncertainty is much larger when high levels of resource dependence exist. Both theories underlying these criteria could be broadened using each other’s characteristics. There might even be a possibility to develop a symbiotic theory that is applicable to different markets, nascent or more developed, in which transaction cost theory, the resource-based view and resource dependence theory are combined. In this way, a general theory of strategic investment decisions can be developed instead of using a different theory in a different situation. Future research should investigate these possibilities.
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Part I: Introduction
Introduction
1 Introduction

Cause
As fossil fuel sources are depleting and the climate starts to change, the focus is slowly shifting to renewable energy. Even though renewables will account for almost one-third of total electricity output in the world by 2035, the average global temperature increases in the long-term with 3.6 °C due to (carbon) emissions (IEA, 2012). Timely action is needed. One of the renewable sources that can provide a solution is geothermal energy because it is a renewable source with limited air emissions and it can provide reliable base-load power (Gonzales, 2013; Kagel & Gawell, 2005).

Geothermal energy can be used to supply heat or power. Temperatures around 60 °C to 70°C can be used for direct heating. Water from aquifers is pumped through a heat exchanger to transfer the heat energy from the produced water to water in a (district) heating network. When temperatures above 90 °C are present, the heated water or steam can be used for power generation in a steam turbine. Because geothermal energy is such a suitable source of renewable energy, the geothermal industry in Europe experienced significant growth in the last decades. Especially in Italy, Iceland and Turkey, where the subsurface conditions are excellent to produce geothermal energy (EGEC, 2012), the industry grew significantly.

Furthermore, over the last ten years, other countries with less suitable subsurface conditions also experienced high levels of growth (EGEC, 2012). For example the Netherlands, where geothermal energy serves as a substitute for gas heating in residential and commercial areas and in the horticultural industry. One of the main advantages of geothermal energy is that the costs of geothermal energy are relatively low compared to other renewable energy sources. As depicted in Figure 1-a, the costs of geothermal heat are estimated around 11 euro/GJ, while solar, wind and biomass are much more expensive.

Geothermal WKK is combined heat and power produced by geothermal sources. Costs for this kind of energy are higher because deeper wells ought to be drilled to reach a suitable water temperature and the efficiency of converting heat to power is low. However, the costs are still lower than many other renewable technologies. Therefore, geothermal energy is a promising renewable energy source that can provide a solution to the well-known problems accompanying fossil fuels.
Problem

Even though geothermal energy has many advantages, there are some challenges to be overcome. The geothermal industry is not a mature market, but a nascent business environment in an early stage of formation. Therefore, several firms that can play a role in this industry, like oil and gas firms, do not know if they should enter the geothermal industry, and which activities they should perform. Nascent markets are difficult to assess because there is no clear view of the firms that will be present, there is no clear view of the policy framework in place, and the technology is still under development. For example, it is unknown which firms would make suitable customers, partners, competitors or suppliers. Many different firms and organizations are active in the geothermal industry, like national and regional governments, horticulturists, geological consultants, drilling managers, energy firms, distribution firms and residents, who all hold different opinions of geothermal energy. In addition, to explore for and produce geothermal energy in the Netherlands, a permit is required. Currently, there are around 100 exploration permits granted (NLOG, 2013). Although this number indicates a high level of popularity, it contrasts with the number of operating facilities, which is only eight. After exploration of the subsurface, many projects turned out to be unfeasible. The reservoir characteristics are often not well-suited to produce geothermal energy. Another reason is the evolution of the safety regulations (Rijksoverheid, 2013a). These regulations have changed over the past years and became stricter. Many firms that would like to be active in the geothermal industry, like horticulturists, do not have the expertise required by the Ministry of Economic Affairs and they often do not have the financial abilities to hire experts to provide this expertise (van Heekeren, 2013). Furthermore, it is difficult to specify costs, dependence relationships and required competencies in nascent markets (Bingham, Eisenhardt, & Davis, 2007; Rao, 1994). Geothermal revenues are low compared to oil and gas exploration, while costs are similar. The application of geothermal energy is often direct and on a decentralized level, like nearby houses or greenhouses. This is a major difference with the oil and gas industry, which is centralized and coordinated by a small number of firms.

Many characteristics of the geothermal industry are uncertain and complex which causes firms not to know whether these characteristics fit their strategy. It is not clear which activities are required in the geothermal industry and what activities should be performed by which firm. Examples of activities are financing the geothermal facilities, operating the geothermal wells, distribution of heat, marketing of heat and more. Will it be beneficial to combine these activities and provide several activities to the geothermal industry? Moreover, firms do not know if they have the capabilities, in terms of physical assets, like technical equipment, and human and organizational capital, like knowledge, experience and relationships, to perform activities in the geothermal industry.

Several theories provide an explanation for the strategic investment decisions made by firms to perform activities in an industry. Transaction cost economics is one of the most important theoretical works to be applied to geothermal energy. It argues that a firm’s strategic investment decision is driven by efficiency, to minimize transaction costs between firms (Williamson, 1975). In contrast, the resource-based view argues that this decision is based on the resources and capabilities a firm possesses in order to gain a competitive advantage (Barney, 1991). A third theory, named resource dependence theory, argues that investment decisions are driven by power, in order to minimize dependence on other firms and maximize organizational autonomy (Johnson, 1995). Apart from their contrasting views, these theories do a poor job in explaining the factors that underlie a firm’s decision to execute certain activities in a nascent market, while clarity of role and purpose is crucial for survival of the firm in a new market (Santos & Eisenhardt, 2009). Therefore, this research project aims to answer the following question: “How can energy firms be supported in assessing strategic investment options in the geothermal industry in the Netherlands?”

To answer this question, theory is explored. In addition, a case study on the geothermal industry, in combination with an evaluation of an oil and gas firm, TAQA, is performed. More specifically, a
theoretical assessment framework that could support firms will be developed and evaluated empirically, with findings from the geothermal industry, and practically, with findings from TAQA. Then, a strategic investment framework is developed to support firms in their decision-making process. Research like this can improve the academic understanding of strategic investment decisions and can help firms to make these decisions in the geothermal industry.

**Structure**
The report consists of four parts:

- **Part I** introduces the research
  - Chapter one is the introduction of the research.
  - Chapter two discusses the research problem, objective and research approach. Furthermore, the research questions are presented. These questions are answered in the subsequent chapters.

- **Part II** consists of the theoretical grounding for the framework.
  - Chapter three is a theoretical section on strategic investment decisions.
  - Chapter four investigates the theories underlying these decisions and their characteristics.
  - Chapter five presents the theoretical framework.

- **Part III** applies the theoretical framework to the geothermal industry.
  - Chapter six introduces the geothermal industry.
  - Chapter seven elaborates on the strategic investment decisions that are made in the geothermal industry and the reasons for these decisions.
  - Chapter eight evaluates the framework with a workshop and survey that was done within TAQA.
  - Chapter nine presents the final assessment framework.

- **Part IV** consists of the discussion, conclusion and reflection.
  - Chapter ten elaborates on the theoretical discussion and discusses the framework
  - Chapter eleven concludes the report.
  - Chapter twelve reflects on the design process.
2 Research approach

As mentioned in the introduction, this research project looks into the strategic investment decision of a firm. In this chapter, the research objective, scope, questions and strategy will be explained.

2.1 Research objective and deliverables

Up till now, literature on strategic investment decisions poorly explained why and how firms choose to execute activities in nascent markets (Santos & Eisenhardt, 2009). Only theory that takes into account mature markets with clear industry structures is amply defined. Therefore, the scientific research objective is to contribute to the scientific literature that provides insight into firm’s strategic investment options and the decision-making process in nascent markets. This is done by confronting it with an empirical case on the geothermal industry and evaluation at an oil and gas firm. This will improve understanding of strategic investment decisions and could support firms during decision-making. The societal research objective is then to make recommendations regarding the assessment of firm’s strategic investment options in the geothermal industry in the Netherlands.

The expected deliverable will be a framework that could be used as a support tool during the firm’s decision-making process to enter a new market. The framework’s objectives are:

- **New business development**: The framework should provide insight in which assessment criteria are important when making a strategic investment decision
- **Investment option comparison**: The framework should provide insight in how to assess and compare alternative strategic investment options

2.2 Scientific relevance

The research is of scientific value because it combines three theories with different views in one framework, which shows the applicability of these theories to strategic investment decisions in the geothermal industry. In addition, as the geothermal industry is a nascent market, the findings might be applicable to a broader field of study than only the geothermal industry. This will be reflected upon in chapter 10. Furthermore, the research will improve the understanding of the dynamics of the decision-making process of a firm regarding strategic investments and the distribution of their activities in the geothermal industry.

2.3 Societal relevance

The societal relevance of this research lies in the information that will be collected on the geothermal industry. It will show how firms in this industry make decisions and which factors are influencing the decision-making of strategic investments. This will bring more transparency to the geothermal industry which is not extensively studied yet. It could lead to more geothermal initiatives. Furthermore, the relevance lies in the framework. Firstly, it will give insight in the strategic investment options in the geothermal industry and the criteria that could be used to select a strategic investment option. Secondly, it could support firms that want to participate in the geothermal industry and are not sure what activities they should carry out.

2.4 Research scope and assumptions

There are different types of geothermal energy. The two most common types today are shallow and deep geothermal energy (Platform Geothermie, 2013d). Shallow geothermal energy is exploration and production of heat up to 500 meters. A wide-used application of shallow geothermal energy in the
Netherlands is a geothermal heat pump (CBS, 2012). Deep geothermal energy is exploration and production of energy over 500 meters. In practice, deep geothermal energy is exploited from about 1500 meters, because heated water from this depth can be used directly without the use of heat pumps. In contrast to shallow geothermal energy, deep geothermal energy is covered by several regulations, like the Mining Law (in Dutch: Mijnbouwwet) and environmental permits. A third type of geothermal energy is an enhanced geothermal system (EGS). In very deep reservoirs, over 4000 meters, water might be present at temperatures that can be used to drive a steam turbine. However, at these depths the water is locked in impermeable rocks. There are many uncertainties involved as relatively few drilling operations have been executed deeper than 5000 meters and technology is not proven yet (Lako, Luxembourg, Ruiter, & in 't Groen, 2011). In this research only deep geothermal energy will be taken into account. Furthermore, the entire value chain of the geothermal industry is considered, from the production of heat up to the end use of heat or power.

Depending on the depth of the well the energy could be used for different markets. Existing facilities in the Netherlands are all exploited for heating purposes. A large share of all exploration permits, around 90%, are targeted at greenhouses because their heat demand is large and concentrated in a relatively small area (Platform Geothermie, 2013b). Others apply to district heating for households. A small number of exploration permits consider power generation from geothermal sources, because this might be feasible in the Netherlands as well. Furthermore, a more innovative way of heat use is the production of cool air. Wang et al. (2012) show that geothermal heat of 70 to 100 degrees can be used in an absorption air-conditioning system. However, this technology is very immature. In this research only geothermal heating and geothermal power production are taken into account.

The perspective taken in this research is that of an energy firm. An energy firm could be defined as a gas- and oil firm like TAQA or a utility firm like Eneco. Furthermore, the research focuses on the Netherlands only.

### 2.5 Research questions

The main research question that follows from the research problem is:

**How can energy firms be supported in assessing strategic investment options in the geothermal industry in the Netherlands?**

To answer this question, several sub-questions are defined. The research is structured to answer these questions.

#### Theoretical grounding

Much research has been performed on various theoretical concepts that touches upon strategic investment decisions (Coase, 1937; Penrose, 1968; Santos & Eisenhardt, 2005; Williamson, 1975). However, the concepts do not provide a univocal definition. The first step is to define a theoretical concept that can be used for the notion of a strategic investment option and strategic investment decision. The second step is to explore theories that can be used to assess a firm’s strategic investment decision. Then, criteria are defined and a theoretical framework is developed that will be used as a support tool.

1. What defines a firm’s strategic investment decision?
2. Which theoretical constructs should be considered to assess firm’s strategic investment options?
3. What theoretical framework can be designed to assess firm’s strategic investment options?
Empirical grounding
The theoretical framework will be applied to the geothermal industry. This way, the criteria can be evaluated on the basis of industry characteristics. Furthermore, the framework will be discussed during an evaluation workshop and survey at TAQA, an oil and gas firm. With these empirical findings, the final strategic investment framework is designed.

4. What strategic investment options are available for energy firms in the geothermal industry?
5. On basis of which criteria are strategic investment decisions made by firms in the geothermal industry?
6. Which criteria are used by TAQA to assess strategic investment options?
7. Is the framework useful to assess energy firm’s investment options compared to the requirements of the framework?
8. How can the framework be operationalized on the basis of findings from the geothermal industry and the evaluation findings?

Discussion
After the design of the framework, the framework and the theories used are discussed. Conclusions can be drawn regarding the tool and recommendations for further research are indicated.

9. Are the theories used to construct the theoretical framework suitable to assess strategic investment options of a firm?

2.6 Research strategy
To answer the research questions, the research is divided into several phases, which can be found in the flow diagram displayed in Figure 2-a. According to Verschuren and Doorewaard (2003) there are five types of research strategies: survey, experiment, case study, history and desk research. The choice for one of these strategies is depending on three key decisions. The first decision is whether the research will have a breadth or a depth view, because there is a trade-off between breadth and depth. If breadth is preferred, the approach will enable the researcher to generalize results. However, this will impose limits on depth, complexity and elaboration of the results. On the other hand, if depth is preferred, the knowledge that is gained cannot be generalized in the same way as when a breadth view is used. Nevertheless, the researchers will be able to achieve depth, elaboration and complexity (Verschuren & Doorewaard, 2003). The research will only go into the geothermal industry in the Netherlands, which is a specific field of study. Furthermore, the research will look into specific factors that define strategic investment decisions. Therefore, depth is preferred above breadth. Secondly, it should be decided whether the research will be qualitative or quantitative. As the output of the research is a framework based on theory, a qualitative research method will be more suitable. Qualitative research is explorative of nature and investigates possible causes or influencing factors for attributes or objects (van der Velde, Jansen, & Anderson, 2007). The third decision, which is closely linked to the second question, is if the research will be empirical or non-empirical. As the research will be based on real situations and on literature, the research will have both empirical and desk research strategies.
When taking the above decisions into account, three suitable strategies are available: desk research, case studies and surveys. When using multiple strategies, triangulation can be reached. Triangulation is “a method of cross-checking data from multiple sources to search for regularities in the research data” (O’Donoghue & Punch, 2003). In other words, triangulation aims to increase the validity of the research findings by using different research strategies. Therefore, all three suitable strategies are used, which can be found in Table 2-a.
The first three research questions are based on theory and are answered with a literature study, which is a desk research strategy. Literature on transaction cost economics (Leiblein & Miller, 2003; Williamson, 1975, 1979), the resource-based view (Barney, 1991; Mahoney & Pandian, 1992) and resource dependence theory (Johnson, 1995) is used. An explanation on the theoretical choice is provided in chapter three. Questions four and five involve both empirical and non-empirical research. Desk research is used to discuss the geothermal industry in an institutional analysis, which is based on documents of firms, projects and other organizations in the geothermal industry. The ninth and last research question discusses the applicability of the previously mentioned theories which is a desk research strategy as well.

Every research strategy has several advantages and disadvantages that should be taken into account. An advantage of desk research is that it enables the researcher to use large amounts of data quickly. A disadvantage could be that the theory that is used is developed for different purposes than this report intends and this might influence the perspective of the research. For example, the work of Ferrier (2013) focuses on organizational governance structures, which could bias the perspective on the assessment criteria for strategic investment decisions. Therefore, it is important that the literature is critically reviewed to be able to use it in a reliable and valid way.

### 2.7 Desk research

Existing literature focuses mainly on the technological characteristics of geothermal energy and limited research concerning the investment characteristics in the geothermal industry is performed. Therefore, a case study is used to gain insight in the industry as it allows the researcher to gain deep information of the field of study from related stakeholders and experts. Gerring (2004) defined a case study as: “An intensive study of a unit for the purpose of understanding a larger class of (similar) units”. In other words, a case study is an in-depth study of a particular phenomenon which will be generalized to a
larger population. The main unit of analysis is defined as the strategic investment decision of a firm in the geothermal industry.

Case studies are well suited for the inquiry of attitudes, values, beliefs and motives (Barriball & While, 1994). However, it is still important to take into account its disadvantages. Case studies are less favourable because it might have unexpected results that show new directions for research. However, this is also an important advantage as it provides great opportunity for flexibility. In the following paragraphs, the case selection, data collection and interview analysis will be discussed.

**Case selection**

There are different types of case studies of which the single case study and the multiple case study are the most important (Verschuren & Doorewaard, 2003; Yin, 1994). As a case study focuses on depth, only a small number of cases are studied. This entails a risk because it might be possible that only exceptions are studied. To increase reliability, multiple case designs are preferred over single case designs. Furthermore, the case selection process is of high importance.

Two unstructured interviews were carried out to gain a better understanding of the geothermal industry, in particular on the technology and the projects and firms. On that basis, cases are selected for further investigation. Different criteria are defined to select these:

- *Type of consumer*: the cases should focus on different types of consumers to decrease the chance that only a specific type of project is researched. It will increase the generalizability of the cases.
- *Project phase*: the cases should be in the end of the construction phase or in operational phase. A number of geothermal projects in the Netherlands is in an earlier stage and are still under development. However, these cases would not provide a complete overview of the strategic investment options as consequences of the options could not be observed yet.
- *Type of firm(s)*: the cases should focus on different types of firms involved to decrease the chance that only a specific type of firm is researched. This will increase the generalizability of the cases.

This resulted in the choice for two projects: A+G van den Bosch and Aardwarmte Den Haag. Both project scores on the criteria are shown in Table 2-b.

<table>
<thead>
<tr>
<th>Selection criteria</th>
<th>A+G van den Bosch</th>
<th>Aardwarmte Den Haag</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of consumer</strong></td>
<td>Greenhouse</td>
<td>Households</td>
</tr>
<tr>
<td><strong>Project phase</strong></td>
<td>Operational - successful</td>
<td>End of execution phase - unsuccessful</td>
</tr>
<tr>
<td><strong>Type of firm(s)</strong></td>
<td>Horticulturists</td>
<td>Energy firms (E-On, Eneco), Housing corporations (Vestia, Haag Wonen, Staedion) and a municipality (of The Hague)</td>
</tr>
</tbody>
</table>

**Table 2-b: Case selection**

**Data collection**

A semi-structured interview approach is chosen to investigate the cases. The interview questions are based on theory and provide a starting point for the interview. These can be found in Appendix B. When research is based on interviews it is a challenge to make the research process both valid and reliable as it depends to a great extent on the methodological skill, sensitivity and training of the researcher (Patton, 1987). Therefore, the findings should be validated. According to Yin (1994) there are three types of validity that should be taken into account when doing a case study: construct validity, internal validity and external validity.

Construct validity can be reached when multiple sources of evidence are used and a chain of evidence is established. Therefore, multiple interviews will be performed with different experts active in
different fields of the geothermal industry, like governmental organizations and operating firms. Written interview transcripts can be found in Appendix B.

Internal validity can be reached by comparing the empirical findings (patterns) with predicted patterns. The predicted patterns can be derived from the theoretical framework. In the case study, the relationships between criteria and the strategic investment options are validated. If these patterns are matching and at the same time no alternative patterns or threads are found, there is a strong case for causal relationships.

External validity concerns the generalizability of the findings. This can be increased by performing multiple cases that could be replicated. Therefore, two cases were chosen. However, it should be noted that the results of a case study alone cannot be generalized to the whole population automatically and will often require further research (Eisenhardt, 1989). Therefore, the survey is used to increase the external validity.

Interview analysis
As said, the unstructured interviews are carried out first. It appears that these interviewees already mention several criteria and factors of importance for the framework. In the semi-structured interviews, theoretical criteria were deliberately discussed. The interviewees all touched upon many similar topics that are of importance in the geothermal industry. Much was said on resources, characteristics that increase interdependency and the regulatory framework in place. Overall, the interviewees were on the same line and little differences were identified. Written transcripts can be found in Appendix B.

2.9 Survey

Besides desk research and a case study, a survey is performed to increase the validity of the research findings. A survey allows to generate particular data without much effort, which could be compared easily. Furthermore, it could balance the disadvantages of a case study as surveys and case studies are opposites in many aspects (Verschuren & Doorewaard, 2003). This way, triangulation is used, which increases the validity of the research as well.

The sixth and seventh research question will look into the strategic investment decision process of TAQA and will be answered with the survey. The focus of the survey will be twofold. Firstly, the framework is evaluated on content in an evaluation workshop in which the criteria are surveyed. Are the right criteria included in the framework and are these criteria normally used by energy firms in their decision-making process? The theoretical framework is used as logic model and is explained during the workshop. In addition, a semi-structured interview approach, based on the framework content, is used. The workshop is organized with TAQA employees from the business development section because these employees are normally involved in the strategic investment decision. The workshop protocol can be found in Appendix E.

Secondly, the working of the framework will be surveyed with the use of a questionnaire on the requirements which are defined during the framework design. What do framework users think of the usability of the framework? How do they assess the framework on the basis of the requirements? Both surveys are performed within the TAQA firm with business people from business development. A disadvantage of the small sample size is that it decreases the reliability of the results. However, this is inevitable due to the predefined duration of a graduation thesis and it is recommended to increase the sample size in further research. Both surveys provide input for the validation of the framework. Based on the case study and surveys, the strategic investment framework will be designed.
Part II: Theoretical grounding
Research approach
In this chapter, theory that elaborates on strategic investment decisions and corresponding notions is discussed. To be able to define a firm’s strategic investment decision, it is important to explore what defines strategy. Many scholars and managers researched the topic of strategic management, of which many use the same kind of definition and approach (Whittington, 2001). In short, strategy can defined as “the direction and scope of a firm over the long term (Johnson, Scholes, & Whittington, 2008, p. 3). There are three levels of strategy:

- Corporate strategy, which concerns the overall scope of the firm and how value will be added to the firm’s business units. This type of strategy typically deals with geographical coverage and diversity of products/services (Johnson et al., 2008);
- Business strategy, which is sometimes called competitive strategy and is concerned with how a firm should compete in a given industry and position itself amongst competitors (Andrews & David, 1987). This type of strategy typically deals with topics as pricing strategies, innovation and differentiation;
- Operational strategy, which concerns how the firm’s components meet corporate and business strategies in terms of resources, processes and people (Johnson et al., 2008).

When a firm assesses its opportunities to enter the geothermal industry, all three strategic levels are touched upon. Firstly, the corporate strategy to enter the geothermal industry. Is there sufficient potential in this market? Secondly, the business strategy which discusses the firm’s position within the value chain of the industry. How should we enter the market? And finally, how to allocate resources in order to optimize the firm’s profitability? To answer these strategic questions, a framework will be developed in the following chapters to support firms during the strategic investment-decision process. This process will be discussed in the following section.

### 3.1 Strategic investment decision-making

The strategic investment decision is part of a decision-making process within a firm. At the beginning of this decision-making process, a firm has different strategic investment options (SIO’s) to choose from. When one of these options is selected, a strategic investment decision is made. A strategic investment decision is defined as the final allocation of activities and their transactions.

To elucidate the definition of a strategic investment decision, examples are shown in Figure 3-b. This figure shows examples of firm’s strategic investment decisions in different colours. Examples of activities in the geothermal industry are operating the geothermal well, selling the heat to end users or owning the power production facility. The transaction is the physical flow of goods like heat, power or consumer products and the monetary transaction that flows in return. The transactions between firms are depicted by the arrows. The dashed arrows indicate an internalized transaction that is dealt with within a firm. As can be seen, a firm could decide to perform one activity or more. One firm could
perform different activities, so the firm’s strategic investment decision could be different for every industry and project. Furthermore, one firm can perform multiple activities in the industry. It must be emphasized that the transaction with the other firms that perform activities is also part of the strategic investment decision. For example, in the first configuration, firm 2 is interacting with firm 1 and firm 3. In the second configuration three activities are part of the firm and only one transaction with another firm should be performed. Every activity requires resources and capabilities. When a firm decides to perform these activities, the activities should match the firm’s capabilities.

Figure 3-b: Similar firms can make different strategic investment decisions

Traditionally, theory on integration shows two SIO’s: the classic make-or-buy choice (Coase, 1937). The make decision indicates that the firm chooses to integrate the function and execute the activity themselves. The buy choice indicates that the activity is outsourced and obtained in the market. In practice, other modes of integration are seen as well (Parmigiani & Mitchell, 2009). Therefore, Harrigan (1984) defined four dimensions of integration:

- Stages of integration: the activities in the value chain, from raw material production to end user.
- Breadth of integration: the number of activities at a particular stage in the value chain
- Degree of integration: the proportion of the total output that a firm or business unit purchases or sells to another firm or business unit.
- Form of the integration: the type of contract in terms of control or equity.

Furthermore, much literature that goes into strategic investment decisions touches upon the decision-making process (Butler, Davies, Pike, & Sharp, 1991; Dobrajska, 2010; Papadakis, 1998). Several steps can be defined which are depicted in Figure 3-c. The figure shows that part of the process is a process within the firm and the other part is an inter-firm process, which requires interaction with partner firms. It must be noted that the sequential fashion of the figure indicates that the strategic decision-making process is a static process in which steps are linear. This is not the case in practice. These processes overlap and different steps interact and earlier decisions might be adapted because of decisions in later steps. This makes the decision-making process a dynamic, complex and iterative process.
When looking at the four dimensions identified by Harrigan (1984), the strategic investment decision includes two dimensions. Firstly, the stages of the integration which is the selection of an activity in a market. Secondly, it includes the breadth of integration in which the number of activities. In Figure 3-c this is displayed as one step, namely the selection of activities. The other two dimensions of integration are not included in the strategic investment decision as they concern a subsequent step in the decision-making process and require interaction with a partner, for example to design a contract.

Strategic decision-making and the purpose of these decisions can be viewed from different perspectives and have different consequences for strategic management. The main strategy perspective is the neoclassical view, which is often used in strategic management literature. The neoclassical perspective on strategy is presented by scholars like Ansoff (1965, 1991) and Porter (1980, 1985), who approach strategy as a rational planning exercise. A contrasting view on strategy is the institutional perspective in which the transaction cost theory introduced by Williamson (1975) is leading. Two other theories on strategy are the resource-based view introduced by Penrose (1968) and resource dependence theory introduced by Thompson (1967). All theories are explored in the following section in order to define the main perspective of this research project.

### 3.2 Contrasting perspectives on firm strategy

When looking at the neoclassical perspective, Porter (1980) argues that every firm has a competitive strategy in order to create value. In his book ‘competitive strategy’ Porter introduces a framework that helps analyse an industry and understand a firm’s position in that industry. According to this view, strategy is about positioning the firm at the right place in the chain of supplier-firm-customer within an industry. When the environment is known, firms are able to predict the outcomes of their actions on the basis of these industry characteristics. It is assumed that the market works perfectly. As a result, a manager can make the right decisions when he has all information about the industry. This view has been a great contribution to the strategy of many firms and is still popular.

However, if all information is known and the market works perfectly, why would firms integrate activities within the firm instead of selling and buying them through the market? Arrow (1969, p. 57) states that “the existence of integration may suggest that the costs of operating competitive markets are not zero, as is usually assumed in our theoretical analysis”. This statement is in line with transaction cost theory. Coase (1937) was the first scholar to propose this theory when he questioned the boundaries of the firm. Later on, Williamson (1975) reformulated this boundary problem by focusing on the minimization of transaction costs between firms. A transaction occurs “when a good or service is transferred on a technologically separable interface” (Williamson, 1981). The costs of such a transaction could be the resources utilized for the creation, maintenance, use, and change of institutions and firms. It is assumed that it is nearly impossible to be fully informed and that actors are bounded in rationality (Williamson, 1975). For example, a contract could be incomplete due to uncertainties in the environment which enlarge the chance of redesign of the contract. Integration could then result in cost reduction and maximization of efficiency.
However, if integration reduces transaction costs, why are not all firms fully integrated and why are some activities still organized through the market in reality? According to Leiblein (2003), transaction cost theory has been developed and tested under assumptions that ignore the influence of a firm’s existing resources and capabilities and implicitly assumes that every firm is identical in terms of resources. This results in similar conclusions on integration for firms that have similar transactional attributes. However, when comparing integration decisions in the industry, it appears that there are large differences between firms with a similar set of transactional attributes. It is important that not only transaction cost characteristics are considered, but also resources and capabilities of a firm (Leiblein & Miller, 2003; Parmigiani & Mitchell, 2009). As Helfat and Peteraf (2003) define: “a resource refers to an asset or an input in production that a firm owns, controls or has access to on a semi-permanent basis”. Barney (1991) argues that the competitive advantage of a firm derives from heterogeneity in resources between firms. More specifically, a competitive advantage can be created when a firm possesses a specific resource which another firm does not possess. Therefore, a strategic investment decision should be made that maximizes the value of the firm’s resource portfolio (Santos & Eisenhardt, 2005). In light of the integration discussion this could mean integration or outsourcing, depending on the resource base of the firm.

In summary, transaction cost theory and the resource-based view both disagree with the assumptions underlying the neoclassical view on strategy. The difference between the two is that transaction cost theory is externally focused and aims for efficiency and cost minimization of transactions, while the resource-based view is focused internally and aims to enlarge the firm’s competitive advantage through resources and capabilities. If both views focus in the opposite way, can they function in addition to each other? According to Mahoney and Pandian (1992) the resource-based view and transaction cost theory are linked; as resource combinations are influenced by transaction cost economizing. In other words, the choice to perform certain activities depends both on resources and on transaction characteristics of that strategic investment decision. Therefore, the resource-based view and transaction cost theory both provide means to assess strategic investment decisions in the geothermal industry.

Recently, Ferrier (2013) researched these two theories to develop a framework to support decision-making regarding organizational governance structures, which are used to manage and control organizational relationships. In Ferrier’s work, the resource-based view was extended with, or actually replaced by, resource dependence theory. This theory argues that the market would be simple if every firm would have complete control over its own resources. However, no firm is completely self-contained and firms are dependent on each other’s resources (Pfeffer & Salancik, 1978). An example is the interdependence between a supplier and its consumer. Therefore, firms must transact with other firms to acquire these needed resources. It is interesting to note that dependence can be perceived as the opposite of power. When firm A is depending on firm B, firm B has power over firm A. As a result, resource dependence creates asymmetric exchange and power relationships between firms, which are often unstable (Pfeffer & Salancik, 2003). Therefore, according to resource dependence theory, the aim of firms is to increase organizational autonomy and decrease dependence in asymmetric power relationships. In relation to strategic investment decisions, resource dependence can enhance integration as this will increase a firm’s autonomy. Therefore, resource dependence also seems a useful theory to assess SIO’s.

It is important to note that the goals of the three theories are different. Transaction cost theory aims for efficiency by cost minimization, the resource-based view aims for a competitive advantage by possessing unique resources and resource dependence theory aims for organizational autonomy by decreasing dependence. An overview is shown in Figure 3-d.
Other theories
The theories applied in this research are transaction cost theory, the resource-based view and resource dependence theory. Whittington (2001) argues that all strategic decisions are in fact investment decisions. Therefore, many financial techniques were developed within the neoclassical perspective of strategy, like corporate finance. These financial calculations are often an important issue when choosing to enter a new market. However, the strategic investment decision is a decision on a high level in which specific projects are not selected yet. Therefore, no specific investment figures are known and, for example, NPV calculations will be difficult to make. Furthermore, transaction cost theory and the resource-based view rely on efficiency and competitive advantage, which indicate an underlying cost motive. Therefore, criteria from the corporate finance domain are not taken into account.

3.3 Strategic investment decisions and firm performance
To assess SIO’s and compare them, the effect of a strategic investment decision on firm performance can be used. However, much research is done on the factors that drive strategic investment decisions, but the link between this decision and firm performance is not researched by many scholars (Mullainathan & Scharfstein, 2001). How can one assess if competitive advantage, efficiency or autonomy has a positive effect on firm performance?

Let us go back to the aim of strategy in the first place. As was already stated, every firm has a competitive strategy in order to create value. But how can value be measured and when does a strategic investment decision create value? According to Amit and Zott (2001) value refers to the total value created in a market regardless of who appropriates this value. When exploring value, one should realize that there is a difference between value creation and value capture. Value creation can be defined by the opportunity space that creates value by reconfiguring business processes. So, the value ‘pie’ will increase. For instance by setting up a new project that adds value for all firms in the industry, both to buyers and suppliers. Value capturing on the other hand, is to capture a large part from this value ‘pie’ (Freeman & Liedtka, 1997). In this view, a strategic investment decision would only increase performance when it manages to capture value from the market.

Value capture can be defined as the creation of rent for a firm (Mahoney & Pandian, 1992). Firms earn rents for different reasons. For example by luck, collusion with competitors or the possession of unique resources (Montgomery & Wernerfelt, 1988). This last class of rents are called Ricardian or economic rents. Economic rents arise from unequal access to or control over resources. This way, a firm has some kind of ‘monopoly’ position for a certain product and the firm could choose to supply less in order to increase the price. Scarcity is created and the firm creating this scarcity gains the surplus of the
Theory on strategic investment decisions

scarcity. This often happens when new combinations or conditions are created that provide greater returns than the costs of innovation (Kaplinsky & Morris, 2001). Furthermore, the rents will only be earned when the innovation is not copied yet. In other words, rents will evolve when a firm is able to produce more cheaply or at a higher quality than competitors, while these competitors are not able to copy this efficient production or quality, so the market price remains equal. An example of rents is a monopoly or oligopolistic position of a firm in a market. The price is kept much higher than the actual production cost. The price stays high because only a small number of firms possess the resources (in terms of technology, skills etc.) to be active in this market. These firms earn the rents created by this market imperfection.

However, earning rents is not without risk. To capture value on firm level, value should be created first (Pitelis, 2009). This means that another firm could capture the created value. These risks exist because of industry characteristics or the characteristics of the firm. For example when large dependencies between firms are present, the risk that value is captured by another firm increases (Freeman & Liedtka, 1997). Therefore, the strategic investment decision will create rents, but is also concerned with risks. In this research it is assumed that the purpose of strategic investment decisions is to create as much value as possible, while risks should be minimized. As a result, every strategic investment option entails a chance of rent and a level of risk, which defines the suitability and the strategic character of the decision (see Figure 3-e).

![Figure 3-e: Every strategic investment option entails a chance of rent and a level of risk](image)

**Rent**

It is important to bear in mind that rent is relative and only has meaning when it is used in comparison to competitors (Kaplinsky & Morris, 2001). Therefore, the performance of other firms should be included in the assessment. Three categories of rents were defined by Kaplinsky and Morris (2001): internal, relational and external generation of rent. The firm itself can construct internal generation of rent. These internal rents often exist because a firm possesses certain resources or capabilities that a competitor does not have. There are five types of internal rent.

**Internal rents**
- Technology rents - having command over scarce technologies
- Human resource rents - having access to better skills than competitors
- Organizational rents - possessing superior forms of internal organization
- Marketing rents - possessing better marketing capabilities and/or valuable brand names
- Natural resource rents - access to scarce natural resources
External rents can be earned because of a competitive advantage over competitors created by external factors, such as the policy framework in a country. There are three types of external rent.

**External rents**
- Policy rents - operating in an environment of efficient government; constructing barriers to the entry of competitors
- Infrastructural rents - access to high quality infrastructural inputs such as telecommunications
- Financial rents - access to finance on better terms than competitors

Relational rents should be constructed in cooperation with other parties and can be earned when these relationships have certain advantages in contrast to the relationships that competitors have. There are two types of relational rent.

**Relational rents**
- Relationship rents - having superior quality relationships with suppliers and customers could decrease operational costs
- Spill over rents - having good relationships, knowledge will spill over from one firm to the other

Internal and external rents could be specified before a partner is selected in an early time of the process. When a specific partner is selected, relational rents can be assessed as well. Therefore, the assessment framework should consist of two parts: one in which strategic investment options are assessed on internal and external rents and one in which strategic investment options are assessed on relational rent.

It is important to emphasize that rents are dynamic. Existing areas of rent will disappear because of competition, while new rents will evolve over time. This dynamicity means that the framework should have an iterative character which is frequently updated and the strategic course ought to have a dynamic character.

**Risk**
In general, risk is defined as probability times impact. In other words, the chance that the project outcome is different than expected. This comes down to project failure, lower profits or bad relationships with partners. Risk can be classified in different categories. There is a difference between performance risk and relational risk. The distinction between these two types of risk is a crucial one as both types have different consequences for strategy decision-making (Das & Teng, 2001). Performance risk is defined as the chance that a performance target is not achieved, for example by a lower price or a lower volume of sales. Relational risk is the chance that a firm which whom you cooperate will behave differently than expected, which could result in an unsmooth collaboration between firms (Das & Teng, 1996). Ferrier (2013) specified these two categories of risk in seven risk types. Performance risk consists of profit risk, product risk and resource risk. Relational risk consists of interface risk, spill over risk, hold-up risk and competitor risk.

However, some of the risks that Ferrier (2013) defined appear to be redundant. Product risk concerns the successfulness of a product in terms of market adoption and quality of the product. This type of risk thus influences the sales volumes. However, this is also covered by profit risk, because when sales volumes are down, profits will decrease as well. Therefore, product risk is not taken into account. Furthermore, interface risk concerns the interface between the resources of the firms. This risk will increase when resources and processes of the firm and the partner do not match or if there are many partners involved. In other words, if many transactions are included in the strategic investment decision, interface risk increases. However, this could lead to a large chance of spill over to other firms, or high contracting costs which could influence profit risk. Therefore, interface risk is redundant with spill over
The risks used in this research project are specified below.

**Performance risk**
- Profit risk - risk that the profit decreases because of an increase in costs or decrease in revenues. Both are relying on sales volumes, market price and production costs of the product.
- Resource risk - risk that resources are lost. A loss of an employee with valuable knowledge can be such a risk.

**Relational risk**
- Spill over risk - risk on leakage of valuable information to the partner.
- Hold-up risk - risk that the partner does not make the necessary investments required for the project. For example investments that secure efficient and effective processes.
- Competitor risk - risk that the firms become competitors instead of partners.

Similar to rents, the two categories of risk are applicable to different steps of the decision-making process. Performance risk is assessed first as this risk category is mainly dependent on factors that are not specific to the relationship, while relational risk is assessed subsequently, when information on the partner is available.

### 3.4 Conclusion

In this chapter, literature underlying strategy and the strategic investment decision is researched. This way, the first research question can be answered: “What defines a firm’s strategic investment decision?”. The strategic investment decision includes the selection of an activity in a market (stage of integration) and the choice for the number of activities to be performed (breadth of integration). It should be noted that the strategic investment decision is not a static decision, but part of a dynamic decision-making process. This increases the complexity of the decision-making process.

Many theories are going into strategy and have different explanations on what factors underlie a strategic investment decision. Three of them will be used in this research project to support firms in their decision-making process in the geothermal industry. These are:

- Transaction cost theory, which aims to minimize of transaction costs to gain maximum efficiency;
- Resource-based view, which aims for a maximized competitive advantage by possessing scarce and unique resources and capabilities and;
- Resource dependence theory, which aims at maximizing organizational autonomy in order to decrease dependence.

Every strategic investment option entails its own rent and risk profile on which it can be assessed. This profile defines the suitability and the strategic character of every available strategic investment option. In the next chapters, a theoretical framework is designed that is able to define these rent and risk profiles for every strategic investment option. This way, firms can be supported during their strategic investment decision-making process.
4 Towards a theoretical assessment framework

In the previous chapter it was determined that transaction cost theory, the resource-based view and resource dependence theory can be used to assess strategic investment options (SIO’s) and make a strategic investment decision. In this chapter, each theory will be explained further and constructs of each theory will be made operational to be able to use them as assessment criteria in the framework.

4.1 Transaction cost theory

Williamson based his transaction cost theory on two assumptions. The first is bounded rationality, which could be described as firms that are neither very rational, nor irrational in their behaviour (Williamson, 2010a). The consequence is that all contracts are incomplete and subject to renegotiation (Leiblein & Miller, 2003). Furthermore, firms could behave opportunistic. Opportunism could be regarded as “self-interest seeking with guile” (Williamson, 1991, p. 79). Even when a contract is concluded, a firm could behave differently in its own interest. Bounded rationality and opportunism cause that transaction costs are hard to define, monitor and enforce. The aim of transaction cost theory is to minimize these transaction costs.

For each transaction the most efficient strategic investment option should be selected in order to minimize the costs of the transaction (Williamson, 1985). However, this shows that transaction cost theory focuses on separate transactions with one partner firm. In practice, multiple partners with multiple transactions can be involved. It is unknown what the effects of multiple activities and transactions are on the decision-making process.

Characteristics of transaction cost economics

Transactions have three core characteristics which can be used to assess each SIO. These are asset specificity, uncertainty and frequency (Williamson, 1979, 1985, 1991). Assets are valuable parts of the firm, for example technical equipment, but also human and organizational skills of employees. Asset specificity is described as “the degree to which durable transaction-specific investments are incurred” (Williamson, 2010a). In other words, how specific or customized are the assets needed for the transaction? Asset specificity can have different forms, namely; physical, site, human and dedicated asset specificity (Ferrier, 2013; Williamson, 1975). If asset specificity is high, transaction costs increase and the risk that partner firms will behave opportunistically is severe (Leiblein & Miller, 2003). Therefore, it is more likely that a firm includes these highly asset specific activities in the strategic investment decision (Williamson, 1991).

There are two types of uncertainty, behavioural uncertainty and environmental uncertainty (Ferrier, 2013). Behavioural uncertainty is related to opportunism of a partner firm which can result in unexpected actions. Environmental uncertainties are changes in the environment which can influence the transaction, for example policy changes or fluctuating demands. In general, when uncertainty of a transaction is high, it is more likely that a firm integrates (Williamson, 1979).

Frequency is defined as the recurrence of transactions. When firms are often involved in transactions with each other, less risk accompanies this long-term relationship. When frequency is high, integration is less likely.

The traditional view of Williamson suggests that asset specificity is one of the most important characteristics of transactions and that this characteristic mostly influences a firm’s SID. However, empirical research reveals different outcomes. Leiblein and Miller (2003) show that both asset specificity and uncertainty do not have a direct significant effect on integration. Only when both uncertainty and asset specificity are high, integration is a more favourable structure. For example, when it is likely that supplier contracts should be renegotiated under conditions of high asset specificity. But there have also been a number of studies showing that if there is uncertainty in demand or supply, part
of the production is outsourced as this creates flexibility (Harrigan, 1985; Milgrom & Roberts, 1990). It is unclear what the effects of uncertainty and asset specificity are. It seems that other factors are influencing the results as well. Therefore, this relationship and other factors accompanying it will be investigated in the case study on the geothermal industry that is discussed in chapter 7.

4.2 Resource-based view

Resources are divided into four types (Barney, 1991; Johnson et al., 2008):

- Physical resources, such as the physical technologies used in a firm, its access to raw materials and production capacity.
- Human resources, such as training, experience, judgment, and intelligence of employees.
- Organizational resources, such as informal relationships, formal and informal planning etc.
- Financial resources, such as capital, cash, debtors and creditors, and suppliers of money like banks.

The basic assumption that underlies to the link between resources and competitive advantage is heterogeneity of resources. Resource-based theory assumes that these heterogeneous resources may not be perfectly immobile and difficult to trade. This could make heterogeneity long lasting (Barney, 1991). A disadvantage of this immobility is that it is difficult to diversify into activities in which the firm is not specialized. For example when resources are not used to their full capacity and could be used for other activities. This is the so-called ‘Penrose-effect’: “there is a virtuous circle in which the process of growth necessitates specialization but specialization necessitates growth and diversification to fully utilize unused productive services” (Mahoney & Pandian, 1992; Penrose, 1968). If a strategic investment decision is made that does not take into account the heterogeneity and immobility of resources, this could be disadvantageous for the competitive advantage of the firm.

Resources as such cannot be used as a source of rent (Barney, Wright, & Ketchen, 2001). Therefore, they must be strategic. There are four characteristics of strategic resources: heterogeneity of resources, imperfect mobility, ex post limits to competitions and ex ante limits to competition (Peteraf, 1993). Ex post limits to competition means that the heterogeneity is not short-lived and is durable in the long term. Furthermore, there should also be ex ante limits to competition (Peteraf, 1993). In other words, there must be limited competition for that competitive position up front.

Resources and capabilities

Many researchers argue that there is a difference between resources and capabilities, but that they are closely linked (Helfat & Peteraf, 2003; Makadok, 2001; Winter, 2000). According to Helfat and Peteraf (2003) a capability refers to “the ability of a firm to perform a coordinated set of tasks, utilizing resources, for the purpose of achieving a particular end result”. In other words, every firm has several resources of which a couple are capabilities. According to Makadok (2001) capabilities have two key characteristics that differ from resources: capabilities are firm-specific and the primary purpose of a capability is to enhance productivity of the other resources of the firm.

Helfat and Peteraf (2003) argue that the resource-based view is not static, but dynamic. Both resources and capabilities evolve and change over time. This is in line with Teece and Pisano (1994) who constructed a dynamic capabilities framework. They argue that to determine a firm’s dynamic capabilities there are three categories to distinguish: processes, positions and paths. Managerial and organizational processes are the routines in which things are done in a firm and patterns of learning in the firm. Position is the current ability or quality a firm has in the terms of technology or intellectual property, but also in the field of customer base and relations with suppliers. Lastly, paths are strategic
options that are available and the attractiveness of chances that lie ahead. In addition, the three categories all have their own components which are:

- Processes
  - Integration
  - Learning
  - Reconfiguration and transformation
- Positions
  - Technological assets
  - Complementary assets
  - Financial assets
  - Locational assets
- Paths
  - Path dependencies
  - Technological opportunities

The components of processes and paths can be used to assess SIO’s. It is important to note that the components change over time and this can affect the rents and risks associated with an SIO. This makes the decision-making process of a firm a complex task.

Empirical research shows that firms that have greater experience with particular technologies are more likely to internalize these activities as they could increase their competitive advantage and increase the chance of rents. On the other hand, when firms have much experience with outsourcing, they are also more likely to outsource (Leiblein & Miller, 2003). This shows that experience with previous strategic investment decisions also influences new strategic investment decisions. In the framework, characteristics from both the resource-based view and dynamic capabilities theory are included as they are both an important driver for competitive advantage.

4.3 Resource dependence theory

Resource dependence theory assumes that every firm is depending on other firms or consumers and that no organization is self-sufficient. Furthermore, it assumes that resources are not equally divided and that power relations emerge. This results in a need for inter-firm exchange of resources (Johnson, 1995).

Resource dependence could be identified by a number of factors. Firstly, resource dependence increases when resources are more important for the operations of the firm. One determinant for the importance of resources is the relative magnitude of the resources. When a firm produces only one product or service, it is more dependent on its customers than a firm that produces several products. Similarly, when a firm requires only one input for production, it will be more dependent on suppliers than firms that use multiple inputs. Another determinant of resource importance is the criticality of the input or output to the firm. Criticality shows the ability to function in the absence of the resource, or in absence of the consumer that buys the output (Pfeffer & Salancik, 2003). Secondly, besides the importance of resources, the control over resources is a major determinant for dependence. Only when the importance of the resource is high and the control over resources is limited, resource dependence is high.

Resource dependence theory is supported by empirical work from Dobratska (2010), who shows that wind manufacturers perform highly interdependent activities in-house. However, Jacobides and Billinger (2006) show that there are also ways to decrease interdependence. In their empirical research it appears that firms decrease dependence by increasing the customer base. In other words, the criticality of the resource is decreased.
4.4 Theoretical compatibility

The above sections discussed the three theories separately. However, are they compatible and can they be used in addition to each other? In first instance, they seem distinct as they use different units of analysis: transaction cost theory (TCT) uses the transaction as main unit of analysis, the resource-based view (RBV) focuses on organizational resources and the resource dependence theory (RDT) focuses on organizational relationships.

However, from another point of view, they are related. In comparison with TCT, RDT shifts the focus from discrete transactions to a broader set of strategic relationships. In other words, a transaction is part of the strategic relationship that is used by RDT. In addition, RDT and RBV both focus on resources but in a complementary way, respectively external and internal. Both internal and external resources of the firm are covered when using both theories. Furthermore, compared to TCT, the RBV is based on similar assumptions, like bounded rationality of actors and opportunism (Barney, 2001). This shows that the theories can be used alongside each other to assess SIO’s.

Comparing definitions

Some of the definitions used in the three theories overlap. In TCT, a transaction occurs when a good or service is transferred across a technologically separable interface. Technologies can be seen as the skills, tools and raw materials through which the goods and services are produced and are often called assets. This definition agrees with the definition of resources according to the RBV and RDT. In this sense, resources and assets are similar.

Because assets are similar to resources, the positions used in dynamic capabilities theory are similar to resources. Technological, complementary and locational assets are included in physical capital resources and financial assets are included in organizational capital resources. To prevent redundancy positions are not included as separate concepts in the theoretical framework.

One of the determinants of resource dependence, resource criticality, is similar to the specificity of a resource. Asset specificity is defined as the interdependent relationship between supplier and buyer and exists because the asset is customized and specific for that relationship (Williamson, 2010b). On the other hand, criticality of a resource is defined as: “the ability of the organization to continue functioning in the absence of the resource or in the absence of the market for the output.” (Pfeffer & Salancik, 1978, p. 46). This shows that both asset specificity and criticality are similar concepts. In addition, when the determinants of asset specificity and resource dependence are compared, they have similar elements. Resources are divided into three categories, which are physical, human and organizational resources. Asset specificity can be divided into four categories, namely site, physical, human-capital, and dedicated asset specificity (Williamson, 1979). These categories partly overlap and include the same types of assets or resources. However, resource dependence uses more determinants than only criticality. Besides criticality of the resource, the magnitude of the resource influences resource importance as well. In addition, the control over resources is important. Only when the importance is high and the control over the resource is low, resource dependence exists. This been said, it is assumed that asset specificity is a determinant of resource dependence and that asset specificity only influences the strategic investment decision if the other determinants are satisfied as well. Therefore, in the framework, asset specificity will be considered as determinant of resource dependence.

Competition between theoretical perspectives

Santos and Eisenhardt (2005) argue that when the three theories are compared, their usefulness depends on the type of market. TCT is most useful in markets with a stable industry structure and strong price competition where behavioural uncertainty is high, the RBV is fits well in highly dynamic competitive environments where technological uncertainty is high and RDT is more relevant in oligopolistic, regulated or ambiguous markets where the industry is highly concentrated and overall
uncertainty is high. As a result, the environment determines which aim, either efficiency (TCT), competitive advantage (RBV) or interdependence (RDT), is driving the strategic investment decision-making process.

Furthermore, empirical research shows that in situations where the perspectives directly compete, RDT dominates because dealing with dependence is often more crucial than resource mismatches that limit competitive advantage or efficiency (Santos & Eisenhardt, 2005). O’Mahony and Bechky (2008) and Mayer and Nickerson (2005) both show in their empirical research that when the three theories compete, control is valued most and dependent activities are internalized, regardless of resource-based considerations, and especially in dynamic environments where efficiency may be less relevant. This is also shown by Jacobides and Winter (2007) who conclude that for entrepreneurs in a dynamic market integration because of efficiency is not necessarily optimal. Instead, the focus is on highest cash leverage. However, other empirical research shows contrasting findings, Dobrajska (2010) and Jacobides and Winter (2005) conclude that firms typically integrate in early stages of the industry life cycle and in presence of radical technological change. As technological change stabilizes, firms disintegrate. Besides, the pace of disintegration is moderated by the learning abilities of firms. In an empirical study on wind turbine manufacturers, wind farm buyers gained experience in building wind farms and learned to coordinate these activities (Dobrajska, 2010). In other words, disintegration is decreased because of resources. Even though RDT is dominating, it is unknown which effects, in terms of integration, are caused by this theoretical focus.

Schilling and Steensma (2002) researched that, instead of only competing, the RBV and TCT may also play complementary roles in the strategic investment decision-making process. Firms might pursue a competitive advantage by possessing unique resources, but this uniqueness may also create potential for opportunism. This together with uncertainty heavily influences the governance mode chosen. In short, the RBV is important when selecting activities to perform and TCT better explains the governance mode. Furthermore, empirical research from Jacobides and Winter (2005) show that there are important links between TCT and the RBV and that they cannot be used just as an additive function. Without heterogeneous resources, no transaction cost characteristic will lead to integration.

4.5 Existing framework

Ferrier (2013) uses of TCT, RBV and RDT to examine the organizational relationship between two firms or subsidiaries. This relationship is governed by an organizational governance structure, which consists of a financial structure, a control mechanism and a type of trust. The framework that Ferrier developed is shown in Figure 4-a. Besides the framework, a risk matrix is used to define an organizational governance structure, which is also depicted in Figure 4-a. Characteristics from the market, product & service, resources and actors are defined in the first (outer) layer. These characteristics have influence on the risks that are associated with the organizational relationship, which are defined in the middle layer. Risks are divided into process and output risks. Depending on the level of process risk and output risk (see matrix) an organizational governance structure is advised in the inner layer.
In light of the value creation and capture discussion, the framework developed by Ferrier (2013) is a mean to enlarge value capturing by the structure of the organizational relationship. As was described in chapter 3, Harrigan (1984) showed that there are four dimensions of integration. Ferrier’s framework is mostly concerned with the form of ownership used to control the vertical relationship, which is the last decision of the four. Hence, the strategic investment decision is a preceding step to the definition of organizational governance structures. This been said, Ferrier (2013) assumes that a firm has already chosen to cooperate with another firm, while this is part of the strategic investment decision.

Ferrier (2013) argues that characteristics from the market, product & service, resources and actors that are involved in an organizational relationship define the level of risk that accompanies this relationship. These characteristics are coupled to asset specificity, resource dependence, behavioural uncertainty and environmental uncertainty. As defined in the previous section, asset specificity and resource dependence are similar concepts. As a result, the primary focus of the framework of Ferrier (2013) lies in the theoretical constructs derived from TCT and RDT. Resources and capabilities of the firms involved in the transaction are not identified.

Ferrier (2013) defines the characteristics of the organizational relationship in terms of risk. This is a useful and understandable way of generalizing a large number of characteristics. However, risk is only one part of the story. The benefits of a certain governance structure are not identified. As Ferrier based the framework mostly on transactional constructs, this also shows that TCT is primarily concerned with the drawbacks of a transaction and less concerned with its benefits.

Within TCT, Ferrier (2013) includes the characteristics of asset specificity and uncertainty, but did not consider frequency. However, one of the most important findings of Ferrier’s research is that trust is an important factor that influences organizational governance structures. This factor can be closely linked to frequency as trust increases when firms interact more often. In addition, Leiblein and Miller (2003) conclude in an empirical study that a firm will be triggered to integrate when ex ante small bargaining problems appear and trust decreases. From these findings can be concluded that less integrated strategic investment decisions are made when high levels of trust are present, because it is believed that there is smaller chance that a firm will behave opportunistically (Bradach & Eccles, 1989). Therefore, trust is taken into account in the theoretical framework.

4.6 Observing the theoretical characteristics

The characteristics that were determined in the previous sections are highly abstract and should be made measurable to be able to observe them. An overview of the operationalized characteristics is
shown in Table 4-a. Some of the characteristics influence rent and others influence risk. In the following paragraphs, all characteristics are explained one by one and the influence on firm performance, in terms of rent or risk types, is discussed.

<table>
<thead>
<tr>
<th>Theory</th>
<th>Theoretical characteristic</th>
<th>Operationalization</th>
<th>Increase in risk or rent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction cost theory</td>
<td>Environmental uncertainty</td>
<td>- High-technology characteristics</td>
<td>Profit risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Market maturity</td>
<td>Profit risk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Degree of competition</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Market complexity</td>
<td></td>
</tr>
<tr>
<td>Behavioural uncertainty</td>
<td>Size of partner</td>
<td></td>
<td>Spill over risk</td>
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<tr>
<td></td>
<td>Product complexity</td>
<td></td>
<td>Competitor risk</td>
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<tr>
<td></td>
<td>Resource overlap with partner</td>
<td></td>
<td>Hold-up risk</td>
</tr>
<tr>
<td></td>
<td>Strategy overlap with partner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resource-based view</td>
<td>Resources</td>
<td>- Resource overlap between firm and SIO</td>
<td>Technology rent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Resource overlap between firm/SIO and resources of competitors</td>
<td></td>
</tr>
<tr>
<td>Dynamic capabilities theory</td>
<td>Learning</td>
<td>- Decentralization of firm</td>
<td>Organizational rent</td>
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<tr>
<td></td>
<td></td>
<td>- Local autonomy of employees in firm</td>
<td></td>
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<tr>
<td></td>
<td>Technological opportunities</td>
<td>- Amount of money spent on R&amp;D in firm</td>
<td>Technology rent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Number of patents in firm</td>
<td></td>
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<tr>
<td>Resource dependence theory</td>
<td>Resource dependence</td>
<td>- Degree of product customization</td>
<td>Profit risk</td>
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<tr>
<td></td>
<td></td>
<td>- Geographical coverage</td>
<td>Resource risk</td>
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<tr>
<td></td>
<td></td>
<td>- Amount of training, skills and experience of employees</td>
<td></td>
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<td></td>
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<td>- Special investments for the transaction</td>
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<tr>
<td></td>
<td></td>
<td>- Share of total number of products</td>
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<td></td>
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<td>- Possession of resources</td>
<td></td>
</tr>
<tr>
<td>Ferrier framework</td>
<td>Trust</td>
<td>- Frequency of transactions</td>
<td>Relationship rent</td>
</tr>
</tbody>
</table>

Table 4-a: Overview of theoretical characteristics and their operationalization

**Environmental uncertainty**

Environmental uncertainty is mainly defined by the market in which the firm is operating. If this market is very dynamic and there is much technological innovation, firms prefer integration because product success is difficult to estimate (van de Vrande, Vanhaverbeke, & Duysters, 2009). Therefore, high-tech characteristics and an immature product increase profit risk. Furthermore, when the market is immature and complex, it is difficult to estimate demand volumes. And if the degree of competition is high, the price of the product may decrease because the product is no longer exclusive (Ferrier, 2013). All these factors increase profit risk.

**Behavioural uncertainty**

Behavioural uncertainty is mainly concerned with the chance that another firm will behave opportunistically. Ferrier (2013) operationalized behavioural uncertainty as follows:

- Size of partner
- Product complexity
- Resource overlap with partner
- Strategy overlap with partner
Towards a theoretical assessment framework

- **Resource dependence**

According to Ferrier (2013) behavioural uncertainty could be measured with resource dependence. However, this factor is also taken into account independently (see section 4.3). To avoid redundancy, resource dependence is considered as an independent factor and not included in behavioural uncertainty.

When the product is highly complex, the contractual relation should be tight and the partner has less room to behave unexpectedly. When the strategy of the focal firm and the partner overlap, the incentives for investment are aligned which decreases the chance that the partner will behave unexpectedly. When resource overlap is high, it is easier to monitor the partner’s actions which decrease behavioural uncertainty. When there is a chance that the partner does not behave as expected, hold-up risk, competitor risk and spill over risk increase. Therefore, behavioural uncertainty increases these types of risk.

The size of partner, strategy overlap and resource overlap with partners can only be defined when the partnering firms are known. This shows that behavioural uncertainty differs per transaction and also per partner.

**Resources**

When the resources required for the strategic investment option overlap with the resources possessed by the firm, a higher chance of rent exists because the firm has experience with these activities. Because rent is relative, overlap between the firm and those of competing firms should also be defined (Barney, 1991). As a result, the chance of rent is measured by two criteria: the resource overlap between the firm and the strategic investment decision and the resource overlap between the focal firm and competing firms.

Depending on the type of resources that overlap, a type of rent will increase. When physical resources of the firm and the strategic investment decision overlap and competitors do not have command over these physical resources, technology rent will increase. Furthermore, physical resources include the access to raw materials which a competitor does not have. This increases natural resource rent. When the firm has command over certain physical technologies, it might be easier to receive permits than competitors, which increases policy rents.

Overlap between organizational resources of the firm and those required for the SIO might also increase rents. For example the relationships with suppliers or consumers increase marketing rent and relationships with regulatory bodies increase policy rents. In addition, organizational planning, organizational efficiency and control systems that overlap increase organizational rent.

Overlap of human resources between firm and strategic investment decision, implies a higher level of human resource rent. For example when specialized skills are present in the organization while competitors do not possess these skills. These skills can be technical, organizational, but also relational. In the latter situation this increases marketing rents.

When the firm has better access to financial capital in comparison to competitors, for example because of a high level of cash available, a financial structure, or relationships with investors, this increases finance rent.

It is important to emphasize that resources are dynamic. Therefore, resource overlap between the firm and those required for the SIO should be defined for every time the framework is used.

**Processes**

Processes consist of integration, learning and reconfiguration and transformation (Teece & Pisano, 1994). Integration is the coordination of activities within the firm. These coordination efforts can be viewed as organizational routines, which are often firm-specific and have persisted over a long time. According to Moingeon and Edmondson (1996) routines emerge from learning processes. This is in line with Teece and Pisano (1994) who define learning as “a process by which repetition and
experimentation enable tasks to be performed better and quicker and new production opportunities to be identified.” Organizational knowledge generated by learning resides in routines. These routines make sure that processes are carried out efficiently.

Although routines create efficiency, they can also make new learning problematic. For example when a new technology is introduced and the current organizational routine does not match the new activities (Grant, 1991; Teece & Pisano, 1994). Therefore, Teece and Pisano (1994) state that in changing environments, adaption (reconfiguration and transformation) of firms is important. Flexibility improves learning processes, while existing routines that increase efficiency could hamper them. As a result, there is a trade-off between efficiency and flexibility.

In short, integration, learning and reconfiguration and transformation could all be defined by the flexibility of the firm and can be combined in learning because this concept covers all three concepts as explained before. When a firm is flexible, it can be beneficial to perform activities which do not overlap with the firm’s resources because learning can arise. Flexibility can be measured by decentralization and local autonomy (Teece & Pisano, 1994). When these are high, the firm possesses superior forms of internal organization in comparison to other firms. Hence, learning will increase organizational rents.

**Paths**

Paths consist of technological opportunities and path dependence (Teece & Pisano, 1994). A technological opportunity is defined as how easy it is to achieve innovations in terms of time and costs. In some industries it is easier to achieve technological improvement than in others. This is caused by the fact that the knowledge needed for technological progress is varying in pace and difficulty (Nieto & Quevedo, 2005). Nieto and Quevedo (2005) state that technological opportunities in terms of innovativeness are often measured in R&D spending or the number of patents. When the R&D spending and number of patents of a firm is high, the chance that a firm has command over scarce technologies is high. Therefore, technological opportunities increase technology rent.

With regard to path dependence, Teece and Pisano (1994) argue that there could be a lock-in effect because of current products or locations. According to Coombs and Hull (1997) there are three types of path dependence: technology as hardware, the knowledge base in which an firm has experience and the collection of routines. These three types of path dependence can be viewed as resources that exist in the firm. However, path dependence caused by existing resources is similar to resource overlap and asset specificity. To avoid redundancy, path dependence is not included in the framework as separate criterion.

**Resource dependence**

As defined in section 4.4, resource dependence is partly caused by asset specificity. The four types of asset specificity are used to operationalize resource dependence. Physical asset specificity is measured as the degree of product customization. When a product needs to be customized for every consumer, there is a high level of physical asset specificity. This increases risk of investment because the production process or physical technology that is used might not be suited for other consumers. Site asset specificity is measured by geographical coverage. When facilities and production and consumer are closely located to each other, inventory and transportation expenses are minimized (Lohtia, Brooks, & Krapfel, 1994). Human asset specificity is measured by the amount of training, skills and experience of employees is needed to carry out the activities that are needed for the transactions. Lastly, dedicated asset specificity is measured by special investments that are made for the transaction, for example when additional investments are made to an existing plant (Lohtia et al., 1994).

When one of the specificity types is present, resource dependence increases. In addition, the importance of the resource and the control over the resource are of influence. Resource importance is operationalized as the share of total number of products. For example, when a firm produces only one product it is more dependent on its customers than when it produces multiple products (Pfeffer &
Salancik, 1978). Control over resources is defined as the capacity to determine the allocation or use of the resource. This is measured by the firm’s possession of the resource (Pfeffer & Salancik, 1978).

**Trust**

If transactions are carried out more frequently, trust will increase (Ferrier, 2013). When trust increases the relationship can develop into a superior long-term relationship that competitors do not have. Therefore, trust increases relationship rent. Similar to behavioural uncertainty, the frequency of transactions can only be defined when the partner firms are known. This shows that behavioural uncertainty differs per transaction and also per partner.

4.7 Conclusion

This chapter addressed the third sub-question: “Which theoretical constructs should be considered to assess firm’s strategic investment options?”. Three theories, transaction cost theory (TCT), the resource-based view (RBV) and resource dependence theory (RDT), were explored to identify characteristics that influence of strategic investment decisions on firm performance (rent or risk). This forms the foundation for the theoretical framework that will be designed to assess strategic investment decisions.

The resource-based view was extended with the dynamic capabilities theory as both concepts are often used interchangeably in literature. Resources and capabilities are highly dynamic which increases complexity of the strategic investment decision-process. Furthermore, it was found that asset specificity and resource dependence are similar concepts. Therefore, these will be integrated and used as one concept. In addition, an existing framework, developed by Ferrier (2013), was discussed. It appeared that the framework developed would be the next step in the decision-making process. First, a strategic investment decision should be made. Then, Ferrier’s framework can be used to find a suitable governance structure for the relationship with partners.

When the three theories are compared, their usefulness depends on the type of market. When looking at the nascent geothermal industry, it is expected that RDT and RBV are both leading in making Strategic investment decisions, while TCT will not be very useful. This is mainly because the RBV and RDT fit well in dynamic and uncertain markets. Furthermore, it is expected that investment decisions are mainly based on RDT, as it dominates the RBV when these perspectives directly compete. However, the effects, in terms of integration, are unknown and should be examined.

The characteristics of each theory can function as starting point for the framework. Therefore, they were operationalized. An overview can be found in Table 4-a. During operationalization it was found that behavioural uncertainty and trust can only be defined when the partner firm is known, because the characteristics of the relationship influence these characteristics. When looking at the strategic investment decision-making process (see 3.1) this is a ‘later’ step in the process. Therefore, the theoretical assessment framework should be able to deal with different levels of information and different steps in the decision-making process.
5 The theoretical framework

In this chapter, the theoretical framework is designed. Framework requirements and variables are defined with use of the theoretical characteristics operationalized in the previous chapter. Lastly, the framework is presented.

5.1 Framework requirements

The framework should satisfy a number of requirements to make sure that the framework does what it is aimed for. These requirements are used as starting point for the design of the framework and are used during evaluation of the assessment framework. First of all, it is important that the requirements match the initially defined objectives for the assessment framework in chapter 2. These are:

- New business development: The framework should provide insight in which assessment criteria are important when making a strategic investment decision
- Investment option comparison: The framework should provide insight in how to assess and compare alternative strategic investment options

These objectives enable to support firms in their strategic decision-making process and advice which strategic investment decisions fit best with the firm and the industry. The following requirements are defined:

- The framework should provide an overview of the assessment criteria that are important to assess strategic investment decisions
- The framework should support energy firms in choosing strategic investment decisions by giving insight in how to assess different strategic investment decisions as part of the strategic investment decision-making process of selecting activities
- The framework should support firms in choosing strategic investment decisions by giving insight in how to assess different strategic investment decisions as part of the strategic investment decision-making process of selecting a partner
- The framework should identify trade-offs a firm is confronted with when deciding on strategic investments
- The framework should be straightforward in order to quickly understand the essence of it
- The framework should communicate the results clearly to the users of the framework
- The framework should provide guidelines through which energy firms could assess strategic investment decisions in an ordered manner

5.2 Design variables

In agreement with the goals of the three theories, each firm has different aims concerning the purpose of a strategic investment. This could be efficiency, competitive advantage or autonomy. Depending on these aims, the importance of each theoretical characteristic differs. In the same way, every firm has a preference for the level of risk or rent that a strategic investment entails. Some firms prefer a high level of risk, while others prefer low risk levels. This depends on the portfolio of the firm, which includes all strategic investments that a firm has done (Dye & Pennypacker, 1999). As perspectives concerning risk and rent differ, it is not possible to show a general ‘best’ strategic investment. A good SIO for one firm could be less suitable for others. Therefore, the framework should show an overview of the risks and rents that every SIO entails. Then, every firm could decide for itself which of these investments is preferred.
Different variables require different knowledge
During the analysis of rent and risk in chapter 3 it was found that different types of rent and risk demand different levels of knowledge. External rent, internal rent and performance risk can be defined at the beginning of the decision-making process. There does not have to be a partner yet. In contrast, to define relational rent and relational risk information on the partner firm and the relationship between the focal firm and the partner is required. During the operationalization of theoretical characteristics in the previous chapter, it was found that behavioural uncertainty and trust influence relational rent and relational risk. Therefore, these criteria can only be defined when the decision-making process is in a further stage and the partner is known. The theoretical assessment framework should be able to deal with different levels of information and different steps in the decision-making process.

In the previous chapter, it was also found that some of the criteria only influence risk and others only influence rent. The difference between these criteria is that some are internal, like resources, while others are external to the firm, like environmental uncertainty. Internal criteria are influenced by the firm’s characteristics. For example the internal criterion learning which depends on the flexibility of the firm. In contrast, external criteria are only depending on the strategic investment decision and do not depend on the firm characteristics. Therefore, a distinction is made between internal and external criteria in the framework. However, the external and internal criteria are not separated into different steps, because the results of both criteria will give a total overview of the risk and rent that the strategic investment entails. When only one of the two types of criteria is assessed and only risk or only rent is the outcome, a distorted view of the comparison of strategic investment options could arise.

Assessment method
There are many methods to assess alternatives. To choose between them, characteristics of the criteria and the SIO’s should be taken into account (Sage & Armstrong, 2000). First, the type of data should be considered. The theoretical characteristics that were defined in the previous chapter could function as criteria to assess SIO’s because they could indicate the level of rent and risk of an SIO. These characteristics are qualitative and cannot be quantified. Furthermore, the relationship between characteristics and their effect on rent and risk are not significantly proven. Therefore, the comparing method should be able to deal with qualitative data and the uncertainties regarding the relationships.

Second, the purpose of the assessment should be clarified. The framework is used for descriptive purposes. It gives a general overview of the influence of an SIO on the chance of rent or risk that they entail for the firm. Hence, the framework is used as a support tool during the strategic decision-making process of a firm. The user of the framework is a business development manager of an energy firm. He should be able to perform the assessment himself without external help. Therefore, the assessment method should be suited for this.

The field of Multi-Criteria Decision Analysis (MCDA) is concerned with the design of methods to support the subjective evaluation of a number of alternatives on the basis of a number of performance criteria (Lootsma, 1999). It is able to deal with quantitative and qualitative data and therefore is suitable to compare SIO’s. The following table shows the general set-up of an MCDA. Alternatives range from 1 to n, criteria range from 1 to m and scores are shown for every criterion and alternative, from \( s_{11} \) to \( s_{mn} \). In the theoretical framework, SIO’s will be used as alternatives and the theoretical characteristics as criteria.
Still, there are different types of MCDA's as scores can be defined in various ways. One possibility is to use the actual score of each SIO on the criteria. For example, when the criterion is costs and SIO 1 costs 100 euros and SIO 2 costs 200 euros. However, this method is based on quantitative data, while the theoretical characteristics are qualitative. Therefore, another scoring method should be chosen. Another possibility is to assign grades to every SIO (e.g. 1-10) for every criterion. A disadvantage of grades is that it is hard to quickly grasp the outcome of the framework. Furthermore, the objective of the theoretical framework is to give an overview of all SIO’s and their relative scores. Hence, another method is used. Every SIO is scored with the use of colours. This way, an overview of all scores is easily observed. When using coloured scores, there are two possibilities:

- The best scoring SIO receives a green colour, which is perceived as good, and the worst scoring SIO receives a red colour, which is perceived as bad
- The colours are compared with a baseline to define scores

A disadvantage of the first method is that it might be biased. If all SIO’s score relatively low, an SIO could still receive a green colour if it is the ‘best of the worst’. Absolute differences cannot be observed. Therefore, the SIO’s will be compared to a baseline score. The following section explains the decision rules underlying this scoring method.

### 5.3 Decision rules

Each SIO will be scored on every criterion according to the following measurement legend.

![Measurement legend](image)

Figure 5-a shows that high rent or low risk results in a green colour. A green colour indicates that the SIO contributes most to the chance on high rent or low risk on that criterion. A red colour indicates the opposite and other colours lie in between.

An example of a decision rule is shown in Table 5-b. The complete overview of all decision rules can be found in Appendix A. The two columns on the right show the extreme ends of the measurement legend. Resource dependence is partly determined by the level of physical asset specificity that was defined as the degree of product customization. If the product or service can be used for any customer, the product is less specific and will decrease risk. An example is the production of sugar, which is not customized for one customer but can be used for everyone. If one customer does not buy the sugar, it can be sold to another. In contrast, an example of a highly specific product is the customized engineering design of a factory that only will be built once. When the product is delivered, the design
cannot be used for another factory because of its specificity. Furthermore, if the customer goes bankrupt during the engineering process, there is no other customer to sell the product to. Therefore, a high degree of product customization entails high risk which results in a red colour. Some products or services will be partly specific and partly general. For example project management services. Every time the project is different, but on the other hand, the same management methods can be used. This will entail a medium risk which results in an orange colour.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Characteristic</th>
<th>Green</th>
<th>Red</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource dependence</td>
<td>Degree of product customization</td>
<td>Can be used for all customers</td>
<td>Customized for one customer</td>
</tr>
</tbody>
</table>

Table 5-b: Decision rules for resource dependence and resources

This scoring exercise is a complex exercise as many different variables should be defined. Furthermore, this scoring method is relatively rigid in comparison to the qualitative character of the data, which implies subjectivity; some actors might score certain criteria differently than others. This could result in ambiguous results that are context dependent. It is important that these limitations are further researched when testing the framework in practice.

5.4 Framework design

Figure 5-b shows an overview of the framework design. Step 1a and step 1b can be performed independently or together. Step 1a shows the performance of the SIO’s, while step 1b shows the relational sensitivity, i.e. the risk and rents that accompany the relationship. Hence, the framework can be used in three ways:

- All three steps are performed: internal and external rent, performance risk and relational rent and risk are assessed; information about both the firm and relationship(s) are used.
- Only step 1a and 2 are performed: internal and external rent and performance risk are assessed; only information on firm characteristics are needed, no partner is/has to be involved yet.
- Only step 1b and 2 are performed: relational rent and risk are assessed; only relational criteria are assessed when the firm is in a further stage of the decision-making process.

In the following paragraphs, the framework will be explained step by step.

Figure 5-b: Theoretical framework
**Step 1a**

In the step 1a external and internal criteria are used to assess the level of risk and rent for every SIO. External criteria define the amount of performance risk associated with an SIO. Internal criteria define the amount of internal and external rent and performance risk. Every SIO has a unique set of scores on every criterion. Resource dependence is for example high for one SIO, while another SIO can have low resource dependence. The score on the criteria is defined by researching the operationalized characteristics and criteria which are shown in Table 5-c. First, the operationalized characteristics should be defined for every SIO with help of the decision rules. Then, the level of risk or rent can be defined. For example, when the degree of product customization is high, resource dependence is high. This will create high performance risk.

<table>
<thead>
<tr>
<th>External criteria</th>
<th>Operationalized characteristics</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource dependence</td>
<td>Degree of product customization&lt;br&gt;Geographical coverage&lt;br&gt;Amount of training, skills and experience of employees&lt;br&gt;Special investments for the transaction&lt;br&gt;Share of total number of products&lt;br&gt;Possession of resources</td>
<td>Performance risk</td>
</tr>
<tr>
<td>Environmental uncertainty</td>
<td>High-technology product characteristics&lt;br&gt;Market maturity&lt;br&gt;Degree of competition&lt;br&gt;Market complexity</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Internal criteria</th>
<th>Operationalized characteristics</th>
<th>Rent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>Overlap of resources between firm and SIO&lt;br&gt;Overlap of resources between firm/SIO and competitors</td>
<td>Internal and external rent</td>
</tr>
<tr>
<td>Learning</td>
<td>Decentralization of firm&lt;br&gt;Local autonomy of employees in firm</td>
<td>Internal rent</td>
</tr>
<tr>
<td>Technological opportunities</td>
<td>Amount of money spent on R&amp;D in firm&lt;br&gt;Number of patents in firm</td>
<td></td>
</tr>
</tbody>
</table>

*Table 5-c: Step 1a*

**Step 1b**

The second step assesses the SIO’s on the basis of relational criteria. The relational criteria influence relational rents and relational risks. As can be found in the following table.

<table>
<thead>
<tr>
<th>Relational criteria</th>
<th>Operationalized characteristics</th>
<th>Risk and rent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust</td>
<td>Frequency of transactions</td>
<td>Relational rent</td>
</tr>
<tr>
<td>Behavioural uncertainty</td>
<td>Size of actors&lt;br&gt;Product complexity&lt;br&gt;Resource overlap with partner&lt;br&gt;Strategy overlap with partner</td>
<td>Relational risk</td>
</tr>
</tbody>
</table>

*Table 5-d: Step 1b*

Similar to step 1a, every SIO has a unique set of scores that should be defined with the use of the operationalized characteristics. Furthermore, more than one partner can be involved. Step 1b should be carried out for every partner to get a full overview of the sensitivity for every partner involved.
Step 2
When the levels of risk and rent are defined, colours are defined as was shown in section 5.3. The following scorecard is used for the scoring of external and internal criteria.

<table>
<thead>
<tr>
<th>Internal criteria - rent</th>
<th>Strategic investment option 1</th>
<th>Strategic investment option 2..n-1</th>
<th>Strategic investment option n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firm strategy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>External criteria - risk</td>
<td>Resource dependence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental uncertainty</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5-e: Scorecard external and internal criteria

The scorecard compares the SIO’s. Depending on the number of SIO’s (n), columns can be added. A similar scorecard is constructed for the assessment of relational criteria and is shown in Table 5-f. It should be noted that this scorecard should be constructed for every partner with which the firm transacts.

<table>
<thead>
<tr>
<th>Relational criteria - rent and risk</th>
<th>Strategic investment option 1</th>
<th>Strategic investment option 2..n-1</th>
<th>Strategic investment option n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trust</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioural uncertainty</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5-f: Scorecard relational criteria

5.5 Conclusion on theoretical framework

In this chapter, the third research question was answered: “What theoretical framework can be designed to assess firm’s strategic investment options?”. The objective of the framework is to support the strategic investment decision-making processes of energy firms. Multi-criteria decision analysis was selected to construct the framework, which is a method to assess alternatives on a number of performance criteria. The alternatives are the different strategic investment options and the criteria are based on theoretical characteristics from transaction cost theory, the resource-based view and resource dependence theory as defined in chapter 4. These characteristics show the level of rent or risk that accompany every strategic investment option and are represented by colours. Because every firm has a different portfolio and prefers a different level of risk and rent, the framework will give an overview of the scores of the strategic investment options on all criteria.

A step-wise framework was designed in order to use the framework in different phases of the decision-making process. The framework consists of three steps. The first step can be performed at the beginning of the decision-making process. Internal and external criteria are used to assess strategic investment options. In the second step, the sensitivity for the partner(s) is defined. For this step, information on the relationship with partner(s) is needed. Then, the risk and rent scores are displayed on scorecards in step 3, which is the end result of the framework. In the next chapters the framework will be applied on the geothermal industry.
Part III: Empirical grounding
6 Introduction to the geothermal industry

This chapter introduces the geothermal industry to provide background information before the framework will be applied to this industry in the next chapter. Two interviews have been performed to gain a better understanding of the geothermal industry, in particular of the technology and the projects and players. The outcomes can be found in Appendix B. Furthermore, books and papers have been researched on the technological characteristics of geothermal energy.

6.1 Activities in the geothermal industry

The value chain of the geothermal industry provides insight into the technology of geothermal energy systems. A value chain is defined as a set of activities, accomplished sequentially, that is performed to transform raw material inputs into finished products through which value is created (Freeman & Liedtka, 1997; Porter, 1985).

The geothermal industry has two value chains: one for heat and one for power. Both can be assessed as individual systems or as a combined system. The physical activities of the geothermal value chain are shown in Figure 6-a. Both value chains start with the production of heat. In the heat value chain the heat is transferred in a heat exchanger and transported to the end user for consumption. After heat production it is also possible to use the heat in the power value chain. This power is transported to the end users. In every step of the value chain, value is added to the product making it more and more valuable as it flows through the value chain.

The coloured arrows indicate the flow of physical material. The blue arrows show the heat produced. This heat is transferred in a heat exchanger or power producing facility. In both processes, the heat is used and cool water is returned to the earth (Glassley, 2010). The reverse pointed arrows show this is a closed-loop system. The purple arrows indicate a flow of heat, which is also a closed-loop. After the exchange of heat in the heat exchanger, the heat flows through the transport network to the end user. During the use of heat, the water cools down and is transported back to the heat exchanger where it is heated again. In the power production step, heat is used to produce power. Power is transported to the end users where it is consumed, so power does not circulate in the system (Glassley, 2010). In the following paragraphs, each part of the value chain is explained to gain a better understanding of a geothermal system.

Heat production

The first step in the value chain is the production of heat. When geothermal heat is produced, hot water is pumped to the surface. In the next step, the heat is transferred in a heat exchanger. The remaining
cooled water is transported back into the earth, because the water flow is high and contains large amounts of salt (Nieuwland, 2013). Two wells are, therefore, drilled and called a doublet: a production and an injection well. An overview of the installation is shown in Figure 6-b. The red pipes are connected to the production well. After use, the cooled water is transported back through the blue pipes into the injection well.

A geothermal well cannot be drilled at any location. A water reservoir has to be present and the reservoir must have the right permeability — the state or quality of the material that allows to pass through liquids or gasses — and porosity — a measure of the void spaces in a material — for production. This permeability and porosity often decrease with depth due to the pressure of the earth above it. The consequence of increasing depth is a decrease in production volume and thus produced heat. Another important technological factor that is defined by depth is the temperature of the water. In the Netherlands, the geothermal gradient is around 30 °C per 1000 meter. Current geothermal facilities in the Netherlands are producing heat ranging from 60 to 85 degrees Celsius from depths of around 1600 to 2500 meters (Platform Geothermie, 2013c).

The potential of geothermal energy in the Netherlands is large. A large part of the Dutch subsurface consists of sedimentary layers which contain hot water and have suitable flow characteristics (100-300 m3/hr). Much data is available on the Dutch subsurface due to the many drilling activities in the oil and gas industry. Kramers, Vis, Pluymaekers, van Wees, and Mijnlieff (2010) researched the geothermal potential in the Netherlands and found that geothermal up to four kilometres deep can deliver around 38.000 PetaJoule of energy. One PetaJoule corresponds to the yearly consumption of heat of 25.000 households.

Still, it is impossible to exactly estimate the temperature and production volume before drilling. If seismic and geological maps are used, the chance of success is around 50%. When no information is used before drilling, the probability of success is very low (20% or less) (Gittins, 2013). Geological and technical knowledge of the reservoir and wells is, therefore, necessary to increase the probability of success, but it remains a complex task which can never provide 100% certainty.

In the Netherlands, oil and gas resides in the subsurface. In the majority of the current geothermal facilities in the Netherlands, hydrocarbons are produced together with the pumped water. In gaseous areas, this amount is around one m³ of gas for one m³ of water (van Eck-van der Suijs, 2013; van Heekeren, 2013). Gas can be used to provide energy for the surface installations. However, unexpected gas or oil could cause unsafe situations, which made the Ministry of Economic Affairs tighten their regulations in January 2012. Geothermal energy is subject to the Dutch Mining law; an exploration permit and production permit needs to be applied for. To prevent unsafe situations caused by gas or oil two changes were made. Firstly, additional safety measures must be taken, which can easily increase investment costs with around 1 million (Lensink et al., 2012). Secondly, producers of geothermal energy are required to have knowledge and expertise on mining, technology and regulations (NLOG, 2013).

There are two possibilities when drilling a geothermal well for heat production: either drilling a new well or using old oil and gas wells, called dual plays. There are two types of dual plays. In the first one, the well will be used to find oil or gas first and when this is not the case, it could be used for heat. Normally, oil or gas wells that are ‘dry’ in terms of oil or gas are abandoned and not suited to use again for the production of heat. The second type of dual plays uses finished oil and gas wells to produce heat. In this case, the well should not have been abandoned yet. When double plays are used to supply heat,
the locations are depending on local demand. Veeger (2012) researched dual plays and found that there are 13 suitable oil or gas wells near heat demands available in the Netherlands.
Heat transfer
The pumped water is transferred in a heat exchanger to extract the energy from the pumped water. This way, the salty subsurface water resides in the closed loop system and does not have to be cleaned. In turn, clean water is heated and ready for use. An example of a heat exchanger is shown in Figure 6-c. Fluid 1 is the heat produced by the geothermal well. This fluid is hot when it enters the heat exchanger from the production well and it is cooled down when it leaves the heat exchanger and subsequently enters the injection well. Fluid 2 is the water that is used for the end use of heat. After use, it flows back into the heat exchanger and this fluid is warmed up by the geothermal heat, fluid 1. When fluid 2 leaves the exchanger it is heated and ready to be transported and used by the consumer.

The exchange of heat is an important step as this process defines the efficiency of the production system. When the temperature difference between the injection and production well is large (temperature difference of fluid 1), the transfer of heat increases and the heat produced by the well is used more efficiently. The temperature difference thus defines the coefficient of performance (COP) of the heat transfer (Platform Geothermie, 2012).

Heat transport
After production, the heat is transported to the end user. The heat produced cannot be transported over long distances as the heat loss is high. The transport distance of the heat depends on the size of the water flow and the insulation used to prevent heat loss (Nieuwland, 2013). The maximum transport distance is around a few kilometres.

Currently, most heating is provided by gas, which can be transported over long distances. This led to the development of an extensive gas network in the Netherlands. However, there are also a couple of district heating networks which use heat instead of gas. These district heating networks have a supply temperature between 90 and 110 degrees Celsius (Platform Geothermie, 2012). In 2009, there were thirteen large-scale heating networks in the Netherlands, with more than 5000 consumers, and around 6900 small-scale networks with around 40 consumers. In the future, these heating networks will probably be expanded (Schepers & van Valkengoed, 2009).

End use of heat
In 2010, 38% of the total energy consumption in the Netherlands consisted of heat, which amounts to about 1300PJ. It is used for industry, the built environment and agriculture. Horticulture and the built environment use heating systems that use a relatively low temperature, between 70 and 110 degrees Celsius (Nationaal Expertisecentrum Warmte, 2013). Therefore, this group is a suitable consumer of geothermal heating. Currently, in the Netherlands most geothermal facilities are producing heat for greenhouses, which are relatively large consumers. A geothermal initiative in Pijnacker is set up to produce heat for several purposes: greenhouses, a school, a swimming pool, and a gym (Platform Geothermie, 2013c).

The heat demand of both horticulturists and the built environment is varying on a daily and seasonal basis. For example, in winter the heat demand of households is high while in summer there is no demand at all. This influences the efficiency of a geothermal well. To increase efficiency, current geothermal systems are often combined with regular gas heating installations that provide heat during peak hours (Platform Geothermie, 2012).
Consumers demand and expect 100% reliability and availability which causes that the producing facilities should be balanced with demand at real-time.

**Power production**

Besides direct use of the produced heat, it can be used for power production as well. This is only possible when the heat temperature is above 100 degrees Celsius. In comparison to other power producing facilities, there are two main differences. First, compared to other renewable technologies, geothermal energy is not intermittent and can provide a base load. Second, compared to facilities that supply base load power, like fossil fuelled plants or biomass plants, there is no need for a fuel cycle to generate the heat (Glassley, 2010). In other words, no raw materials are needed. This makes geothermal energy a reliable source of renewable energy.

The power generated depends on the efficiency of the generator and turbine and on the rate at which thermal energy is supplied to the turbine. The rate of thermal energy supplied depends on the temperature of the heat supply. The heat temperatures in the Netherlands are lower than 150 degrees Celsius. For these temperatures, a binary power plant is suitable (Glassley, 2010). The heat produced is used to heat a fluid with a lower boiling point. This fluid is then used to drive a steam turbine. Efficiencies of a binary system are around 10 to 20%, which is relatively low compared to power plants that are driven on coal or gas. To increase the efficiency of the plant, the cooled water, which is the output of the power plant, can be used to deliver heat to greenhouses or residential areas.

**Power transport**

After production, power is transported to the end user. Currently, there is an extensive network available in the Netherlands to which every building or facility is connected. Power can be transported over large distances due to the low power loss. In contrast to heat transport, it is not necessary to build a new network when a power plant is built, because it can be connected to the existing grid. The transport of power is an important step because power cannot be stored. The supply and demand of power should, therefore, be balanced real-time.

**End use of power**

The power produced is used by different end users: industry, agriculture, and residents. Especially residents have fluctuating demands during the day. When people get up in the morning and arrive at home in the afternoon, the use of power is high. Similar to heat consumption, power should be 100% reliable and available. Therefore, demand should be matched to supply real-time.

### 6.2 Development of the geothermal industry in the Netherlands

The total amount of renewable energy consumed in the Netherlands in 2011 was 4.3%. Geothermal resources account for 3% of the consumption by renewable sources, or 0.1% of the total amount of energy consumed in the Netherlands (CBS, 2012). Geothermal energy is mainly produced by shallow geothermal sources. Deep geothermal sources account for a very small part of production. Currently, only heat is produced from geothermal sources in the Netherlands. Power generation might be feasible as well when heat is produced from higher depths (Chamorro et al., 2012; Self, Reddy, & Rosen, 2013).

There are many similarities between geothermal energy and oil and gas in terms of: required geological knowledge, risks, and legislation. The oil and gas markets are well-developed in the Netherlands. However, geothermal energy did not receive any attention in the Netherlands until 2006. By then, the first project took off in Heerlen without any governmental support in the form of, for example, subsidies. A well up to 800 meters was constructed in old mine galleries (Platform Geothermie, 2013c). The reason to start this initiative was to provide a sustainable utilization of post mining infrastructure and it would bring along positive socio-economic results for the region (Roijen, Op ’t Veld, & Demollin-Schneiders, 2013). In the summer of 2007, the first deep geothermal doublet was realized.
up to 1600 meters in Bleiswijk at horticulturist A+G van den Bosch to heat greenhouses where tomatoes are grown. A second doublet was realized there in 2009. After the success of these initiatives, the government became aware of the benefits of geothermal energy (van Heekeren, 2013). It could provide a contribution to the sustainability goals, because the European Union recognized heat as a sustainable source of energy equal to renewable sources of power or transport (Rijksoverheid, 2013a). In 2009, a guarantee regulation was established to decrease the risk of unsuccessful drilling activities. For many experts, this regulation is one of the most cost-effective measures to stimulate geothermal energy (Platform Geothermie, 2013a). In 2011, the Ministry of Economic Affairs set up an action plan to encourage the use of geothermal energy in the Netherlands and formulated the goal of 11 PetaJoule of geothermal energy in 2020. As a result, geothermal energy was included in the SDE+ subsidy in 2012. These developments boosted the application and authorization of exploration permits to around 100 in 2013. In 2010, drilling operations commenced in Pijnacker, The Hague and Pijnacker-Nootdorp. In 2011 a project was started in the Koekoekspolder and in 2012 in Honselersdijk. Furthermore, the TU Delft set up a foundation that promoted research in the field of geothermal energy. Part of this foundation is the initiation of a geothermal project at the TU Delft campus (Crooijmans, 2013).

Geothermal power might be feasible as well in the Netherlands when heat from higher depths is produced. However, well costs are large at these depths. Currently, one firm, Transmark Renewables, is looking into the possibilities of heat production over 4000 meters (NLOG, 2013). It is unknown what their results are yet.

Dual plays are another option for future projects (Veeger, 2012). They have large advantages in terms of risks and costs which could be shared between firms. Oil or gas well can be adjusted in several ways to fit heat production. This reduces drilling costs significantly. However, more integration between the oil and gas industry and the geothermal industry is necessary because currently only new wells are drilled in the Netherlands for the geothermal industry.

To sum up, in the past few years a number of facilities has become operational and geothermal energy is getting more and more attention in the Netherlands. However, there is also a large number of exploration permits that have not yet resulted in any facility.
7 Applying the framework to the geothermal industry

In the previous chapter, the geothermal industry was introduced. In this chapter, the theoretical framework is applied to this industry. Interviews helped to determine available strategic investment options (SIO’s) and important criteria. Furthermore, an institutional analysis is performed to understand the context around the cases. This analysis can be found in Appendix D.

7.1 Strategic investment options in the geothermal industry

The value chain is the starting point to define the activities performed in the geothermal industry. In line with the four dimensions of integration defined by Harrigan (1984) (see section 3.1), the steps in the value chain are viewed as the stages of integration. These are depicted in Figure 7-a in the blue and orange boxes. Furthermore, in every stage of integration, a number of specific activities are identified, which are defined as the breadth of integration. These are depicted in the purple boxes in Figure 7-a. A firm can choose to carry out any of these purple activities solely or in combination with other activities.

![Figure 7-a: Strategic investment options in the geothermal industry](image-url)

Besides the activities shown in Figure 7-a, many other activities are carried out in every value chain step (an overview is provided in Appendix C). However, not all activities are available SIO’s for energy firms. For example, power transport is regulated by the Dutch government. Four firms are assigned the task of network operator. The transmission network is operated by Tennet and the distribution networks are operated by Stedin, Enexis and Alliander (de Vries, Correlje, & Knops, 2012). Therefore, energy firms are not allowed to perform transport activities.

The interviews made apparent that every physical value chain step constitutes of an investor, operator and project manager. The investor invests in and owns the facility. It is also possible that multiple investors share the investment costs and the facility together. The investor is active during the entire lifetime of the facility. The project manager takes care of all project management related activities during project development and execution. This includes construction, engineering and delivery of the project within time and budget. Project management is a temporal activity; after completion of the facility, the facility is handed over to the operator. The operator operates the facility for the remainder of the lifetime of the facility, including abandonment. Both the power and heat value...
chain have a retailer that takes care of marketing and sales to the consumer. The retailer is not physically involved in the heat or power operations. In general, the investor transacts with the operator and project manager, while no transaction takes place between the project manager and operator. The investor also transacts with other investors in the value chain and the retailer.

The number of SIO’s is large as every activity displayed in Figure 7-a could be performed separately and in combination with any other activity. This brings the total number of options to 1152. It will be impractical to assess every option in the framework. Therefore, a selection should be made before assessing the options in the framework. The next section shows the strategic investment decisions made by the firms involved in the geothermal industry.

7.2 Strategic investment decisions in the geothermal industry

Two cases are considered to apply the theoretical framework to the geothermal industry: A+G van den Bosch and Aardwarmte Den Haag. The interviews show there are two main strategic investment decisions taken by firms currently active in the geothermal industry. One strategic investment decision is typical for horticulturists, A+G van den Bosch is considered in the case, and another is the case of the Aardwarmte Den Haag project. Both cases are introduced in the following sections.

A+G van den Bosch

Seven of the eight operating projects in the Netherlands are initiated by horticulturists. One of them is A+G van den Bosch. Greenhouses are suitable end users for geothermal heat as their heat demand is large. Heating costs account for 25-30% of their total costs (van den Bosch, 2013). The strategic investment decision made by Van den Bosch is shown in Figure 7-b. The activities within the red line are included in the strategic investment decision and performed by Van den Bosch.

Van den Bosch is investor, operator and consumer of heat in all steps of the value chain shown in the above Figure. The project management activities are outsourced. This is a common choice for horticulturists and the projects are often successful (van den Bosch, 2013). After realization of the first geothermal well, another geothermal well was constructed on the A+G van den Bosch premises. Besides A+G van den Bosch, who performs the activities on its own, there are a number of projects which are cooperations between different horticulturists. The firms invest together, share risks and returns, and are all consumers of heat. The next sections show why horticulturists choose to integrate with use of the theoretical framework.
Aardwarmte Den Haag

The Aardwarmte Den Haag project (ADH) is the only Dutch project that delivers heat to households. The project is situated in a residential area in The Hague and is operated by a cooperation of six firms that are in a partnership (v.o.f.). These are the municipality of The Hague, E-on, Eneco, and three building corporations: Vestia, Haag Wonen and Staedion. All firms have invested an equal amount of money (2.5 million euros per firm) and have an equal position within the partnership (Aardwarmte Den Haag, 2013a; Schoof, 2013). The strategic investment decision of the partnership is shown in Figure 7-c.

As can be seen in the above figure, ADH invests and operates heat production, heat transfer and heat transport. Furthermore, ADH provides retail services to the consumer. The project management activities of the heat transfer and transport step are ‘outsourced’ to E-on and Eneco, which are in fact both part of the partnership. Note that these transactions with the project managers are only present during construction, before operation. An important difference with A+G van den Bosch is that the consumer is not part of the strategic investment decision. Moreover, the consumers are not large but small. As a result, a large number of households are connected to the transport network.

Recently, all investors of Aardwarmte Den Haag, withdrew from the project. In the fall of 2012, the housing corporations quit the project because they were not able to pay their investment costs due to the current economic crises (College van burgemeester en wethouders, 2012). In addition, the 4000 houses that would have been built were partly postponed. These two changes made that E-On and Eneco also withdrew from the project (Baldewsingh, 2013). Lastly, the municipality was not able to support the project on its own and also withdrew (College van burgemeester en wethouders, 2013). In contrast to the seven operating horticulturist projects, this project is unsuccessful. Is this related to the strategic investment decision? And if so, why did the partnership choose for this strategic investment decision?

Both ADH and A+G van den Bosch made highly integrated strategic investment decisions. Several reasons were found during the interviews. In the following sections, each framework criterion is discussed in light of the strategic investment decisions in the geothermal industry.

7.3 Regulation as enabler for resource allocation

Resource allocation is one of the most important factors in the geothermal industry as every interviewee mentioned it. However, there are different opinions about the necessity of certain resources to perform activities. Since the first geothermal project, regulation has become more
stringent. The State supervision of Mines currently treats a geothermal well like an oil or gas well because of safety reasons, which implies heavy requirements for operators (van Eck-van der Sluijs, 2013). On the other hand, the Ministry of Economic Affairs wants to stimulate the development of geothermal energy by easing the permit requirements (Rijksoverheid, 2013a). In addition, horticulturists that operate geothermal wells argue that the current regulations are needlessly strict and that this hampers the development of the geothermal industry (van den Bosch, 2013). In the end, the State supervision of Mines decides on the regulations. This results in little to no approvals of permits applied for by municipalities or horticulturists, because they do not have the required technical and geological knowledge (van Eck-van der Sluijs, 2013). Besides regulation on heat production, the operation of power production and retail of heat are regulated as well. These are regulated by the authority for consumer & market (Autoriteit Consument & Markt, 2013).

Although certain activities are highly regulated and resources cannot be freely chosen, activities have been performed without having much experience in the past. In particular, no firm had any experience with geothermal energy because it is a new technology. However, heat production is very similar to oil and gas production, which shows that this knowledge is available. Both ADH and the horticulturists who applied for a heat production permit had no experience with geothermal heat production. In both cases, experts were hired to provide this knowledge. This contrasts the resource-based view which argues that these activities are better not included as they do not contribute to high rents. The activities are internalized for different reasons. In the case of A+G van den Bosch, control is valued higher than competitive advantage (van den Bosch, 2013). Competitive advantage is not important because horticulturists do not compete in the geothermal market as it is a one-time project. For ADH, the reason is partly to have control over activities. In addition, The Hague already has an established heat network, which would function as a back-up. When heat production would fail, it could still be supplied to the consumer through this network.

The activities with no specific requirements on resources are the investing and project management activities. It appears that, besides knowledge and experience in heat production, financial capital is missing in the geothermal industry (de Jong & Lugthart, 2013). One of the main problems associated with many types of renewable energy and also with geothermal energy is the high investment costs compared to fossil fuels. For geothermal wells, these costs are becoming similar to oil and gas wells. The installation costs are estimated at 9.7 million euros for a reservoir at 2300 meters (Lensink et al., 2012). Both knowledge and financial capital could be supplied by oil and gas firms (Crooijmans, 2013; de Jong & Lugthart, 2013; Hagedoorn & Veeger, 2013; van Eck-van der Sluijs, 2013).

In sum, much technological knowledge, experience and financial capital is required in the geothermal industry. Although many interested firms (horticulturists and municipalities) do not have the required resources, they still choose to perform the activities in order to gain control. Nowadays, this is not possible anymore because the regulations have become more stringent.

**Oil and gas firms are reluctant to invest**

Even though the investment costs are approaching those of oil and gas wells and subsidies are available (see Appendix D), revenues of geothermal heat are lower than revenues of oil and gas. This is caused by the difference in energy content between heated water (in this example 100 °C) and oil or gas, which is respectively around a factor of 150 or 25 for one barrel (van Heekeren, 2013).

Both gas and heat are used for the same purposes and compete directly. Investment in geothermal heat production is only beneficial for oil and gas firms when the gas price is low and heat is relatively more valuable and delivers high returns. In contrast, a consumer would rather use heat when the gas price is high and the heat price is low, because its energy bill will turn out lower. Hence, there is an asymmetry in interest between the producer and consumer which hampers the allocation of optimal investments.
Even though there is a difference in returns and an asymmetry of interests, EBN, a non-operating firm that participates in oil and gas projects to generate revenues for the Dutch State, is investigating if they could participate in the Delft Aardwarmte Project (DAP) which is in the project development phase. Their motivation to participate is to share risks and revenues. Furthermore, it would be an opportunity to share knowledge and in turn learn from the project (de Jong & Lugthart, 2013). Although there are differences with their current businesses, there are also advantages in terms of learning effects.

In sum, firms that do not have the required resources want to invest, but are hampered by the stringent regulations. Firms that have the required resources (mainly oil and gas firms) are reluctant to invest. This hampers the development of the geothermal industry.

**Framework implications**

Resource overlap is an important criterion in the geothermal industry. When this criterion is included in the framework, firms can easily investigate if they own the required resources and if this will lead to high rents (an overview of all activities can be found in Figure 7-a). The decision rule is shown in Figure 7-d.

If all resources of the firm overlap with the resources required for the strategic investment option (SIO), there is a high chance of rents, indicated by the green colour. However, the possession of these resources does not automatically lead to high rents. This is only the case if other firms do not possess these resources and there is a clear competitive advantage. In general, only a little number of firms in the geothermal industry has the required resources which indicate little overlap between competitors and the SIO. The following paragraphs show the resources required for the activities performed in the geothermal industry.

**Investor in heat or power**

As investor, the main goal is to earn sufficient returns in order to be profitable. However, knowledge of the market is needed to estimate if an investment is a good decision. Resources required to invest are market knowledge and intelligence and financial resources. In heat production, many criteria must be fulfilled to apply for a permit. Only one of the investors, which is also operator, must fulfil these criteria. Other investors do not have to fulfil them (Peters, 2012; van Eck-van der Sluijs, 2013). Therefore, these criteria are not included as resources in this list.

- Market knowledge and intelligence
Applying the framework to the geothermal industry

- Knowledge on regulations
- Financial capital
- Access to physical technology and equipment

Project manager
As project manager, technical knowledge of the technology is required. Even more important are the organizational resources and previous experience with project management. An essential part of this experience is how to deal with third parties (Crooijmans, 2013; Hagedoorn & Veeger, 2013; Schoof, 2013).

- Experience and education of employees in the field of physical technology
- Knowledge and experience with project management of large engineering projects
- Knowledge and experience with regulations (permits etc.)
- Communication to (third) parties

Operator of heat production
To operate the heat production facility, many criteria that are defined by the State supervision of Mines need to be fulfilled (Peters, 2012) (see Appendix D). However, once a permit is obtained, competitor firms are automatically not allowed to use that land. This creates a natural resource rent.

- Being able to assess risks for employees that are involved in heat production activities
- Being able to construct drilling plans
- Experience and education of employees in the field of mining, geology and use of equipment
- Knowledge on regulation
- Being able to have a safety and healthcare system present in which policy, organization, planning, execution, monitoring, evaluation and quality assurance of the heat production activities is measured
- Being able to carry out a self-assessment in which knowledge and capabilities of the firm are assessed in terms of well design, well construction, well control and emergency response
- Relationships with other operators in the value chain
- Financial capital

Operator of heat transfer
As operator of the transfer facility there are fewer requirements than as operator of the heat production facility. However, there is still a need for experience and education on the use of equipment and technology.

- Experience and education of employees in the field of physical technology and the use of equipment regarding heat transfer
- Knowledge on cheap transfer at high quality
- Relationships with other operators in the value chain

Operator of heat transport
Similar to heat transfer, there are little required resources to operate the heat network.

- Experience and education of employees in the field of physical technology and the use of equipment regarding heat networks
- Knowledge on cheap transfer at high quality
- Relationships with other operators in the value chain
Retailer of heat
In contrast to power production and retail of power, retail of heat is not regulated yet (see Appendix D). Therefore, the number of resources that are required is small. The retailer of heat provides a large number of customers, so the retailer needs the ability to close contracts with these customers, bill them and provide them service.
- Being able to offer contracts in which tariffs, a clear and reasonable payment policy and a clear and reasonable policy to cancel or terminate the contract is defined
- Being able to handle complaints

Operator of power production
The authority for consumer & markets defined a number of criteria that must be fulfilled to receive a permit to produce power (see Appendix D). These criteria are defined as required resources.
- Knowledge on cheap transfer at high quality
- Being able to manage program responsibility, this means that the firm should inform the transport operators one day ahead about their production for the following day
- A good administration
- Relationships with operators of power network
- Being able to offer contracts in which tariffs are defined, a clear and reasonable payment policy is defined and a clear and reasonable policy to cancel or terminate the contract is defined
- Financial capital
- Being able to handle complaints in a good manner

Retailer of power
Similar to the operator of power production, the authority for consumer & markets also defined a number of criteria that should be fulfilled to receive a permit to retail power (see Appendix D). These are shown below.
- Being able to manage program responsibility, this means that the firm should inform the transport operators one day ahead about their demand for the following day
- A good administration
- Being able to offer contracts in which tariffs are defined, a clear and reasonable payment policy is defined and a clear and reasonable policy to cancel or terminate the contract is defined
- Financial capital
- Being able to handle complaints in a good manner

7.4 Learning versus resources
In contrast to resources, learning was not named specifically by interviewees. However, as many firms chose to perform activities for which they did not have the required resources, learning was present. A+G van den Bosch (2013) stated that it was a ‘learning’ project because no geothermal energy project was performed before in the Netherlands. When projects are carried out more frequently, costs will go down and more will be known on the organizational design of projects (Hagedoorn & Veeger, 2013; Schoof, 2013). The learning effects in horticulturist projects do not have many benefits as they are performed once. Hydreco stated that they only participate in projects when expansion possibilities are present and learning can be achieved. Otherwise, investments in new resources are too high. This is especially true for the temporal project management activity in which a project organization is set up for a short period of time. However, horticulturists share some of the obtained knowledge. For example regarding the performance of the contractors and hired project managers (van Eck-van der Sluijs, 2013;
van Heekeren, 2013). Lastly, learning can also be the goal of performing an activity (Gittins, 2013). This way, rents are increased in subsequent projects by previously gained knowledge.

**Framework implications**

The interviews show that besides flexibility, learning is also influenced by frequency. Therefore, frequency is added to the determinants of learning. These are shown in Table 7-a. The two columns on the right indicate if there is a high level of learning or a low level of learning. Note that the two columns display extreme situations. Learning exists in the following two situations:

- If decentralization and local autonomy are both high
- If frequency is high

<table>
<thead>
<tr>
<th>Determinant</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decentralization of firm</td>
<td>Firm is small, and has limited managerial layers</td>
<td>Firm is large, and has many managerial layers</td>
</tr>
<tr>
<td>Local autonomy of employees in firm</td>
<td>Much autonomy: employees can plan activities themselves</td>
<td>Little autonomy: all activities are predefined</td>
</tr>
<tr>
<td>Frequency of performing activities</td>
<td>Activity is performed often (&gt;5 times)</td>
<td>Activity is only performed once</td>
</tr>
</tbody>
</table>

Table 7-a: Determinants for learning

To be able to learn, the initial state of knowledge is important. Learning will only add to rents if required resources are lacking. When the resource overlap between the firm and the SIO is high, learning is not of influence. No new resources are needed. When the resource overlap is low, learning could add to rents. The decision rule for learning is shown in Figure 7-e.

**7.5 Little technological opportunities**

Most firms involved in the geothermal industry do not have much financial capital available, let alone for R&D. In the Netherlands, most projects are focusing on decreasing development and execution costs (Schoof, 2013; van Heekeren, 2013). This results in lots of creativity, but not in innovation and new opportunities per se. Currently, one research foundation, DAP, is actively trying to increase R&D activities in the Netherlands (Crooijmans, 2013). Furthermore, in the power value chain there are some more R&D activities worldwide. However, because there is no experience in power generation from geothermal heat in the Netherlands, these activities are not significant. To conclude, there is not much
innovation in the geothermal industry in the Netherlands which lowers the number of technological opportunities.

To decide on the importance of technological opportunities for the framework, technological opportunities are further researched during the evaluation workshop (see section 8.5).

### 7.6 Environmental uncertainties

Several environmental uncertainties are identified, but no interviewee mentioned it as the main driver for their strategic investment decision. In the case of ADH, building corporations withdrew from the partnership because of their financial situation, which then also urged the other firms to withdraw (College van burgemeester en wethouders, 2013). Their financial situation is a result of the economic crises, which can be identified as an uncertain environmental influence. At the start of the project, it was never thought possible that houses would not be built and that building corporations would get in trouble. Hence, market complexity is definitely an important determinant of environmental uncertainty.

Furthermore, regulations in heat production have changed significantly over the past few years and will be changed in the coming years as well (see Appendix D). Besides regulations regarding heat production, the Heat Law will be implemented which will affect transport and retail activities of heat. However, this introduction is already postponed two times. Some interviewees named these regulatory uncertainties as important factors for horticulturists. If these changes are unexpected, trust in the government will decrease and firms will invest in geothermal projects less likely. It increases profit risk as costs regarding production might increase if regulations change.

A third uncertainty encountered concerns the development of a heat production facility, which is based on geological information. There is never full knowledge before drilling. (Crooijmans, 2013; de Jong & Lugthart, 2013; den Boer, 2013; van Eck-van der Sluijs, 2013). This increases environmental uncertainty and causes profit risk. However, this risk could be insured by the government or at regular insurance firms (van den Bosch, 2013). If the output would be lower than expected, the investment costs could be reimbursed (Agentschap NL, 2013a). This decreases the risk and the uncertainty to a large extent.

Fourthly, daily and seasonal patterns in heat consumption cause demand to fluctuate (Schoof, 2013; van den Bosch, 2013). There is a difference between heat patterns of consumers, greenhouses and industry. Greenhouses have a stable demand in comparison to households and industry has an even more stable demand pattern. These fluctuations should be balanced by heat production, transfer and transport capacities. When the capacities are built to deal with peak demand, the facilities will be overdimensioned because these peak capacities are only needed for short periods of time. Therefore, in current geothermal installations, these fluctuations are balanced by boilers installed near the heat production facility. In addition, consumers of power have fluctuating demand patterns as well.

Lastly, there is a chance of coproduction of hydrocarbons when drilling for geothermal energy. Coproduction has been a topic of discussion because it is unclear which party owns these accidentally produced hydrocarbons. On the one hand, oil and gas firms own the hydrocarbon permits in the Netherlands and they might compete with geothermal energy and these firms can claim the oil or gas. On the other hand, the Mining Law states that everything that is unavoidable produced together with the geothermal water belongs to the geothermal heat producer. The definition of ‘unavoidable’ is the topic of discussion. The State supervision of Mines is currently writing a protocol in which this topic will be clarified (van Eck-van der Sluijs, 2013).

### Framework implications

The identified uncertainties contrast with the theoretical determinants that focus on market characteristics. The market characteristics initially defined are similar concepts and are not all important because the criteria are high-level. They are more important when comparing different types of markets.
instead of investment decisions in a value chain. Instead, market complexity and regulatory changes are used to define environmental uncertainty in the framework.

Regulatory changes are especially important in heat production and retail of heat, shown in Table 7-b. Market complexity depends on the markets in which the firm is present. The decision rule is shown in Appendix G.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Regulatory changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investor and operator of heat production</td>
<td>Red</td>
</tr>
<tr>
<td>Retailer of heat</td>
<td>Green</td>
</tr>
<tr>
<td>Other activities</td>
<td>Yellow</td>
</tr>
</tbody>
</table>

Table 7-b: Decision rule regulatory changes

7.7 Resource dependence as driver for integration

High specificity of resources in the stages of integration

Resource dependence is one of the most important criteria that drives the strategic investment decision in the geothermal industry. This is a result of different characteristics:

- High specificity of resources:
  - High geographical specificity
  - High dedicated up-front investments
  - Physical dimensions of the facilities should match, performance depends on other activities
- Share of total number of products is large (for ADH heat is the only product and horticulturist cannot produce without energy)
- Dependence is decreased by controlling resource dependent activities

Geographical specificity is high in the heat value chain. A heat reservoir must be present, heat loss during transport is high and heat cannot be stored, which causes that heat can only be transported over short distances (den Boer, 2013). In addition, the heat network requires high up-front investments (Schoof, 2013). Costs of drilling a geothermal well are similar to costs of oil and gas wells. A doublet to 2000 meters costs approximately 10 million euros, depending on the specific subsurface conditions (around 1500 euros per kW) (Lensink et al., 2012; Schoof, 2013). In contrast to the investment costs, operational costs of a heat producing well are small. As no raw material is needed, operational costs only consist of maintenance and control. In the ADH case, the costs of the heat transfer facility were approximately 5 million euros to be able to transfer 150 m$^3$ of water per hour. Costs of the heat network are around one million per kilometre. In ADH, 25 kilometres of network is built, which accounts for over half the investment costs (Schoof, 2013). To own and operate all steps of the value chain, horticulturists invest considerable amounts of money in the project. The costs of a geothermal well are close to two times the annual turnover of such a firm (van den Bosch, 2013).

The high investment costs in combination with the geographical specificity ties the facilities to a fixed location. Therefore, heat facilities should be located near a local heat demand (de Jong & Lugthart, 2013; den Boer, 2013; Schoof, 2013; van Heekeren, 2013). The fixed investments and high heat loss also result in the construction of only one heat production facility, one heat transfer facility and one heat transport facility. There is no market with multiple suppliers and buyers. In other words, there exists a monopoly. This makes consumers highly dependent on local supply. If one of the facilities is not available, the consumer is not served. On the other hand, supply is dependent on local demand. If the consumer does not want to be served anymore, there is no other consumer nearby.
Because there is only one production facility, one transfer facility and one transport network, the dimensions of the facilities heavily rely on each other in terms of dimensions. These capacities should be matched with production volume and consumer demand. In addition, the performance of the heat transfer facility depends on the temperature difference by the production well and the heat use of the customer (also see 6.1 on heat transfer) (Platform Geothermie, 2012; Schoof, 2013). Integration minimizes risks and dependencies on the supplier side, as only one transaction has to be managed: the transaction with the consumer (Schoof, 2013). The dependencies between the supplier and consumer can also be decreased by other means than integration. In the ADH case, the district heating network in place in The Hague makes sure that end users could always rely on other suppliers in the city heating network (Schoof, 2013).

There is a large difference between power and heat. The heat production facility is tied to a specific location because it should be close to a heat source. The power production facility should be situated close to the heat production facility because of the heat loss during transport. However, the production of power is not depending on the consumer location as it can be easily transported. As long as the producing facility is connected to the power grid, the power can be sold easily. The power network is regulated (de Vries et al., 2012) and, therefore, power production does not have to be matched to the power network capacity by the production operators. This is the responsibility of the transport operators. Furthermore, there is a large power network present in the Netherlands. Power production activities are not physically and geographically depending on the consumers or retailers of power. Because of this low dependency, power is traded on the market. In comparison to power, specificities are much more apparent in the heat value chain.

Resource dependence within the breadth of integration
Besides specificities between the steps of the value chain, specificities also exist within one step of the value chain. More specifically, between the investor and operator and between the investor and project manager, because the operator and project manager do not transact (see section 7.1).

Physical customization is present between investor and operator. The investor is the only firm that owns physical resources. However, the operator cannot do its work without access to the investor’s facilities. Therefore, there is a high dependency from the operator’s point of view.

Human specificity is defined as the specialized investments in experience and knowledge that is needed to perform transactions between activities. Specific knowledge and experience is needed for many activities (see section 7.3). The investor is dependent on the knowledge and experience of the operator and project manager for the project to succeed, because he does not have to possess that knowledge himself.

Furthermore, dedicated asset specificities exist. While investors are dependent on knowledge and experience of project managers, project managers are in turn depending on the investments in the project that investors should make. Otherwise, project managers do not have any work.

As seen in the above table, the dependencies of investor, operator and project manager are high for one of the activities. When the dependencies are added there exists mutual dependency derived from different types of specificity. In the case of ADH and Van den Bosch, the dependencies created by these specificities are decreased by integrating activities.

Number of resource dependent transactions
When assessing SIO’s, it is not only important to look at the unique transactions that a firm is involved in, but also at the effect of combining a number of transactions. Firms can choose to perform an activity that interacts with several other activities. As power producer, a firm is involved in a couple of transactions. It is assumed that if the number of resource dependent transactions is high, more risk is associated with resource dependence.
Learning and resource dependence

Besides the single use of resource dependence, resource dependence influences learning as well. As already touched upon in 7.4, Hydreco only participates in the geothermal industry when there are possibilities for expansion on the same location (Hagedoorn & Veeger, 2013). Because heat production is so specific, learning will not be high if a new facility is built on a new location. So, specificity is important in learning processes. When specificity is high, learning effects will be low. In turn, when resource dependence is low, learning effects will be high. Because the level of specificity in the heat value chain is high, learning will be low. The decision rule on learning, therefore, includes the relations between learning and resource dependence (see Appendix G).

Environmental uncertainty and resource dependence

During the interviews it is encountered that there is also a relation between resource dependence and uncertainty. In the case of ADH, the driver for withdrawal of firms from the partnership was the economic crises. Fewer houses were built due to this environmental factor. In addition, resource dependence was very high which caused that if one party withdrew, the other activities were immediately affected. Therefore, if resource dependence is high, the effect of environmental uncertainty is more pronounced. The decision rule on environmental uncertainty, therefore, includes this relation between environmental uncertainty and resource dependence (see Appendix G).

Framework implications

In the framework, the number of resource dependent transactions is used to define resource dependence. Based on Figure 7-a, a maximum of seven transactions are possible depending on the activities included in the SIO. As a result, a red colour indicates seven resource dependent transactions and a green colour indicates zero resource dependent transactions. The decision rules for resource dependence are explained below.

For every transaction:
1. Does the firm possess or control the resources exchanged in the transaction?
   1.1. Yes: this transaction is not resource dependent. Do not continue to 2.
   1.2. No: this transaction might be resource dependent. Continue to 2.
2. Is there a high level of specificity or resources?

<table>
<thead>
<tr>
<th>Transactions</th>
<th>Overall specificity</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transactions between investors in heat</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat production – Heat transfer</td>
<td>High for both</td>
<td>1</td>
</tr>
<tr>
<td>Heat transfer – Heat transport</td>
<td>High for both</td>
<td>1</td>
</tr>
<tr>
<td>Heat transport – Large consumers</td>
<td>High for both</td>
<td>1</td>
</tr>
<tr>
<td>Heat transport – Retail of heat</td>
<td>High for both</td>
<td>1</td>
</tr>
<tr>
<td>Retail of heat – Heat consumption</td>
<td>High for both</td>
<td>1</td>
</tr>
<tr>
<td><strong>Transactions between investors in power</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat production – Power production</td>
<td>High for both</td>
<td>1</td>
</tr>
<tr>
<td>Power production – Power transport</td>
<td>High for both</td>
<td>1</td>
</tr>
<tr>
<td>Power production – Large consumers</td>
<td>Low for both</td>
<td>0</td>
</tr>
<tr>
<td>Power production – Retail of power</td>
<td>Low for both</td>
<td>0</td>
</tr>
<tr>
<td>Retail of power – Power consumption</td>
<td>Low for both</td>
<td>0</td>
</tr>
<tr>
<td><strong>Transactions between investor, project manager and operator</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investor – Project manager</td>
<td>Medium for both</td>
<td>0,5</td>
</tr>
<tr>
<td>Investor – Operator</td>
<td>High for both</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 7-c: Overview of specificities

1. Add the weights of all transactions and score them as follows:
For example, when a firm chooses to act as investor in heat production and heat transfer, there are five transactions present. These are added with the use of Table 7-c:

- with the investor of heat transport (+1)
- with the operator of heat production (+1)
- with the operator of heat transfer (+1)
- with the project manager of heat production (+0.5)
- with the project manager of heat transfer (+0.5)

This comes down to a total of 4 on a scale of 7, which indicates an orange colour.

7.8 Trust

During the interviews appeared that, besides frequency, trust increases when the performance of a partner firm was high in previous projects (Crooijmans, 2013; van Eck-van der Sluijs, 2013; van Heekeren, 2013). Because the geothermal industry is a developing market and there is not much experience in heat production, trust is low at many firms (van den Bosch, 2013). Performance in previous projects is used as determinant of trust in the framework.

The results of Veeger (2012) show that there are many dual play possibilities. However, oil and gas firms are currently not very willing to participate. Besides the reasons named in 7.3, it appeared that they are not willing to outsource heat production because they own the hydrocarbon concession and still have the responsibilities accompanying this concession. Trust in other firms is too low to outsource the activities (Gittins, 2013). The only possibility is that the total concession is sold to another firm. However, the knowledge lack of firms outside the oil and gas industry restrains this from happening. Before dual plays can take off, more integration between the oil and gas industry and the geothermal industry is needed in order to increase trust.

Framework implications

The decision rule for trust is shown in the below Figure. If both frequency and performance in previous projects is high, trust is high which can result in relational rents and thus receives a green colour. When both are low, trust is low which results in a red colour.
7.9 Behavioural uncertainty

In both the ADH case and the Van den Bosch case, there is a high level of integration chosen to decrease risks associated with behavioural uncertainty. More specifically, the involvement of three building corporations in ADH is based on this. The corporations do not have any knowledge on the technical activities and act as investor. They participate because they want to stimulate the development of renewable energy projects that involve the built environment, but also to control the risk that their houses are not supplied because the other firms do not live up the agreements (Schoof, 2013). Furthermore, horticulturists also choose for high levels of integration to be in control and because they are afraid that other firms act opportunistically.

In addition, behavioural uncertainty depends on the type of consumer. There is a difference between delivering to large and small consumers as a supplier. According to van den Bosch (2013) the high level of integration in the geothermal industry is possible because the heat production facilities deliver to one or a few customers and the project is small. Greenhouses have a large heat demand is, so there are only a couple of greenhouses connected to the heat producing source. However, due to the current economic situation, greenhouses are more likely to go bankrupt (van den Bosch, 2013). Hence, this small group of large consumers and their financial situation causes them to be a risky group of consumers.

Framework implications

Besides resource and strategy overlap, type of consumer was added to the determinants of behavioural uncertainty. In addition, product complexity was not identified as a determinant in the case study and, therefore, not taken into account when defining behavioural uncertainty.

The measurement of behavioural uncertainty is shown in Table 7-d. In this case, the determinants add up equally to the level of risk or rent. The determinants first have to be scored according to the table. It should be noted that these scores are extreme situations. Scores in between should be scored as the firm sees fit.
<table>
<thead>
<tr>
<th>Determinant</th>
<th>Outcome</th>
<th>Score</th>
<th>Outcome</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of consumer</td>
<td>Small</td>
<td>1</td>
<td>Large</td>
<td>0</td>
</tr>
<tr>
<td>Resource overlap with partner</td>
<td>All resources overlap</td>
<td>1</td>
<td>No resource overlaps</td>
<td>0</td>
</tr>
<tr>
<td>Strategy overlap with partner</td>
<td>Strategies of firm and partner are similar</td>
<td>1</td>
<td>Strategies of firm and partner are totally different</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7-d: Measurement behavioural uncertainty

When the scores are added up, they can be measured on the following scale to define the right colour.

![Colour Scale](image)

Figure 7-h: Decision rule behavioural uncertainty

### 7.10 Conclusion

This chapter answers the fourth and the fifth research questions:

4. What strategic investment options are available for energy firms in the geothermal industry?

5. On basis of which criteria are strategic investment decisions made by firms in the geothermal industry?

In Figure 7-a an overview is shown of all strategic investment options (SIO). In short, several steps in the value chain can be selected: heat production, heat transfer, heat network and power production. These steps are divided into three activities: investor, operator and project manager. In addition, retail of heat and retail of power are activities that can be included in the strategic investment decision. It appeared that many SIO’s are available (1152). Therefore, the numerous SIO’s should be decreased to a workable number before they can be assessed in the framework.

The cases of Aardwarmte Den Haag and A+G van den Bosch show that the geothermal industry is currently highly integrated. In both cases, the investor, operator, and retail activities are all performed in one firm. Only the temporal project management activities are outsourced. An important driver for this integration is the high level of resource dependence that is present in the heat value chain. In contrast to power, supply and demand are tied to a specific location. In combination with high fixed investments, this results in a local monopoly instead of a market with multiple suppliers and multiple demands. To prevent risks accompanying dependence, activities are integrated.

However, not all activities can be integrated easily. Many activities, like heat production, power production and retail are regulated, which require certain resources to be present before a permit is authorized. Although horticulturists and municipalities have received permits in the past, they are not approved anymore by the Ministry of Economic Affairs. Firms that can participate in the geothermal industry because they have much knowledge are oil and gas firms. However, they are reluctant to invest because of the low returns compared to oil and gas and the competition of heat and gas. Besides resource dependence, resources are also of high importance.

Another important factor is environmental uncertainty. This uncertainty is mostly determined by the complexity of the market that the firm is in (see 7.6 on building corporations) and the regulatory changes that are currently going on in the geothermal industry. In addition, when high resource dependence is present, the impact of environmental uncertainties is even larger.

Furthermore, two other relations between criteria are found. First, learning can only take place when resource overlap between a firm and strategic investment decision is low. Second, learning decreases when there are high specificities present.
Lastly, the factors accompanying partner sensitivity were researched. Behavioural uncertainty is influenced by the type of end user, which could be a large number of small end users (households) or a small number of large end users (horticulturists). Both cases show that the risks accompanying behavioural uncertainty are a driver for integration as well. The next chapter evaluates the theoretical framework in a business setting to validate the importance of the criteria. Furthermore, the practical use of the framework is tested.
8 Evaluation

A workshop with TAQA employees from the business development department was carried out to evaluate the framework. All criteria from the theoretical framework were discussed one by one to identify if they are of importance in practice. The workshop protocol can be found in Appendix E. After the workshop, a survey was performed to test the practical use of the framework. The chapter discusses the findings.

Firm profile: TAQA Energy B.V.

Abu Dhabi National Energy Company (TAQA) is a global energy firm active in power generation, water desalination, oil and gas exploration and production, pipelines and gas storage. TAQA was established in 2005 by the Abu Dhabi government after privatization of the Emirate’s water and power sector (TAQA, 2013a). TAQA is listed on the Abu Dhabi Securities Exchange and the Abu Dhabi government retains 72.5% of the shares. The remaining shares are traded publicly. TAQA’s vision is to deliver “energy for growth: growth within our business; social and economic progress in the communities in which we operate; and increased value for our shareholders. We aim to run our company not only profitably but also sustainably, operating to the highest ethical standards”. In 2012 TAQA established their Energy Solutions business, which aims at developing alternative and technology-driven energy initiatives to access new growth opportunities. TAQA is active in a number of countries, including the Netherlands. Currently, TAQA owns several oil and gas fields in the northern part of the Netherlands, a gas storage facility near Alkmaar and TAQA is developing a second much larger gas storage facility in the same area (TAQA, 2013b). The TAQA strategy is based two pillars:

- Capabilities
- Geographical location

First, the strategic investment decision should fit the capabilities of the firm, in line with the resource-based view and dynamic capabilities theory. Second, the project should be in a suited location. For example a location where a regulatory framework is in place with which the firm already has experience. The findings of the workshop and survey at TAQA are discussed in the following sections.

8.1 Survey results

In this survey, the framework was tested on the requirements that were defined in chapter 5 (see Appendix F for full results). Four respondents scored the questions on a scale of 1 to 7. The outcome of the survey is shown in Figure 8-a below. Questions 3, 6, and 9 score relatively high overall. It can be concluded that the framework clearly shows how the SIO’s can be compared and that it provides clear guidelines. It also supports the strategic investment decision-making process in choosing what activities to perform. Question 8 scored lowest. The framework does not communicate the results clearly. When discussing this outcome with the respondents, it appeared that the colours are clear because they provide means to compare the options (also shown by question 6). In contrast, the scorecard does not show which options are assessed because the SIO’s on the scorecards are numbered (SIO 1, SIO 2 etc.). Therefore, this is adapted in the final framework with use of graphic representations of the strategic investment options.

Another important outcome of the survey and workshop is that not all criteria are equally important (see questions 2 and 5). The next sections discuss the relevance of the criteria and the implications for the final framework.
Overlap between the resources required for an activity and those owned by the firm is one of the most important drivers to make a strategic investment decision for TAQA. Especially the type of resource plays a significant role. For example as operator in heat production, it is essential to have experienced reservoir engineers and geologists. These human resources are difficult to imitate as an extensive study program is needed for this type of knowledge. Furthermore, these skills have a limited availability because not many students choose this field of study. Therefore, the type of resources required for an SIO could offer a strategic competitive advantage in comparison to other firms.

Framework implications
To provide an overview of all potential criteria, the four types of resources are included separately instead of as one large pile of resources. This way, it stands out which types of resources are present in the firm and which not. As a result, the firm can identify which resources should be acquired by the exchange of resources with other firms. The resources are categorized as physical, human, organizational or financial resources as shown in Table 8-a. The decision rule for resource overlap established in the previous chapter is used to assess the SIO’s (see Figure 7-d).

Figure 8-a: Scores evaluation survey
<table>
<thead>
<tr>
<th>Activity</th>
<th>Resource type</th>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investor in heat or power</td>
<td>Human</td>
<td>Market knowledge and intelligence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge on regulation</td>
</tr>
<tr>
<td></td>
<td>Financial</td>
<td>Financial capital</td>
</tr>
<tr>
<td></td>
<td>Physical</td>
<td>Access to physical technology and equipment</td>
</tr>
<tr>
<td>Project manager</td>
<td>Human</td>
<td>Experience and education of employees in the field of physical technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge and experience with project management of large engineering projects</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge and experience with regulations (permits etc.)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Communication to (third) parties</td>
</tr>
<tr>
<td>Operator of heat production</td>
<td>Human</td>
<td>Being able to assess risks for employees involved in heat production activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Being able to construct drilling plans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Experience and education of employees in the field of mining, geology and use of equipment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Knowledge on regulation</td>
</tr>
<tr>
<td></td>
<td>Organizational</td>
<td>Being able to be a safety and healthcare system present in which policy, organization, planning, execution, monitoring, evaluation and quality assurance of the heat production activities is measured</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Being able to carry out a self-assessment in which knowledge and capabilities of the firm are assessed in terms of well design, well construction, well control and emergency response</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relationships with other operators in the value chain</td>
</tr>
<tr>
<td></td>
<td>Financial</td>
<td>Financial capital</td>
</tr>
<tr>
<td>Operator of heat transfer</td>
<td>Human</td>
<td>Experience and education of employees in the field of physical technology and the use of equipment regarding heat transfer</td>
</tr>
<tr>
<td></td>
<td>Organizational</td>
<td>Knowledge on cheap transfer at high quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relationships with other operators in the value chain</td>
</tr>
<tr>
<td>Operator of heat network</td>
<td>Human</td>
<td>Experience and education of employees in the field of physical technology and the use of equipment regarding heat networks</td>
</tr>
<tr>
<td></td>
<td>Organizational</td>
<td>Knowledge on cheap transfer at high quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relationships with other operators in the value chain</td>
</tr>
<tr>
<td>Retailer of heat</td>
<td>Organizational</td>
<td>Being able to offer contracts in which tariffs, a clear and reasonable payment policy and a clear and reasonable policy to cancel or terminate the contract is defined</td>
</tr>
<tr>
<td></td>
<td>Human</td>
<td>Being able to handle complaints</td>
</tr>
<tr>
<td>Operator of power production</td>
<td>Organizational</td>
<td>Knowledge on cheap transfer at high quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Being able to manage program responsibility, this means that the firm should inform the transport operators one day ahead about their production for the following day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A good administration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relationships with operators of power network, TSO and DSO’s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Being able to offer contracts in which tariffs are defined, a clear and reasonable payment policy is defined and a clear and reasonable policy to cancel or terminate the contract is defined</td>
</tr>
<tr>
<td></td>
<td>Financial</td>
<td>Financial capital</td>
</tr>
<tr>
<td></td>
<td>Human</td>
<td>Being able to handle complaints in a good manner</td>
</tr>
<tr>
<td>Retailer of power</td>
<td>Organizational</td>
<td>Being able to manage program responsibility, this means that the firm should inform the transport operators one day ahead about their demand for the following day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A good administration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Being able to offer contracts in which tariffs are defined, a clear and reasonable payment policy is defined and a clear and reasonable policy to cancel or terminate the contract is defined</td>
</tr>
<tr>
<td></td>
<td>Financial</td>
<td>Financial capital</td>
</tr>
<tr>
<td></td>
<td>Human</td>
<td>Being able to handle complaints in a good manner</td>
</tr>
</tbody>
</table>

Table 8-a: Resource types
8.3 Learning

Besides frequency and flexibility, relational learning appeared as determinant for learning in the workshop. A firm can acquire resources with which it has only little experience by learning from partner firms. The knowledge from the partner can be copied or spills over. However, the partner firm(s) should indeed have experience with the activities. If not, both firms will have little experience and learning will not take place. In sum, the resource overlap between the firm and partner firm(s) should be low and the resource overlap of the partner firm(s) and the resource required for the SIO should be high. This way, relational learning could exist and increase spill over rents.

Framework implications
To determine if relational learning increases rents, information about the resources of the partner(s) is necessary. Therefore, relational learning is added to the relational criteria. Figure 8-b shows the decision rule. As seen in the figure, the resource overlap between the firm resources and the resources required for the SIO should be low, while the partner’s resources and the required resources for the SIO should be high.

![Rents driven by relational learning](image)

Figure 8-b: Decision rule relational learning

8.4 Environmental uncertainty

During the evaluation workshop, the importance of the regulatory scheme was confirmed. However, TAQA emphasizes the experience with the regulatory scheme before entering a market in a specific country. In other words, knowledge on regulation is needed before entering. Regulatory changes were not marked as specific problem. Even though the market and its regulatory changes are of importance in the geothermal industry (see 7.6), these and other determinants of environmental uncertainty are far less important according to TAQA. This been said, transaction cost criteria are of far less importance than the resource-based view. This is also caused by the fact that risks are not necessarily perceived as negative characteristic. As already said, every firm has its own risk and rent profile depending on its portfolio (see 5.2). In the oil and gas industry, high risks are often accompanied by high returns. In the Netherlands, there is only a 30-40% chance to find gas or oil (even with extensive exploration research). These risks can easily be borne because the returns are high and can balance the risk. However, risks caused by resource dependence and market complexity must not be underestimated as shown by the failed ADH project. Therefore, different risks have different effects.
Framework implications

In general, technological risks, like subsurface related uncertainties, can be insured as shown in section 7.6, and are of less importance for energy firms when making a strategic investment decision. Only market complexity and regulatory changes are taken into account.

8.5 No technological opportunities

Similar to the findings from the geothermal industry (see 7.5), technological opportunities are not of importance for TAQA. The techniques that are used to produce heat, transfer heat and transport heat are perceived mature which results in little to no R&D activity. Furthermore, the firms in the geothermal industry focus on cost reduction and increasing efficiency. R&D will only be performed by research institutes or by firms who have specialized R&D departments and are willing to invest a substantial amount of money in cost reduction technologies. Because the R&D activities are so little in number, technological opportunities will not be taken into account as a criterion in the framework.

8.6 Behavioural uncertainty

As shown in section 7.9, behavioural uncertainty is different for small and large consumers. However, during the workshop was found that the underlying problem is the difference between business and consumer. Both types have benefits and disadvantages which could decrease or increase risk. It is assumed that businesses, when the capacity of a heat source is equal, have a large demand and therefore will be small in number (range 1 to 20), while consumers have a small heat demand and will be large in number (>500). If a supplier delivers to large businesses, like greenhouses or industry, the risk of non-payment is spread over a little number and they all contribute to a large share of the supplier income. In contrast, consumers contribute only a minor part to the income of a supplier which lowers the risk.

Furthermore, the skills that are needed to service consumers are totally different than the skills that are needed to service businesses. For the first one, a wide range of retail resources are needed, while business end users do not require these resources. So, the contracts between consumers and business differ greatly and a firm should be experienced in one of these. In the framework, size of actors will be replaced by type of consumer as determinant of behavioural uncertainty. The decision rules can be found in Appendix G.

Framework implications

Because the type of consumer does not necessarily depend on size, but on the difference between business and consumer, the measurement of behavioural uncertainty is adjusted. Instead of small and large consumers, consumers and businesses are distinguished.

8.7 Conclusion on evaluation

In this chapter the sixth and seventh research question were answered:

6. Which criteria are used by TAQA to assess strategic investment options?
7. Is the framework useful to assess energy firm’s investment options compared to the requirements of the framework?

TAQA mainly uses resource-based view criteria in its assessment of strategic investment options. This is mainly caused by the fact that risks are not always seen as a negative effect as it often combines with high returns. It turned out that these risks are mainly technological risks. Other risks, for example resource dependence and environmental uncertainty, should not be underestimated as their impact can be large.
The survey demonstrated that the framework clearly shows how the SIO’s can be compared and that it supports the strategic investment decision-making process in choosing what activities to perform. However, improvements are necessary. The assessed strategic investment will be depicted with graphic overviews instead of number. Furthermore, resource overlap is divided in four types to increase the clarity of the framework results: physical, human, organizational and financial. Relational learning is added to the relational criteria, because the firm might be able to learn from its partners. The type of consumer, as determinant of behavioural uncertainty, is changed to business and consumer instead of small and large consumers. On basis of findings from chapters 7 and 0 the final framework is designed in the next chapter.
9 The strategic investment framework

This chapter answers the eight research question: “How can the framework be operationalized on the basis of findings from the geothermal industry and the evaluation findings?” The theoretical framework is applied to the geothermal industry and evaluated at TAQA. From these analyses appears that resource overlap, learning, resource dependence, and environmental uncertainty are of high importance to assess strategic investment options (SIO’s). In addition, besides behavioural uncertainty and trust, learning also plays a role in the relationship with a partner. Figure 9-a shows an overview of the resulting strategic investment framework. The framework consists of three rings that the user must go through from the outer ring towards the inner circle. In the following paragraphs, this framework is explained.

![Strategic investment framework](image)

**Outer ring**

The outer ring is the selection of SIO’s that will be assessed. The available activities and combinations between them can be found in Figure 7-a (see section 7.1). In section 7.1 appeared that there are many activities and combinations of activities possible. Depending on the firm’s preferences, a couple of SIO’s is selected. Some firms are used to combine certain activities and will continue this for geothermal energy. In addition, the preferences can result from the firm’s strategy and previous activities.

**Middle ring**

After selection of the SIO’s, three paths can be chosen based on the place in the decision-making process and the available knowledge on the partner.

- Internal, external and relational criteria are used when all knowledge is present and the firm is at the start of the decision-making process.
- Only internal and external criteria are used when no knowledge on the partner is present.
Only relational criteria are used when the firm prefers to define the partner sensitivity only. For example when the preferred activities are already determined, but different partners are available.

Table 9-a shows the external criteria. Every SIO is assessed by measuring the characteristics from the middle column. These characteristics define the amount of risk associated with the SIO. Internal criteria are shown in Table 9-b. Again, the middle column shows the characteristics which measure the amount of rent of the SIO. The decision rules for the measurements were defined in chapter 7 and 8. A full overview is provided in Appendix G. It can be concluded that external criteria define the amount of risk accompanying an SIO and internal criteria define the amount of rent accompanying and SIO.

<table>
<thead>
<tr>
<th>External criteria</th>
<th>Characteristics</th>
<th>Risk or rent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource dependence</td>
<td>Number of resource dependent transactions</td>
<td>Risk</td>
</tr>
<tr>
<td></td>
<td>Physical asset specificity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Site asset specificity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Human asset specificity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dedicated asset specificity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Share of total number of products</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Possession of resources</td>
<td></td>
</tr>
<tr>
<td>Environmental uncertainty</td>
<td>Market complexity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regulatory changes</td>
<td></td>
</tr>
</tbody>
</table>

Table 9-a: External criteria

<table>
<thead>
<tr>
<th>Internal criteria</th>
<th>Characteristics</th>
<th>Risk or rent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical resources</td>
<td>Overlap of physical resources between firm and SIO</td>
<td>Rent</td>
</tr>
<tr>
<td></td>
<td>Overlap of physical resources between firm/SIO and competitors</td>
<td></td>
</tr>
<tr>
<td>Organizational resources</td>
<td>Overlap of organizational resources between firm and SIO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overlap of organizational resources between firm/SIO and competitors</td>
<td></td>
</tr>
<tr>
<td>Human resources</td>
<td>Overlap of human resources between firm and SIO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overlap of human resources between firm/SIO and competitors</td>
<td></td>
</tr>
<tr>
<td>Financial resources</td>
<td>Overlap of human resources between firm and SIO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Overlap of human resources between firm/SIO and competitors</td>
<td></td>
</tr>
<tr>
<td>Learning</td>
<td>Decentralization of firm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Local autonomy of employees in firm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resource overlap between firm and SIO</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency of performing activities</td>
<td></td>
</tr>
</tbody>
</table>

Table 9-b: Internal criteria

Relational criteria influence relational rents and relational risks as shown in Table 9-c. These criteria influence both risk and rent. Note that these relational criteria have to be scored for every partner to get a full overview of the sensitivity for all partner(s) of an SIO.
The level of risk or rent of an SIO is identified for every criterion has to be displayed in the scorecard shown in Table 9-d. To make the overview clear, the SIO’s are added as figures to see which alternatives are assessed. Examples of two graphical representations are shown in the table. The two strategic investment options are both including activities from the heat value chain. In the left column, the firm is investor in heat production, heat transfer and heat transport, and retailer of heat. In the right column, the firm is both investor and operator in heat production, heat transfer and heat transport. Similar to the theoretical framework, every SIO is scored with use of colours (see Appendix G for a total overview of the decision rules).

<table>
<thead>
<tr>
<th>Relational criteria</th>
<th>Characteristics</th>
<th>Risk or rent?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>Resource overlap between firm and partner firms</td>
<td>Rent</td>
</tr>
<tr>
<td></td>
<td>Resource overlap of partner firm and partner SIO</td>
<td></td>
</tr>
<tr>
<td>Trust</td>
<td>Frequency of transactions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Performance of partner in previous projects</td>
<td></td>
</tr>
<tr>
<td>Behavioural uncertainty</td>
<td>Size of actors</td>
<td>Risk</td>
</tr>
<tr>
<td></td>
<td>Product complexity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Resource overlap with partner</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strategy overlap with partner</td>
<td></td>
</tr>
</tbody>
</table>

Table 9-c: Relational criteria

Table 9-d: Performance scorecard
Part IV: Discussion, conclusion and reflection
10 Discussion and future work

In this research, a strategic investment framework was developed with use of theory and practice. Firms can use the framework to assess strategic investment options in order to make a strategic investment decision. Characteristics from transaction cost theory, the resource-based view and resource dependence theory were applied to the geothermal industry in a case study and evaluated at TAQA. This chapter discusses the theories used and the strategic investment framework.

10.1 Theoretical discussion

Transaction cost theory
The geothermal industry is currently highly integrated. All activities in operational projects are combined and performed by one firm or partnership (see chapter 7). In previous theoretical research, transaction cost theory was often named as the most important determinant in the decision to integrate activities in a firm. In other words, it is the most important determinant of the strategic investment decision (Madhok, 1998; Williamson, 1975, 1979). However, the case study and evaluation workshop show that transaction cost constructs were of less importance than initially assumed by theory. The main drivers in the geothermal industry and at energy firm TAQA were resource dependence and the overlap between resources required for the strategic investment and those owned by the firm.

Resource dependence versus transaction costs
Asset specificity, a transaction cost characteristic, is defined as a determinant of resource dependence. This is a justified assumption as firms partly base their decision to integrate activities on the specificities in the heat value chain. Hence, transaction cost theory and resource dependence are closely linked.

However, asset specificity and resource dependence are different theoretical concepts. Transaction cost theory assumes that dependence originates only from the specificity of an asset that is related to a transaction. The goal is to reduce the costs associated with this transaction to increase efficiency. In contrast, resource dependence assumes that dependence is defined not only by the specificity of a resource. Otherwise, every specific resource would create dependence which is not the case in practice. It is also important that the firm cannot control or possess the resource, because this necessitates resource exchange between firms. The aim of resource dependence theory is to decrease dependence by increasing control over resources. As a result, resource dependence shifts the focus from efficiency of the transaction to a broader field of power and control.

The case study shows that resource dependence is one of the most important factors in the geothermal industry. This is created by asset specificity. However, the goal is not to create efficiency, as transaction cost theory prescribes, but to gain control, which is in agreement with resource dependence theory. This is especially true for horticulturists who are currently operating the majority of the projects. They do not trust other firms and want to be independent. In the Aardwarmte Den Haag project, the goal of the integration was to gain control as well. Integrating activities decreased risks created by resource dependence. Again, the aim of transaction cost, namely efficiency, was not applicable.

A likely explanation of the preference for control in the geothermal industry is the nascent character and the fact that there exist no real market, but local monopolies. Could it be the case that resource dependence is more important in these kinds of markets? This agrees with the findings from Santos and Eisenhardt (2005) who argue that resource dependence is more applicable in oligopolistic or ambiguous markets where the industry is highly concentrated and overall uncertainty is high. During market development, the structure of the market is not yet clear and it is difficult to specify costs, dependence relationships and competencies that are of importance (Bingham et al., 2007; Rao, 1994). When these market characteristics are not clear, efficiency is too complex to define and not of
importance yet. Firms focus on the establishment of power relations and resources and capabilities needed for the market. When these factors are clear and the market is mature, the time has come to focus on efficiency.

Future work should investigate the relation between efficiency and power in a more extensive way to gain a better understanding of the applicability of both concepts in different development stages of a market. The analysis of the geothermal industry implies that the most important aim of transaction costs, efficiency, would be inapplicable to markets in an early stage of development.

Besides researching the theories in a competitive way, there should also be room for situations in which both theories are applicable. As seen in the Aardwarmte Den Haag case, environmental changes reinforce the risks associated with resource dependence. This contributed to the failure of the project. In markets with low resource dependence, the effect would have been much smaller. There is a large possibility that other end users or other partners would have been willing to enter the project. Both transaction cost theory and resource dependence theory could be elaborated on by using each other’s characteristics. There even might be a possibility to develop a symbiotic theory that is applicable to different markets, nascent and more developed, in which both theories are combined. Future research should investigate these possibilities to contribute to the development of the geothermal industry.

**Resource-based view versus resource dependence**

Besides efficiency, competitive advantage created by resources is also not of importance in a non-competitive environment like the geothermal industry. Horticulturists do not use a geothermal well to become a major player in the geothermal industry. This means that a competitive advantage is not the main goal of integrating activities. In fact, horticulturists are very cooperative because it is a one-time project.

In contrast, the evaluation shows that resources are the most important criterion to assess strategic investment options for TAQA. What makes the case studies and the evaluation within TAQA different? Because horticulturists are doing a one-time project, control is valued more than resources. Activities for which firms did not have the required resources were still carried out to gain maximum control. In non-competitive environments, resource dependence overrules the importance of resource overlap between the firm resources and those required for the strategic investment decision, in agreement with the empirical findings from O’Mahony and Bechky (2008) and Mayer and Nickerson (2005). In contrast, TAQA operates in a competitive environment where resources and capabilities define the firm’s competitive advantage. In these environments, the resource-based view characteristics are of high importance. However, if an energy firm like TAQA wants to enter the geothermal market, it is advised to take into account resource dependence as well, because it is high in the geothermal industry. Future work should investigate the relationship between the resource-based view and resource dependence theory in nascent markets. What are consequences of focusing on one of the theories and does resource dependence always prevail over the other theoretical views in these types of markets? Hence, the understanding of strategic investment decisions in nascent markets is enlarged and better decisions can be made.

**Resource-based view and dynamic capabilities**

The resource-based view was broadened with dynamic capabilities theory because resources and capabilities are closely linked and often used interchangeably. During the analysis it appeared that many characteristics of dynamic capabilities overlap with other theoretical characteristics that have a more prominent place in research. Only one capability appeared to have a large influence: learning. Learning increases the chance to obtain rents when a low overlap exists between the firm resources and the resources required for the strategic investment. If the firm does not possess the required resources, they can be acquired when the firm performs an activity more often. However, learning becomes problematic if activities are highly specific because every activity is then different. Future research
should investigate the relationship between resources, learning, and specificity in relation to the strategic investment decision to gain a better insight in these learning processes. Furthermore, more insight into the relation between the resource-based view, dynamic capabilities and transaction cost theory is gained.

**Conclusion**

In this section, the ninth sub-question is answered: "Are the theories that were used to construct the theoretical framework suitable to assess strategic investment options of a firm?". The differences between the case study and the evaluation workshop shows that not one theory is suited for every situation as the theories have different aims. This mostly depends on the development of the market: is it mature, nascent or something else? It appears that resources are especially important in competitive markets; while resource dependence is important in markets where the firm does not directly compete, like horticultural industry. Transaction costs might be important in mature markets and did not prove to be of high value for the geothermal industry with its nascent character.

### 10.2 Framework discussion

**Reliability and validity of the framework**

The final framework is developed with the use of a case study and an evaluation session at TAQA. This gave much insight into the geothermal industry and into strategic investment decision-making in practice. However, there has not been an extensive validation of the framework yet. In order to increase validity and reliability of the strategic investment framework, testing is needed.

First, the contents of the framework should be tested. Because the framework is based on an evaluation workshop at TAQA, the framework might be biased towards the preferences of TAQA. To overcome this bias and increase the generalizability of the findings, it is proposed to test the framework in a real-life context at other energy firms. It should especially be tested at other oil and gas firms (e.g. Shell, Exxon etc.) and energy firms with more experience in other parts of the value chain. In other words, energy transport and energy retail firms (e.g. Eneco, E-on etc.). The importance of the criteria can be researched by doing more interviews or by organizing a workshop with different actors and interaction between them. Furthermore, the validity of the decision rules is studied. As a result, consensus on the most important criteria and their measurement may be reached.

Besides improvements on the content side of the framework, the practical use of the framework must be tested more extensively. During this test, it is important that the firm that uses the framework is able to use it without external help from a facilitator. Therefore, a framework manual should be constructed. This manual should contain the following documents:

- Introduction to the strategic investment framework, explanation of its aim and how it works
- All available strategic investment options (Figure 11-b)
- Decision rules (Appendix G)
- Scorecards (Table 9-d)

Furthermore, the test should be performed at different firms and multiple times to increase the validity of the test. The test shows whether the firm is able to use the framework without external help and if the framework is easy to use.

To implement the framework, the user needs to understand the firm, its resources and the market in which the firm is active. While this might seem evident, it can be difficult in some situations. Danneels (2011) argues that it is not only resources that affect competitive advantage, but also the managerial resource cognition about those resources. Resources cannot be considered as a given to managers. Firms often lack a clear understanding of their own capabilities (Schreyögg & Kliesch-Eberl, 2007). The resources required to pursue activities in the geothermal industry, as defined in Table 8-a,
Discussion and future work

are defined in order to ease this exercise. However, it will be of interest to pay special attention to the framework user’s capabilities during testing.

Strategic decision-making processes

The strategic investment decision is part of a decision-making process within a firm (see 3.1). Up to this moment, it was indicated that this increases the complexity of making a strategic investment decision, but no specific attention was given to the problems surrounding such a decision-making process. As appeared in the interview with Gittins (2013), decisions are made in a network of employees who have to agree with the next step the firm takes. In a network of actors, there might be opposing views, which could result in strategic behaviour (de Bruijn & ten Heuvelhof, 2008). When implementing the framework using its results, this network of actors should be taken into account. The role of this decision-making process should be further explored.

In a further stage of the decision-making process, a project and partner firms are selected. While selection implies free choice, this is a decision-making process as well. Is the framework able to advice strategic investments that are fit for the focal firm and its partners? The role of this decision-making network in relation to the framework should be investigated in future research.

Applicability of the framework

While the strategic investment framework is designed for energy firms in the geothermal industry, it might be applicable to other firms as well. As the framework gives an overview of all rents and risks, the outcome is not focused on a particular type of firm. Every firm can choose if it likes to take certain risks and levels of rent. The strategic investment options included might be broadened towards construction, maintenance and, consulting or engineering activities as displayed in Appendix C. However, several criteria have to be defined first before the framework can be used for these activities in practice. The resources required for the strategic investment options, the resource dependence of the transactions and the environmental uncertainties of these activities are currently unknown.

Although the criteria are customized for the geothermal industry, they are based on general theoretical characteristics that are not coupled to specific industries. Therefore, they might be applicable to other industries as well. Several criteria appeared to be of little importance in the geothermal industry, like technological opportunities. When applying the framework to new industries, it is interesting to investigate if these criteria are also of little importance and if additional criteria are used in practice. To be able to apply the framework to other industries, strategic investment options for these industries must be identified. In addition, criteria have to be defined in practice (resource dependence, required resources etc.).

When the framework is applied to other firms and other industries, it is possible to verify the criteria and maybe also to discover other additional criteria. Therefore, it is encouraged to research the applicability of the framework in other industries and discover the application range of the strategic investment framework.
11 Conclusion and recommendations

Geothermal energy gained more and more attention over the past few years in light of our fossil fuel based economy and its effects on the climate. Geothermal energy is a renewable source with limited air emissions and it can provide reliable base-load power. The potential for geothermal energy in the Netherlands is large and geothermal heat is cheaper than many other renewable energy sources. However, firms do not know which actors and regulations are important, as the geothermal industry is a nascent market. Furthermore, current geothermal facilities deliver heat to greenhouses, which are often local projects. The only project that would deliver heat to a large number of households, Aardwarmte Den Haag, has foundered. In short, firms do not know what role to play in the geothermal industry. Therefore, the following research question was defined in this research:

*How can energy firms be supported in assessing strategic investment options in the geothermal industry in the Netherlands?*

In this research, a strategic investment framework is developed to support energy firms in the assessment of strategic investment options. The framework is based on theory, empirical cases from the geothermal industry and an evaluation session at an energy firm. The following sections answer the main research question and provide recommendations for future research.

11.1 The strategic investment framework

The framework developed in this research is depicted in Figure 11-a. It consists of three components, which the user must go through from the outer ring towards the inner circle.
In the outer ring, the strategic investment options for energy firms in the geothermal industry are selected in order to assess them. In the middle ring, these strategic investment options are assessed with use of three types of criteria: internal, external and relational criteria.

Internal criteria look inside the firm. Does the firm have the required resources, for example technical knowledge, financial capital or organizational relationships, to perform the activities in the geothermal industry? And if not, is the firm able to acquire these resources through learning? For example by performing the activity often or because the firm is highly flexible and can easily adapt to new activities?

External criteria deal with the environment of the firm. Is there a large chance of regulatory changes or changes in the market when choosing this strategic investment option? Are the activities included in the strategic investment option dependent on resources of other firms in order to succeed?

Relational criteria look at the sensitivity of the partner when choosing a strategic investment option, if there is a partner involved. Is a high level of trust present between the firm and the partner(s) in this strategic investment option? Is there a large chance that the partner does not behave as agreed in the contract? And is the firm able to learn from the partner(s)? Relational criteria have to be defined for each partner.

If all these criteria are defined, the inner circle can be entered in which the criteria are scored on their performance level. The performance level is measured in rent and risk. What is the chance that a strategic investment option will deliver high rents to the firm? And what are the risks accompanying this strategic investment option? This is displayed in the following score card, shown in Table 11-a.

<table>
<thead>
<tr>
<th>External criteria - risk</th>
<th>Resource dependence</th>
<th>Environmental uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal criteria - rent</td>
<td>Physical resources</td>
<td>Organizational resources</td>
</tr>
<tr>
<td></td>
<td>Human resources</td>
<td>Financial resources</td>
</tr>
<tr>
<td></td>
<td>Learning</td>
<td></td>
</tr>
<tr>
<td>Relationa l criteria – rent and risk</td>
<td>Learning</td>
<td>Trust</td>
</tr>
</tbody>
</table>

Table 11-a: Performance score card

In order to assess a strategic investment decision on relational criteria, information on the partner firm is necessary. However, in early stages of the decision-making process, this information might not be available. In that case the strategic investment options are only assessed on internal and external criteria.

The evaluation session at TAQA showed that the framework supports the decision-making process and is useful to compare strategic investment options. To support energy firms in the
geothermal industry in the Netherlands, the strategic investment options available were identified. These are discussed in the next section.

11.2 Strategic investment options in the geothermal industry

Theory was used to explore strategic investment options. It was found that each strategic investment option has two dimensions: the stage of integration and the breadth of integration. The stage of integration is the step in the value chain in which the firm is active. The breadth of integration is the number of activities within this step of the value chain. In the geothermal industry, two value chains appear: the heat value chain and the power value chain. The value chain steps are depicted in blue and in orange in Figure 11-b. Four activities can be distinguished within the breadth of integration: investor, operator, project manager and retailer. These are depicted in purple in the figure below. Every firm in the geothermal value chain has a transaction with other firms in the value chain. These are depicted with black arrows. An energy firm can choose to perform any of the purple activities in the value chain and can choose to perform only one activity or perform a combination of activities. An example of a strategic investment option is to invest in heat production and heat transfer and also to manage the project of constructing the heat production and heat transfer facility. By combining different activities, many strategic investment options are possible.

![Figure 11-b: Overview of activities that could be performed in the geothermal industry](image)

The selection process of strategic investment options is part of a decision-making process that is partly internal to the firm, but also partly an inter-firm process. The framework will be used as a support tool during this process. This way, the firm can make a provisory strategic investment decision and the framework outcomes can be used during the negotiation process with partner firms.

Besides strategic investment options in the geothermal industry, criteria applicable to this specific industry were researched. This increased the knowledge on the geothermal industry and on the applicability of theories used to develop the framework.

11.3 Implications for the geothermal industry

From the case study analysis can be concluded that strategic investment decisions of firms in the geothermal industry are highly integrated. The current projects all deliver heat to greenhouses and the
horticulturists are performing all activities by their selves. They are investor, operator and consumer in all steps of the heat value chain. Reason for this integrated strategic investment decision is the high level of resource dependence present in the geothermal heat value chain. In contrast to power, heat cannot be transported over large distances because of heat loss. Geothermal heat projects are, therefore, always dependent on local demand. In combination with high fixed up-front investments, local monopolies arise with only one supplier and a small number of consumers. This increases dependence between the steps in the heat value chain. Besides, there is a low level of trust between firms and they fear for opportunistic behaviour of partner(s). To increase control and decrease dependence, firms choose for integrated strategic investment options. However, not every activity can be integrated easily as many resources are required to receive a permit for heat production, power production, and retail activities. Horticulturists and municipalities no longer receive permits as they do not have the required technical knowledge. Firms that have the required knowledge, like oil and gas firms, are reluctant to invest because of the lower returns compared to oil and gas and the immaturity of the industry. The high level of both resource dependence and required resources hampers the development of geothermal heat projects in the Netherlands. High levels of resource dependence on the other hand do not affect geothermal power. However, this technology is still in development. Hopefully, geothermal power will become an important renewable alternative for fossil fuels in future projects.

11.4 Recommendations for future theoretical work

Besides implications for the geothermal industry, opportunities for future research were found. The assessment criteria are based on three theoretical views: the resource-based view which focuses on maximizing competitive advantage, transaction cost theory which focuses on minimization of transaction costs, and resource dependence theory which focuses on maximizing control in order to decrease dependence. As shown in the previous section, resource dependence theory is the driver for strategic investment decisions in the geothermal industry. On the other hand, the evaluation at TAQA showed that the resource-based view is one of the most important drivers for decision-making in energy firms. Transaction cost theory was of less importance in both the case study analysis and the evaluation.

The different preferences depend on the maturity and type of market in which a firm is active. In nascent markets where limited competition exists, dealing with dependence is more crucial than minimizing transaction costs or resource mismatches that limit competitive advantage. Horticulturists perform the project only once and do not pursue a competitive position in the geothermal industry. In contrast, TAQA operates in more competitive markets and aims for a competitive position. Future work should investigate the relation between market maturity and the importance of criteria in more detail to be able to encourage the development of the geothermal industry and the understanding of strategic investments.

However, the three theories are not always competing. In some situations, theoretical characteristics of different theories reinforce each other. For example, environmental uncertainty and resource dependence. Future work should investigate the relationship between characteristics from the three theories in order to broaden the different views. There even might be a possibility to develop a symbiotic theory, in which different theories are combined in such a way that it is applicable to different markets, nascent and mature.

11.5 Recommendations for the strategic investment framework

The framework developed in this research is based on theory, empirical findings and an evaluation at TAQA. This evaluation consisted of a workshop and survey with four respondents. This is a small sample size and, therefore, additional testing is recommended. Furthermore, the practical use of the framework and the validity of the decision rules have not been extensively tested. Specific attention should be
given to the validation of the decision rules and the importance of the criteria at other energy firms. When the framework is validated by energy firms in the geothermal industry, it might also be possible to apply the framework to other firms and other industries. This way, it is possible to discover the framework’s applicability in a broader environment and potentially develop a general assessment framework for strategic investment decisions of firms.

11.6 Practical recommendations

Besides recommendations on theory and the framework, recommendations can be made to TAQA, because insight was gained on the decision-making process and the geothermal industry. First of all, each firm and each industry is unique. This entails that no general strategic investment option can be chosen for the geothermal industry. The best strategic investment depends on the resources of the firm, resources required for the strategic investment, the partner firms and environmental factors like the market and the regulatory scheme. Second, these factors are dynamic and subject to changes in the firm and the environment. Therefore, continuous evaluation of the strategic investment framework, the strategic investment options and the decision rules is recommended to cope with this dynamicity. Thirdly, during the evaluation workshop appeared that TAQA’s strategic investments are mainly driven by high resource overlap between the firm and those required for the investment. However, in the geothermal industry, resource dependence is of high importance and this might be the case for other industries as well. Therefore, when TAQA considers to enter an industry, it is advised to investigate all criteria included in the strategic investment framework to assure that other factors are not overlooked.
12 Reflection

In this chapter, a reflection is given on the scientific and societal contribution of the research, the research approach and design and the research result.

12.1 Scientific contribution

The scientific purpose of this study was to advance scientific literature, in particular transaction cost theory, the resource-based view and resource dependence theory, by confronting it with an empirical case study and evaluation. The resource-based view was broadened with dynamic capabilities theory because resources and capabilities are used interchangeably. Also, an existing framework developed by Ferrier (2013) was used to gain insight in these theories. The case study and evaluation definitely gave new insights into the practical use of the theories as it showed that resource dependence is the main driver for strategic investment decisions in the geothermal industry and the resource-based view is the main driver for TAQA’s strategic investments. In addition, the case study and evaluation showed why these theories are of importance and why certain theories are used in nascent markets and others are not. Furthermore, relations between the theoretical views were found as some of the theoretical characteristics reinforce each other. The relationships between the criteria come back in the framework and it is believed that the framework clearly represents the findings from the geothermal industry and the evaluation. Even though the framework needs additional testing at energy firms in the geothermal industry, it provides a clear overview of the effects of strategic investment options on firm performance.

12.2 Societal contribution

This research is one of the first non-technical contributions to the geothermal research field. There are currently several operational facilities in the Netherlands, which have little to no technical difficulties. This research shows that many non-technical problems are of high importance for the development of the geothermal industry. The main problems in the geothermal industry arise from the high level of resource dependence, the strict regulations on required resources by the State supervision of Mines, regulatory changes and the high level of fixed up-front investments. These industry characteristics define why strategic investment decisions are made and why firms show certain behaviour. When designing policy measures to support the development of the geothermal market, these characteristics are very important to take into account. However, it must be noted that many of the characteristics result from factors that are hard to influence, like the high heat loss during transport of heat or environmental uncertainties like the economic crisis. This makes the design of policy measures to support the geothermal industry a complex task.

12.3 Research approach

The research was an incremental journey. During the research, definitions have been changed several times. The most important struggle was the definition of strategic investment decision. At the start of the project, ‘role’ was used to cover the activities in the geothermal industry. This caused the focus to shift to stakeholders, while the problem was not a stakeholder problem, but a firm problem. Furthermore, roles are not a well-known concept in theory. After many detours through theory and conversations with supervisors and experts in the field, strategic investment decision was chosen as the main definition and the focus of the research. I must say that I am happy with this definition, as it is a definition that is easy to grasp both in the academic world and in business environments. However, the use of strategic investment decision in theory is not common. It might be of value to explore this definition in more detail in order to develop a more common understanding.
Besides the struggle with the strategic investment decision, I also struggled with the definition of the firm performance. It was assumed that rent and risk could cover firm performance. During the evaluation workshop, supervisory meetings and conversations within TAQA, it appeared that rent is not commonly used in practice and hard to grasp when you are not familiar with the topic, while risks are often used as the unit of analysis in business environments. This could hamper the practical use of the framework. Therefore, it would be of value to explore this definition to come up with a definition of rent that is easier to grasp.

Initially, all activities in the geothermal industry and geothermal projects were taken into account. Examples are consulting activities, engineering, provision of financial capital, insurance and construction activities. This made the framework very unworkable and the focus shifted from a firm’s strategic investment decision to project management. The reason for this initial ‘project’ focus was the phase in which the industry is in at this moment. Currently, many projects are initiated, developed, built or in operation for a short period of time. Therefore, all interviewed experts of the industry talk about projects. However, to define strategic investment decisions of a firm, not all project activities are relevant. So, when the focus shifted to only a small number of activities, a clearer overview and workable framework was achieved.

It was assumed in the scope definition that there are a fixed number of steps in the value chain and that there are a fixed number of activities that should be carried out. However, technological innovations show that there are more activities that can be included. Examples are storage of heat or the use of heat for cooling purposes. This indicates that the activities in the geothermal industry are not fixed and subject to changes due to the dynamic environment. Furthermore, there is an additional activity that was not taken into account: the heat transfer step in the house of the consumer. It was believed that this would not have any influence on the strategic investment decision of a firm.

Only a few energy firms are currently active in the geothermal industry while this is the key user of the framework. Around ten interviews for the case study were carried out, but with different actors from the market. Many of the findings on the geothermal industry are derived from the horticulturist case. This enlarged the understanding of the geothermal industry, but the findings could not all be used for the framework. An increased number of interviews at energy firms would have been very valuable.

As further on in the research more insights were gained on theory, it would have been very useful to carry out more interviews to test the assumptions and relationships between criteria. However, this was a trade-off between time and number of interviews. I could either do more interviews or finish the project within a reasonable time. Instead of additional interviews an evaluation workshop was carried out at TAQA. This way, information from an energy firm was gained that was not yet active in the geothermal industry. This showed many new findings and was very useful.

The interviews were all very different and every interviewee answers questions differently. In some cases, not all questions were handled because of limited time. This could have influenced the research results. Furthermore, the interview questions were subject to the learning curve of the interviewer. In the first interviews it became clear what interview questions were easy to understand for interviewees and what questions were hard to explain to interviewees. Therefore, the interview questions improved as more and more interviews were carried out. However, because multiple interviewees covered most topics and different interviewees often repeated statements, valid conclusions could still be drawn from the interviews.

12.4 Research result

The result of the research is a strategic investment framework that can be used during decision-making processes in making a strategic investment decision. The framework output shows the risks and rents associated with different strategic investment options. This gives a clear overview of the benefits and disadvantages of an option. However, there are some criteria that could show that a strategic
investment decision is not be suitable. These criteria are not included in the framework, for example, the detailed technical or detailed financial feasibility of a certain project. It is assumed that the technical and financial departments will perform these analyses when strategic investment decisions are being made. So, these types of criteria are important in a later phase of the decision-making process. In discussions with TAQA employees appeared that detailed financial information is of key importance when selecting a project. Important criteria are among others: well depth, network size and number of end users. The criteria can only be defined if detailed project information is available. Still, it would be interesting to explore these criteria in more depth to see if they could fit the framework in some way.

The framework shows the risks and rents that accompany a strategic investment option. It should be noted that rent is relative. Therefore, a thorough competitor analysis should be carried out to define the competitive advantage that is created by the possession of resources. The framework does not provide guidance in how to perform such an analysis at this moment, which could be improved in further research.

There is no direct relationship between the theoretical criteria from transaction cost theory, the resource based view and dynamic capabilities and risk and rent. This relationship should be statistically tested with empirical cases to determine if these relationships are valid.

Control (or dependence) is a choice according to resource dependence theory, for example by choosing (non)-ownership mechanisms to control partner firm(s). Resource dependence theory assumes that even though there are no specificities, firms could choose to integrate to gain control. At this moment, non-ownership mechanisms are not included in the framework. Only integration or outsourcing is possible, the traditional make or buy decision. Future research might look at other types of (non)-ownership mechanisms to enlarge the validity of the framework and to make the framework applicable to a wider range of situations.
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