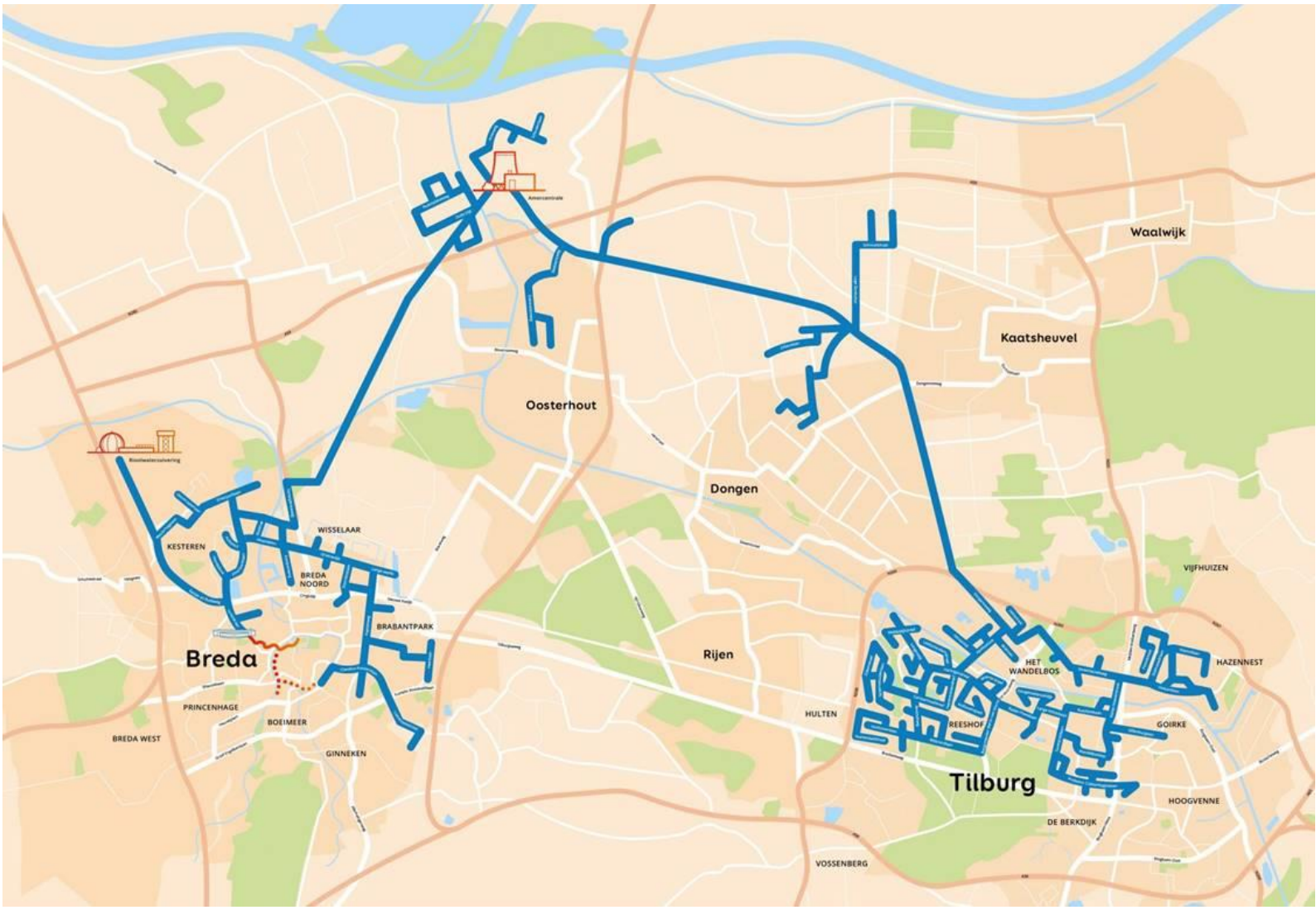
Adding sustainable heat sources to the Amernet

An institutional problem or an institutional chance?



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Abstract

Adding sustainable heat sources to existing district heating networks is an answer to the increasing focus on becoming sustainable. However, adding sustainable heat sources to existing district heating networks is difficult. This aim of this research is to understand which change is needed to create an institutional framework which can allow for the addition of sustainable heat sources. This will be assessed by focusing on opportunities, barriers, and windows of opportunity. 12 semi-structured interviews were held with stakeholders of the Amernet (Noord-Brabant, Netherlands). These interviews were analysed using the SPELT analysis (a variation on the PESTEL analysis). Opportunities include a cooperation platform and the SDE subsidy. Barriers include lack of trust, lack of public support for biomass, waiting for political decisions and the need for a lower temperature. Windows of opportunity include the creation of Heat vision plans, a new Heat law and the focus on creating a smart network. Most of the barriers can be addressed by windows of opportunity, indicating that institutional framework changes help in adding sustainable heat sources to existing district heating networks.

Table of contents

1. The problem

1.1. Introduction

District heating exists in the Netherlands for some decades (Schepers & Van Valkengoed, 2009). Many district heating networks exist since the 1980s, a network in Rotterdam even since 1946. Although the technique is old, there is a wave of new district heating networks evolving in the Netherlands, for example in Groningen, Hoogezand and Wageningen. The municipal government is often the main initiator of these new district heating networks. The governments of these municipalities put an effort in setting up these new modes of heating, because of expected legislation (2021) of the national Dutch government to change their neighbourhoods from natural gas based to sustainable-energy based (Natuur & Milieu, 2019). In addition, this new focus on sustainable energy (consumption) gives rise to challenges for already existing district heating networks (Fang et al., 2017; Sayegh et al., 2017). These challenges are likely to result in deadlocks (Heldeweg et al., 2017).

1.2. The challenge

Attracting new sustainable heat sources to already existing district heating networks is difficult (Sayegh et al., 2017). First, financial responsibilities are difficult to divide, the initial investment costs as well as the financial risks are (too) high (Osman, 2017). The government needs to circumvent these financial problems, because private parties are not willing to participate under these circumstances (De Boer, 2019). Second, different sources of heat provide different qualities of heat, like temperature and capacity to provide for peak demand. This influences the isolation that houses need, the amount of houses that can be connected to district heating and the distance over which heat can be transported (Fang et al., 2015; Lund et al., 2014).

Besides attracting new sustainable heat sources, existing district heating networks face a growth in consumption. There needs to be enough energy to provide for this growth. More neighbourhoods are being connected to existing district heating networks. This growth is often wanted by municipalities and housing corporations, pressured by upcoming legislation to become less dependent on natural gas (Rekenkamer Metropool Amsterdam, 2019). On the other hand, consumers often resist or distrust district heating networks. When connected, consumers do not have control over which company supplies their heat (Homan, 2018). In addition, when consumers have ownership over their house, they have to pay for the new connection to the grid. Besides, consumers have to pay a higher price than the price for natural gas (Overheid, 2019; RTVOost, 2017). Adding to this, many consumers have the feeling that they are cheated by monopolism, whilst heat distribution is forced by law to be run by a monopolist.

Attracting new sustainable heat sources, whilst enlarging the existing district heating network is difficult to balance. For example, stakeholders of the Amernet try to attract new sustainable heat sources and enlarge the amount of connections to the Amernet at the same time. This aim led to the signing of a contract of good intentions (ISSUU, 2019). Unfortunately, it is not clear how to solve the problems yet.

These problems are not only technical (Ayah et al., 2007; Heldeweg et al., 2017; Lund et al., 2014), but can also arise from existing laws and business structures (Lammers & Heldeweg, 2016). These laws and structures can be seen as an existing framework. According to De Roo (2014), this existing framework can be seen as the institutional component of reality. An important problem of the institutional reality of district heating is economical (Colemenar-Santos et al., 2015). It is often difficult to construct a fitting business case to add a sustainable heat source to already existing district heating networks, as investment costs are high and an established alternative already exists. Besides, attracting new sustainable heat sources is a political problem. Reducing CO_2 emissions and heating without natural

gas have become goals in policies (RVO, 2019). The political system tries to influence this transition by demanding sustainable heat sources to be added to existing district heating networks. These policy goals are often translated into laws. Laws are perceived to be part of the legal dimension. Therefore, also the legal dimension affects the institutional reality. In addition, social problems define institutional reality as well. As already mentioned, there is in some places a distrust against district heating due to its monopolism. Next to this, some sources of heat require an improved isolation of houses (Lund et al., 2014). Both a connection to the grid and isolation of houses requires support from civilians. Therefore, public support has to be established in order to include new sustainable heat sources successfully.

1.3. Research questions

Facing these problems, this research will go deeper into how new sources of heat can be incorporated in existing district heating networks. This will be done by the following question, followed by three sub-questions:

"How should the current institutional framework be changed to overcome the barriers in adding sustainable heat sources to existing district heating networks?"

1. What are opportunities for adding sustainable heat sources to district heating networks in the current institutional framework?
2. What are barriers for adding sustainable heat sources to district heating networks in the current institutional framework?
3. How should be the current institutional framework be changed to overcome the barriers resulting from the current institutional framework?

The aim of this research is to understand which change is needed to create an institutional framework which can allow for the addition of sustainable heat sources. The first sub-question will support this aim by addressing what does not need to be changed and should remain in place. The question will be answered using a case: the Amernet.

1.4. Relevance

This study is relevant from a social and from an academic perspective. The academic relevance is established in the contribution of this study to keep up with global trends. District heating is a growing phenomenon in the world (Colmenar-Santos et al., 2015). A more efficient use of energy is one of the ways to go in the sustainability era. However, not much is known about how district heating networks can add sustainable heat sources. The possibility of adding sustainable heat sources to district heating networks is assumed by Colmenar-Santos et al. (2017), but district heating networks in the Netherlands often have one main source to rely on (Schepers & Van Valkengoed, 2009). There is a knowledge gap on how adding sustainable heat sources in the Netherlands can be best achieved institutionally. This will be addressed in this study.

For example, the academic relevance is apparent in planning. First, adding sustainable heat sources to existing district heating networks requires implementing these new sustainable heat sources in available space. This is planning in itself. Second, adding sustainable heat sources to existing district heating networks is a task which needs the cooperation of multiple stakeholders, wherein the district heating network is owned by a private grid operator (Overheid, 2014). How to plan for the addition of sustainable heat sources in such a network is unclear as this goal is only recently established. Therefore, this study adds to planning theory from a network perspective. Third, district heating networks are relevant to the field of planning theory due to the alternative it poses to the largely dominant natural gas heating infrastructure. However, due to political willingness to change this

dominance, it is especially relevant from a planning perspective to investigate how planning can contribute to increasing sustainability in other infrastructure types than the dominant natural gas infrastructure.

The social relevance of this study originates from the urgent need of the Dutch society to become more sustainable. This will be addressed on district heating level. Stakeholders do not know what to expect from each other in the current deadlock situation, leaving many dissatisfied. This research will try to seek a way out of this deadlock situation, by focusing on one particular case in the Netherlands: the Amernet. This study will especially be relevant to district heating networks in the Netherlands, because these often have the same context as the Amernet.

1.5. Structure

The next chapter elaborates on what district heating is, the context of district heating networks, as well as which new sustainable sources are possible and the implications of these sources on district heating networks. Chapter 3 will explain what institutional design is and how this theoretical background can help us find a perspective on adding sustainable heat sources to existing district heating. Chapter 4 will explain the methodology used in this study and will argue choosing for the Amernet as a research case. Chapter 5 provides a description of the data, the data analysis and the results. Chapter 6 will answer the research questions mentioned above. Chapter 7 will provide a reflection on the conclusions in this study.

2. District heating and its sources

First, an explanation will be provided what district heating is and which sorts of district heating there are in order to create an understanding on the concept as used in this study. Second, this chapter will present reasons for using district heating. Third, several sustainable heat sources of district heating will be identified. Fourth, this chapter will point out which processes are relevant in current district heating systems in relation to demand and supply in district heating.

2.1. District heating

According to Ayah et al. (2007), district heating networks are networks that rely on industrial waste heat. This is produced in a central 'plant' and distributed through a network of pipelines. Industrial waste heat may come from businesses, but much of the waste heat comes from industries that create electricity (Sayegh et al., 2017).

In reality, district heating networks often rely on a central plant or two central plants, often based on the same energy source (Schepers & Van Valkengoed, 2009). However, district heating networks do not necessarily have to rely on a *central* plant. Several sources can be integrated into one district heating system (Schmidt, 2018; Zhang et al., 2015). In addition, Schmidt (2018) discusses the possibilities of other sources of heat rather than waste heat. He claims that this is a way forward, because integration of multiple sources leads to a better efficiency and a greater emission reduction. The definition of Lund et al. (2014, p. 1) does take this into consideration: "district heating comprises a network of pipes connecting the buildings in a neighbourhood, town centre or whole city, so that they can be served from centralised plants or a number of distributed heat producing units." However, the regional scale can be even bigger than Lund et al. suggest. In the Netherlands, there are regional district heating networks bigger than the municipal scale (Schepers & Van Valkengoed, 2009).

Summarized, the following definition of district heating, related closely to Lund et al. (2014), will be applied in this study: district heating networks transport thermal energy from a central heat source or multiple heat sources, which is distributed through a network of pipelines, to connected buildings on a scale that is at least neighbourhood level. They are the connecting factor between a supplier of heat (heat source) and an end-user (heat consumer). One can think of them as a gas network, but instead of natural gas, heated water is transported. One essential difference between the gas network and district heating shall be pointed out here: heated water loses heat over distance. Whereas gas can be transported over enormous distances, heated water cannot be transported over such long distances (Colmenar-Santos et al., 2015; Zhang et al., 2015). For that reason, distance is more relevant in district heating compared to natural gas.

2.2. Justifications for district heating

District heating systems are traditionally aimed at more efficient use of energy by using waste-heat (Ayah et al., 2007; Danish Energy Agency, 2017; Ekker, 2019; Schepers & Van Valkengoed, 2009). Waste-heat can be considered heat that comes from industry with a focus on production of goods with heat as a second product (Ayah et al., 2007). This heat is often discharged in nature. Therefore, district heating systems were set up to use this heat and create a more efficient production process. Often, these waste-heat industries are big central plants (Sayegh et al., 2017). These central plants provide high temperatures for a big district heating network.

Another reason to set up district heating networks is to decrease the dependency on imported fossil fuels (Danish Energy Agency, 2017). Up till now, the Netherlands mainly used their own fossil fuel, so this reason hardly applied to the Dutch case. However, in the near future the natural gas exploitation

in Groningen will end (Rijksoverheid, 2019), adding to the argument to set up district heating networks in the Netherlands. District heating can be an alternative to foreign natural gas.

The Dutch government provides a related reason to set up district heating networks. Their goal is that neighbourhoods should not use natural gas for heating anymore. Therefore, the Dutch government decided that 50.000 houses per year are disconnected from the gas grid (RVO, 2019). Furthermore, the gas law has changed in the Netherlands. Small buildings are not automatically connected to the gas grid and projects have to ask permission of exemption of this rule if a gas connection has to be made (Gaswet, 2018). This makes district heating a viable option, because this network can accommodate many other heat sources apart from natural gas.

A fourth reason for creating or enlarging district heating networks is environmental. District heating networks can use sustainable resources and thereby can provide a possible answer in the search for adaptation to climate change (Busch et al., 2017). However, much can still be won here. Even Denmark, praised for its district heating network (Lund & Mathiesen, 2009; Zhang et al., 2015), needs adaptations towards sustainable sources for district heating (Culig-Tokic et al., 2015). This entails that district heating sources are often not sustainable nowadays. If district heating networks are to become a CO_2-neutral alternative, changes have to be made in heat sources.

Fifth, there is a more practical reason for a connection to a district heating network that is based on path dependence. If buildings are already attached to a district heating network, it is rather cheap to buy the heat from the district heating network. There are buildings that do not have a connection to the gas grid nowadays. There are buildings in the Netherlands that do not have an alternative to district heating without having to invest in it. Then, natural gas is a very costly option. Therefore, a reason for continuing a district heating connection can be that this district heating connection already exists.

2.3. District heating sources

There are several possible sources of heat for district heating. Each has its own advantages and disadvantages. Lund et al. (2014) identify possible sources of heat. They rank sources of heat for a district heating network based on the capacity of that network. District heating networks have different capacities. These capacities determine if a heat source can be included in the district heating network. The capacities tend to differ over time, which enables Lund et al. to identify four generations of district heating, each with its own characteristics. A summary of the different generations of district heating can be found in table 1. An apparent trend in district heating is decreasing temperatures. Lund et al. advocate for the 4th generation district heating. An important difference between the 4th generation district heating and the earlier generations is the needed alterations on the demand side of district heating. Isolation is needed for low temperature district heating. This influence is not present in the earlier generations of district heating.

District heating generation	*Period*	*Characteristics*
1st	1880-1930	Steam heating generated by coal.
2nd	1930-1980	Pressured water heating over 100° Celsius generated by coal or oil.
3rd	1980-2020	Pressured water heating under 100° Celsius by large CHP plants.
4th	2020-?	Water heating of 50° Celsius by renewable sources. Measures need to be taken at the demand side.

table 1: district heating generations (Lake et al., 2017; Lund et al., 2014).

Nowadays, district heating with temperatures close to 100 degrees Celsius is the norm (3rd generation). In this generation of district heating systems belong the sources of solar thermal, biomass, waste heat from Combined Heat and Power (CHP) and waste heat from industry. In the 4th generation district heating systems, geothermal sources are possible as well. Next to this academic source, several heat sources can be found in societal sources as well (Hierverwarmt, 2019), like waste heat, biomass, geothermal and water thermal.

There are several requirements that new sustainable heat sources have to meet. First, every sustainable heat source needs a business case (Colmenar-Santos et al., 2015). The business case depends on two factors. The first factor is the investment budget (including risk reservations) needed to create a new heat source. The second factor is the financial costs a source has when it is operating. The higher the costs and the lower the merits, the lower the chance of a business case. A second requirement for a heat source is sustainability. This requirement needs to be met due to goals established in the political realm (RVO, 2019). A third requirement is reliability. The service that is delivered (heat) is ensured by law (Overheid, 2019). It may not fail. Therefore, a back-up heat source has to be in service that can provide as much energy as the greatest source a district heating network has. When the main source is failing, the back-up heat source provides enough energy to ensure heat delivery to the consumers.

In table 2, an overview is provided of the advantages and disadvantages of several heating sources based on these requirements. The advantages and disadvantages will be supported in the next paragraphs by arguments and academic sources. Not every heat source mentioned in this section is present in table 2. A choice has been made to use the sources of the 3rd generation district heating systems identified by Lund et al. (2014) and include geothermal sources. Lund researches trends in European district heating and is therefore a reliable source for the possible district heating sources (Lund et al., 2010; Lund et al., 2014; Lund et al., 2018). According to Lund et al. (2014), geothermal energy is not yet an option because it often supplies temperatures between 30°C and 70°C (which is considered to be too low). However, because it is considered an option in societal debate

	Advantages	*Disadvantages*
Geothermal	It is a sustainable source Provides a stable base load	High investment costs Runs on lower temperatures Building process involves the risk of earthquakes
Industrial waste heat (including data centres)	It is cheap Efficient use of resources Provides a stable base load	Often runs on lower temperatures Durability is not guaranteed
Biomass	It is a sustainable source Provides potential for peak-load It can replace coal	Subsidy will be stopped in 2027 Sustainability is debated because of CO_2 emittance
CHP	It is cheap Provides potential for peak-load It is well connected to electricity production	Heat is often not produced in a sustainable manner Durability is not guaranteed
Solar thermal	It is a sustainable source It can be well connected to electricity production	Is variable in how much heat it delivers. It delivers heat in moments of low heat demand.

table 2: possible sources for district heating and their conditions (financially, sustainability, reliability and unique opportunities)

(Hierverwarmt, 2019), this option is included in the analysis as a possible source for district heating as well.

Industrial waste heat and CHP are overall the cheapest options (Lake et al., 2017). This is because these sources provide waste-heat. Their core business is production and the heat resulting from the process will be there anyhow. Geothermal is cheap after it is built, but this source has high investment costs, making it financially less attractive (Drinkwaterplatform, 2019). Biomass is rather cheap as well. It faces investment costs, but those are not as high as for a geothermal source (Bioconomy, 2019). However, there are rumours that subsidy in the Netherlands applying to this resource will be stopped in 2027 (Marcelissen, 2018). It is unknown if this resource is viable when the subsidy ends. Financial consequences are important for civilians. In the end, the financial costs will be translated into the heat price. Next to this, investment costs are a disadvantage for financial bearers of risk. Often the government has to step in when the risks are too high. Otherwise, the investment will not be made.

Next to this financial comparison, the sources differ in terms of sustainability. Solar thermal, geothermal and biomass are considered to be sustainable by the Dutch government (Lake et al., 2017). However, biomass is often considered an outsider. Biomass still emits CO_2 and is only sustainable if it is compensated by building up new nature conserving CO_2 (Bilgili et al., 2017). CHP waste heat and industrial waste heat are often not considered sustainable sources of heat. This is practically often the case, because the waste heat is often produced by fossil fuels. However, does not necessarily have to be the case. CHP plants in the Netherlands do invest in biomass as a resource, because they are not allowed to use coal anymore in 2025 (Marcelissen, 2018). Nevertheless, the usage of CHP waste heat and industrial waste heat leads to a significant CO_2 reduction, because the production process becomes more efficient by this usage (Lake et al., 2017). In this light, waste heat can be seen as a free resource. The consequences of sustainability are especially relevant for the government. They are forced by policy to become CO_2 neutral and to build new houses without a connection to the gas grid (RVO, 2019). However, there are more stakeholders for whom sustainability of sources is relevant. Housing corporations, district heating companies and heat suppliers face legislations in order to become more sustainable.

A last criterion for comparison between the heat sources is reliability. Biomass and CHP waste heat have a high temperature and can burn on demand (Lund et al., 2014). Therefore, these sources are most reliable for district heating. Geothermal heat and industrial waste heat can be seen as constant sources of heat. However, these do often not provide high temperatures, especially geothermal heat (Lake et al., 2017; Lund et al., 2014). Besides, industrial waste heat might not always be applicable because of opening hours of the industry and the possibility of industry closing down. Solar heat is the least reliable of the sources mentioned here (Lake et al., 2017). It can only produce during daylight, and has to be attached to a buffer in order to become more reliable. Reliability can be seen as a necessary condition for district heating. District heating has to be reliable in order to protect consumers of heat, which is ensured by law (Overheid, 2019). Therefore, when introducing new sources of heat to an already existing district heating network a plan has to be made to ensure reliability for producing enough heat on the needed temperature.

2.4. Trends in district heating

There are three trends in district heating that need to be understood in order to know what implications different sources have for district heating. First, there is an overarching trend in district heating to lower the temperature of water in district heating networks (Lund et al., 2014). Nowadays, the continuing lowering of the temperature in district heating is the result of changing sources providing heat for district heating (Schmidt, 2018). The lower temperature has an influence on what kind of energy demands can be provided. A lower temperature is only possible if houses use less

energy. Otherwise, the temperature becomes too low to provide enough energy at the end of the pipeline. Therefore, in many cases more isolation of houses is needed (Werner, 2017).

Second, a related trend in district heating is a shifting focus towards sustainable sources of heat. As mentioned already, there is currently a focus on improving sustainability and this applies for district heating as well (Culig-Tokic et al., 2015). This trend has two important consequences. First, sustainable sources often provide a lower temperature, as mentioned in the paragraph above. Second, sustainable sources tend to need more space, leading to a very different use of space if district heating systems are fully fuelled by sustainable resources. Lund & Mathiesen (2009) stated that Denmark could transform fully to sustainable resources, but that integration of land uses is needed to make that possible. It is doubtful if the Netherlands can ever reach this if many district heating networks are erected, because the Netherlands has a far more dense demand of energy than Denmark (CBS, 2018; Worlddata, 2015).

Third, another trend for district heating is not on the supply side, but on the demand side. District heating is increasingly seen as an alternative to natural gas. This entails that more connections to the district heating grid are being established. Research discusses how old infrastructure can provide for this new higher demand (Guelpa et al., 2019). Busch et al. (2017) even go as far as stating what type of actor should have responsibilities to upscale district heating. They analyse the capabilities of local actors in several cities of the United Kingdom in order to provide insight in how these local actors can create district heating networks. Not surprisingly, they suggest that municipalities, businesses and communities all have different capacities and should work together in order to reach this goal.

2.5. Towards an institutional analysis

This chapter shows relevant processes for district heating by stating justifications for district heating, listing possible heat sources and their consequences for district heating and identifying trends present within district heating. In chapter 3 will be argued how the institutional framework of district heating can be understood by using different perspectives. Several institutional perspectives will be analysed in order to argue which perspective(s) are useful in solving the problem on how to add sustainable heat sources to district heating. In this way an own institutional perspective will be created. Chapter 4 will argue how the new institutional perspective will be applied to a single case. In chapter 5, the results regarding how to add sustainable heat sources to existing district heating using this institutional perspective will be provided. Chapter 6 will include a discussion on what these results mean. This study will be concluded in chapter 7.

3. An institutional perspective

The concept of district heating and the main sources of and trends in district heating are provided in the previous chapter. In this chapter, the theoretical concept of institutional design is understood using different perspectives. This chapter will provide the tools to find barriers and opportunities in adding sustainable heat sources to existing district heating systems.

3.1. Institutional framework

There are many ways to define institutional frameworks. These diverge from defining the content of an institutional framework (Fung, 2003; Van Karnenbeek & Janssen-Jansen, 2018), to defining different perspectives on institutional frameworks (Salet, 2018; Sorenson, 2015), or placing the institutional framework in a broader context (De Roo, 2014). This chapter will be started by placing the concept of an institutional framework in the broader context. Afterwards, examples will be provided of the content of institutional frameworks. There will be concluded with mentioning different institutional perspectives and assess which institutional perspectives are appropriate for the research question. The different perspectives will result in a conceptual model, which is the foundation to this study.

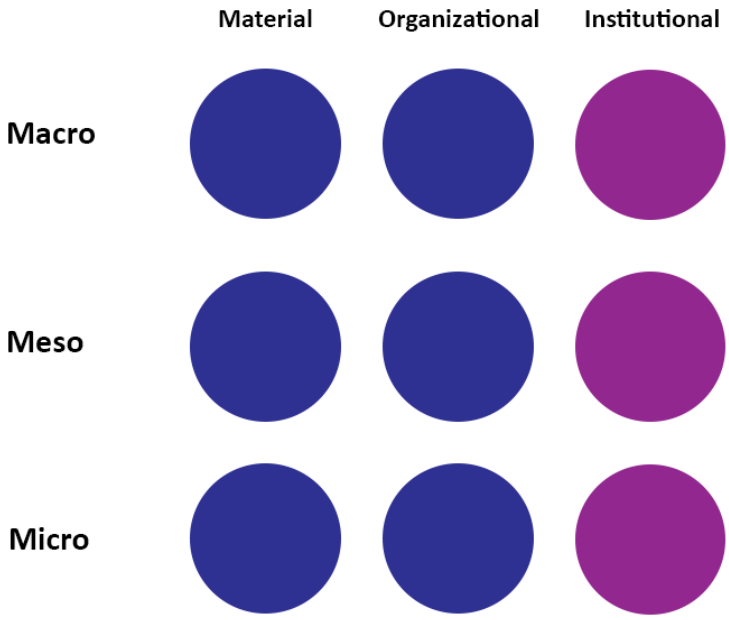

figure 1: a division in perceiving reality (De Roo, 2014, p. 39)

De Roo (2014) has identified institutional reality as a way of perceiving reality. His distinctions in perceiving reality can be found in figure 1. De Roo distinguishes three ways of looking at reality: material reality, organizational reality and institutional reality. With *material reality* is meant the technical, functional and social reality. What is possible is defined by objects and the status of their social relationship. The *organizational reality* entails the process of interaction between stakeholders. It involves every aspect of coordination, task division and cooperation. The *institutional reality* is the framework of interaction between stakeholders, which is made up by laws and procedures. They are sometimes mentioned the 'rules of the game' by academic planners (De Roo, 2014; Gertler, 2010; Williamson, 1998). This definition will also be used in this study. Institutions are a framework of laws, rules and procedures in which actors work to achieve their goals. These can be formal as well as informal (Van Karnenbeek & Janssen-Jansen, 2018). The institutional reality will be researched in this study, and is therefore made purple in figure 1.

All these perceived realities have effect on reality on the macro, meso and micro scale in different ways (De Roo, 2014). The scales itself are imaginary. The scales are used to structure reality. The scale boundaries are arbitrary and together they include every possible scale. The macro level is considered to include (supra)national effects, the meso level is considered to include regional effects and the micro level is considered to include the effects on individual actors on the local scale. All of these levels are affected by the three perceived realities in figure 1. Besides, all of these levels have an influence on institutional design. Therefore, all levels will be considered in this study. In the next paragraph,

examples will be provided of the ways scales are affected by the institutional dimension and/or how these scales influence the institutional dimension.

The macro level is considered to be regulations and policies on the national level directly or indirectly influencing on what is allowed or obligatory in district heating. An example of direct influence is the Heat law (Warmtewet) (Overheid, 2019). An example of indirect influence is the policy goal of heating without natural gas (RVO, 2019). This does not need to be district heating. However, it is a push factor to create alternative heating. One of these alternatives is district heating. Second, the meso level is considered to be a coordination for district heating if existing district heating supersedes the local level. In this case, the meso level affects district heating often by subsidies for certain sources or diminishing risks of investment. Patil et al. (2006) find financial stimulation to be an important institutional factor to the success of creating a sustainable district heating system. Thirdly, the micro level affects district heating. For example, the need to have support of civilians in creating new sources is an important institutional force in local politics (Oteman et al., 2014).

3.2. Examples of institutional frameworks

To underline the importance of institutional frameworks on adding new sustainable heat sources to existing district heating, additional examples will be provided. The political factor is influencing district heating by creating a dominant organisation structure (Oteman et al., 2014). The Netherlands are market-oriented and creating new sources will therefore often be done by companies. In addition, the economic factor influences the addition of new sustainable heat sources to district heating. For example, high investment costs for some sustainable heat sources make these sources more difficult to implement in existing district heating networks (Colmenar-Santos et al., 2015). In addition, the production of heat is cheaper in some heat sources than in others (Lake et al., 2017). Besides, the social factor is present in this discussion due to the visibility of some heat sources and the influence on households low-temperature heat sources can have (Homan, 2018; Stigka et al., 2014). Next to this, there are technical factors that should be incorporated, due to different temperature regimes (Lund et al., 2014; Schmidt, 2018). The ecological factor can be seen as the goal of adding sustainable heat sources to existing district heating networks. Creating a more sustainable energy system gives an answer to environmental concerns (Culig-Tokic et al., 2015; RVO, 2019). Moreover, the legal factor influences the institutional design of district heating, with the already mentioned renewed Heat law (Overheid, 2018). In addition, regulations like subsidies for biomass will probably stop in 2027. This influences the development of heat sources in existing district heating networks (Marcelissen, 2018).

3.3. Using perspectives

Although the section above gives some indications on what institutional design is, there is no clear definition. Salet (2018) provides some valuable insights on how to overcome this problem. He argues that institutional design can be viewed by different perspectives, which he calls paradigms. These paradigms on institutionalism can all be useful in the social sciences. The usefulness is dependent on the research questions that are asked. Salet identifies the following paradigms:

- Historical institutionalism
- Institutional-actor approaches
- Regime analyses
- Critical political economy with a focus on regulatory school
- Cultural institutions

In the following discussion, the characteristics and the applicability of the perspective to the research question will be discussed. Besides, another perspective is included in the analysis, based on Buitelaar et al. (2007). After taking into account the scientific discourse, their perspective proved not to be

covered in the perspectives of Salet (2018). Therefore, the characteristics and applicability of this perspective will be discussed as well. This perspective is called in this study:

- Institutional change-agents

3.3.1. Historical institutionalism

Sorenson (2015) is one of the main advocates of historical institutionalism. He points at the usefulness of the main concepts of historical institutionalism in order to press his case that historical institutionalism is relevant for planning. One core idea of historical institutionalism is 'path-dependency'. This concept applies to the tendency of institutions "to become increasingly difficult to change over time" (p. 21). This happens due to positive feedback-loops within the institution that self-assure its power. However, change can still happen. A path-dependent institution can be broken open by a 'critical juncture' (p. 25). This critical juncture is the moment in time when external forces are too strong and create a new institution.

There is another idea within historical institutionalism that challenges the idea of path-dependency and critical junctures. Small changes in institutions can lead to a slow overall change within the institution itself, due to small power disbalances arising within the institution. Old powers protect the advantageous old institution, but new powers try to change it. There is often no simple lock-in, but mutual forces are present at the same time.

In both views exist path-dependent forces and changing forces. According to Salet (2018), this perspective is useful for trying to discover the margins of change. This perspective is useful for finding opportunities (within the margins) and barriers (outside the margins). Therefore, this is a useful perspective in answering sub-questions 1 and 2.

3.3.2. Institutional-actor approaches

Institutional-actor approaches analyse how actors tend to move within certain institutions (Salet, 2018). These approaches analyse which nested structures exist. They do so by considering what actors will do provided a certain set of boundaries. An important researcher within these approaches is Ostrom. Together with Crawford, she identifies seven rules that need to be analysed in order to discover the institutional design (Ostrom & Crawford, 2005). This division improves the capacity of analysis, because rules change. Therefore, analysing rules is complex.

Van Karnenbeek & Janssen-Jansen (2018) use this framework in their research to assess institutional changes in a Navy Yard in Amsterdam. In addition to the formal rules used by Ostrom & Crawford (2005), Karnenbeek & Janssen-Jansen (2018) include informal rules. Their research shows that the rules of Ostrom & Crawford (2005) can provide a historical overview on how institutional change happens.

However, the rules identified by Ostrom & Crawford provide no insight in how barriers and opportunities can be found. Besides, the problem in existing district heating is not that actors do not want to go in the same direction. Sustainability and adding sources seems to be the goal of many stakeholders, like the government and the grid operator. Therefore, using this perspective is inappropriate in answering the research question.

Nevertheless, the inclusion of informal rules is useful. Many of the already mentioned institutional problems (in the introduction) are informal, like the lack of support by civilians or the need of funding of several sustainable sources.

3.3.3. Regime analyses

According to Salet (2018), regime analyses are defined by a distinction that is established between general rules that define relationships and goal-specific interventions. The general rules are considered to be determining which goal-specific interventions can be made and how certain goal-specific interventions will play out in an area, because of area-specific rules. This perspective is especially relevant for comparative research, because this branch is comparing contexts with different general rules.

Therefore, this perspective is not appropriate to use in this research, because this is not a comparative research. Looking into adding sources to existing district heating is more in-depth and does not fit with this perspective.

3.3.4. Critical political economy with a focus on regulatory school

The perspective of critical political economy on institutions is quite normative (Salet, 2018). It has a focus on how the capitalist institution overcomes crises and overcomes self-created problems. Institutions are considered to be "endorsing growth, stabilizing production and consumption … and establishing and reproducing themselves to control conflict" (Harvey in Salet, 2018, p. 117). For a great part, this can be achieved by regulations. This institutional perspective on institutions looks mainly at the economical (capitalism) and legal (regulations) dimensions.

District heating is connected to more dimensions than the legal and economical dimension. As earlier mentioned, political and social dimensions have a huge impact on how to add sources to an existing district heating network as well. Therefore, this institutional perspective is not appropriate for this research.

3.3.5. Cultural institutions

The cultural institutionalist perspective views institutions as constantly changing due to interactions between actors (Gonzalez & Healey, 2005). By these interactions institutions are constructed. These again influence the way actors interact. Therefore, history determines institutions only partly. Institutions are influenced by former social interactions as well as current interactions.

Is this perspective useful in trying to identify barriers or opportunities? The institutions around district heating (especially in energy transition) are certainly moving, just like in the cultural institutionalist perspective. This perspective seems to describe a reality present in existing district heating networks in the Netherlands. However, this perspective does not help in answering the research question. The research question needs an answer to what are opportunities and barriers in the current institutional framework. This question needs a perspective that can find out the borders of movement within an institution. The cultural institutionalist perspective is inappropriate for the research question, because it assumes that the borders are always changing when interaction happens.

3.3.6. Institutional change-agents

Buitelaar et al. (2007) take another perspective on institutions. They specifically look into how institutions can be changed. They identify that there are special agents, called 'bricoleurs', that have transformative capacity. They try to establish change from within the institutional system. This is the main difference between historical institutionalism and this perspective: historical institutionalism assumes change is established from forces outside the control of humans, the institutional agents perspective assumes agents can influence institutions as an internal force (Burch et al. in Buitelaar et al., 2007). A path-dependent institution can be broken open by 'windows of opportunity'. These windows of opportunity are seized by bricoleurs. Windows of opportunity are moments in time when big changes in transforming an institution are possible or are made. Changes become possible by

'critical moments'. This is a moment of reflection on the current institution, created by a combination of bricoleurs and external forces. If this reflection leads to the advocation of an alternative by bricoleurs a 'critical juncture' is reached (Huitema et al., 2011). Critical moments and critical junctures are both windows of opportunity. If the advocation of an alternative institutional design in the critical juncture is successful, an institutional change is made.

This institutional agents perspective is useful in answering the third sub-question: How should the current institutional design be changed to overcome the barriers to add sources to existing district heating systems resulting from the current institutional design? This question assumes that institutional change has to happen, on the basis that the current institutional design cannot provide for adding new heat sources to existing district heating systems. The search for windows of opportunity (critical moments and critical junctures) can provide answers to what should be changed.

A broader understanding will be provided to 'windows of opportunity' in this study than is provided by Buitelaar et al. (2007). Windows of opportunity are not considered to be only short moments. Windows of opportunity can be established in slow change due to internal change processes as well, as presented by Sorenson (2015) under historical institutionalism. The difference between windows of opportunity and opportunities is that windows of opportunity are a currently evolving response to current barriers in adding sustainable heat sources to existing district heating, whereas opportunities are already present and developed chances to add sustainable heat sources to existing district heating.

3.4. The institutional perspective of this research

To conclude, the historical-institutionalist perspective is appropriate to find opportunities and barriers. Besides, slow changes will be considered part of windows of opportunity. The institutional-actor perspective is not appropriate to answer the research question, although Van Karnenbeek & Janssen-Jansen (2018) do add the idea to look at informal institutional frameworks. This will be done when looking into the opportunities, barriers, and windows of opportunity for adding sustainable heat sources to existing district heating networks. Regime analyses, critical political economy with a focus on regulatory school and cultural institutionalism are all perspectives are not appropriate to answer the research question. The perspective of institutional change-agents is partly appropriate to find windows of opportunity.

All in all, the institutional perspective used in this research combines perspectives from historical institutionalism and institutional change-agents. This combination is merged in a conceptual model provided in figure 2 (next page). There are three kinds of effect that will be investigated in this study. First, the upper line represent current opportunities. Opportunities are needed changes that can be made within the current institutional design. These opportunities are needed to answer sub-question 1: "What are opportunities for adding sustainable heat sources to existing district heating networks in the current institutional framework?" The middle line represents the changes that are needed, but are prevented by barriers. Barriers are the obstacles encountered when trying to add sources to existing district heating systems. These barriers are needed to answer sub-question 2: "What are barriers for adding sustainable heat sources to existing district heating networks in the current institutional framework?" Until now, this fits the historical institutionalist perspective. This is combined with the concept of windows of opportunity from the perspective of institutional change-agents. Windows of opportunity are represented by the lower line. Windows of opportunity are a way to break through the barriers of the current institutional design and create a new institutional design in order to establish the change that is needed, in this case to implement new sustainable heat sources. These windows of opportunity are needed to answer sub-question 3: "How should be the current institutional framework be changed to overcome the barriers resulting from the current institutional framework?"

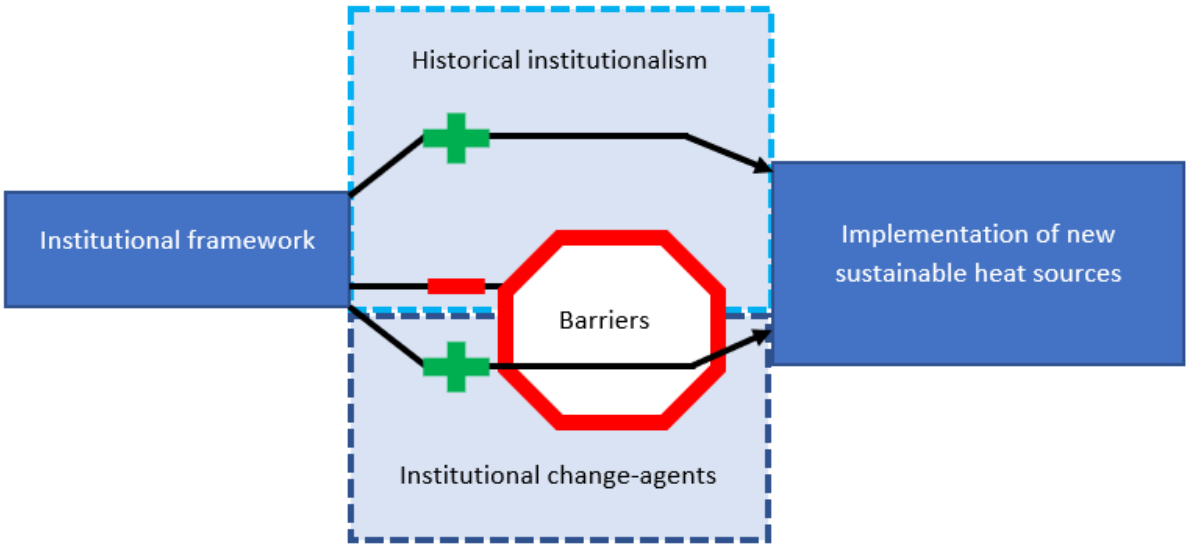

figure 2: conceptual model

4. Methodology

4.1. A case study

The research questions will be answered using a case study. This is a study of a severely limited number of cases (possibly one) within their context (Yin, 1984 in Zainal, 2007). Case studies are a research strategy design that is not appropriate to use for testing existing information, but is appropriate to use when searching for new information. This research is looking for new information regarding opportunities, barriers, and windows of opportunity in adding sustainable heat sources to existing district heating networks. This research will not be testing information already present in academic sources. This new information can be supplied well by qualitative information. Qualitative information is detailed information about one phenomenon. It can provide new variables not known before. Besides, in opposition to quantitative information, qualitative information is not looking for statistical significance. Testing statistical significance is not needed when in-depth questions need to be answered, whilst finding new information is. Therefore, a case study analysis is a good way to answer in-depth questions (Zainal, 2007). It can answer questions about how a process should be and is therefore quite normative. This possible normativity implies that a careful design of a case study is important.

Therefore, Zainal (2007, p. 2) created a list of criteria that should be met for good case study research. First, the case study approach has to be the only viable method to get implicit and explicit data from the subjects. This is applicable to this research. Analysing an institutional design, which is a complex web of rules and interactions and contains many variables, can never be done well without focusing into one case to identify these variables first. Besides, adding sources to district heating is an evolving subject. This means that there are proper case studies available. Second, the case study method has to be appropriate to the research question. Case studies can answer in-depth questions (often starting with 'how') that are meant to identify new information. Again, this is applicable to this research. The research question is in-depth and wants to find new information on how sources can be added to a current institutional design, because this is found to be a societal problem at the moment. Therefore, it supplies the demand of the research question to achieve qualitative in-depth information. Third, due to the difficulty in reproducing a case study (procedures and interactions will change over time) it is important to thoroughly provide evidence of the results. This will be done in this research. Fourth, the case study should be linked to a thorough scientific theoretical framework. This is already provided in chapter 3.

A fifth requirement is that the case study method should carefully follow 'the scientific method'. It is not sure what is exactly meant, when Zainal (2007) claims this criterion. The other four criteria could be a way to state that the approach follows the scientific method. Maybe Zainal hints at the interpretation of the results. Already in 1965, Oskamp warns us that case studies are often attributed too much explanatory power. Generalisations cannot be made within a case study. It is an in-depth investigation that gives insight into processes. However, due to the unique context of case studies, it is never sure how much of the established insights are applicable to other cases. This entails that an investigation in the institutional design of one district heating network does not automatically lead to results that are applicable to other district heating networks outside the Netherlands, or even district heating networks within the Netherlands.

Nonetheless, case studies do add to scientific research. The case study method identifies new variables that can be further investigated by other scientific methods (Flyvbjerg, 2006). Its ability to find new information gives the case study method an important role in the beginning of the scientific research.

4.2. The Amernet

The case studied in this research is the Amernet. This is a regional district heating network, already created in 1981 (Schepers & Van Valkengoed, 2009). The network has one primary heating source. This is a coal and biomass fired Combined Heat and Power Plant in Geertruidenberg. The main places of demand are situated in Breda and Tilburg, two major cities in the province Noord-Brabant. More geographical details are visualized in figure 3.

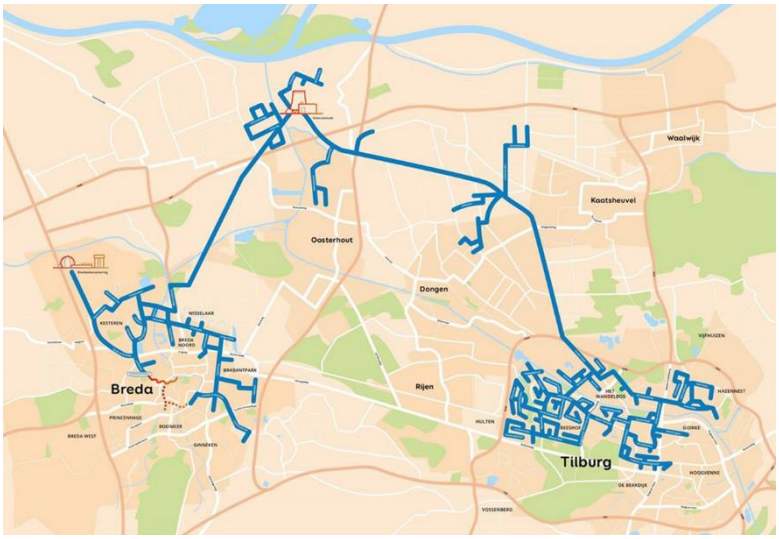

figure 3: the Amernet and its surroundings (Warmtenetwerk, 2018).

The Amernet is chosen for several reasons. First, it is an already longer existing district heating network struggling with achieving diversification in heat supply (ISSUU, 2019). Therefore, it is one of the existing district heating networks that this study aims to address. Second, the Amernet is the 4th largest district heating network in the Netherlands with regard to the amount of users (Schepers & Van Valkengoed, 2009). This entails that there are a lot of stakeholders. The institutional problems that existing district heating networks face will be highlighted due to the increasing tension of higher complexity. Third, the CHP of Geertruidenberg is partly fuelled by coal (Reijn, 2019; Schepers & Van Valkengoed, 2009). It is the only large district heating network that is based on coal as a fuel, and has therefore the largest chance of a shut down when the coal plant has to close (Eerste Kamer der Staten-Generaal, 2019; Nieuwenhuis, 2018). Adding heat sources is therefore an urgency for this network. Fourth, due to the struggles in achieving diversification in heat supply and the chance of closure of the main heat plant, there is an increased willingness of several stakeholders to change the institutional design as it is now (ISSUU, 2019). This network is willing to look for answers on how to add sustainable heat sources to the Amernet. Therefore, research in case Amernet will have fertile ground. The fifth point is an operational argument. During the research, a lot of data can be accessed from Royal Haskoning DHV due to the fact that this research is combined with an internship at this company. Getting the appropriate stakeholders to cooperate in this research is crucial to the success of this research. Because Royal Haskoning DHV is involved in the process of adding heat sources to the Amernet, this is an appropriate case to focus on in this research.

The envisioned changes in the Amernet

The process of changing the Amernet is already happening. Already in 2017, an agreement was signed between municipalities (Breda, Tilburg, Geertruidenberg, Drimmelen, Oosterhout and later Dongen), housing corporations (Laurentius, Alwel, WonenBreburg, Tiwos & TBV Wonen), the grid company and heat supplier (Ennatuurlijk), public utility Enexis and the province Noord-Brabant (ISSUU, 2019). The goal of this agreement is six fold. First, more houses are to be connected to the district heating network (2% growth of household equivalents per year). This is a wish from municipalities and housing corporations. District heating is a heating source without natural gas. Connecting more households is important for Dutch municipalities due to the renewed gas law (RVO, 2019). In addition, it helps achieving CO_2 reduction goals. This is important for municipalities, the grid operator and housing corporations (De Woningstichting, 2019; RVO, 2019). The second goal is related to this heightened demand for district heating: district heating has to become sustainable (30 MW of decentralised sustainable heat sources in 2024). Only when this goal is (partly) reached, the first goal can be

successful. The second goal is a premise for the willingness of municipalities and housing corporations to proceed in achieving the first goal. However, the second goal is a goal in itself as well, because CO_2 reduction goals have to be achieved as well if there is no grid growth. Third, the temperature in the Amernet has to decrease with 1°C to allow for the introduction of sustainable heat sources. Fourth, energy savings have to increase with 2% each year. Fifth, public participation has to increase in the development of sustainable heat sources. Sixth, a yearly report on CO_2 emission will be drafted.

Adding sustainable heating sources to the Amernet is managed within projects. Until now, there are no finished projects yet. There are three main projects within the Amernet program that might be exploited in the future. First, there is an initiative to create a small biomass plant by glasshouse companies in the municipality Drimmelen (Van Leest, 2019). This project is delayed. A very detailed construction proposal had to be delivered to the municipality due to serious concerns on the subject by the municipality. When concluded, the permission got stuck at the provincial level due to a nitrogen regulation crisis that puts almost all construction projects on hold (Julen, 2019). Second, there is an ongoing project to create a geothermal heat source in the same municipality. There is a reasonable chance that this site has a good potential for geothermal production. However, extensive research has to be done just to provide a detailed view of the underground. That research does not include the actual placement of a pipeline yet. How the financial resources for this research are gathered, is not yet clear. Although a permission is provided by the municipality Drimmelen, a SDE+ subsidy from the national government has still to be provided (Gemeente Drimmelen, 2019b). Third, there exists a project to create solar thermal energy in the municipality Breda (Gemeente Drimmelen, 2018). This is a citizen initiative. However, due to prolonged negotiations between the citizen cooperation and the municipality, the project has not started yet. Furthermore, waste-heat sources near Dongen and Tilburg are investigated (Gemeente Drimmelen, 2018).

Law changes in institutional design influencing the Amernet

Besides the wanted changes in the Amernet by current stakeholders, there exists a rapidly changing formal institutional context that needs to be taken into account. The current institutional design is already changing, making this a complex issue. There are six changes that need to be taken into account here. First, the Dutch government has adopted a Coal law (Eerste Kamer der Staten-Generaal, 2019). This law wants old electricity production plants to stop producing electricity by coal. The coal plant providing heat to the Amernet is part of these old electricity production plants (Overheid, 2018). From 2024 no coal should be used for production or the plant has to be closed down. An option for the coal plant at Geertruidenberg is changing its fuel to biomass. Second, from 2027 onwards it is likely that biomass will no longer be subsidized by the Dutch government (Marcelissen, 2018). This decision stems from the idea that biomass should be a transitional sustainable sources towards other sustainable sources. With this decision, it will become more difficult for biomass sources to establish a working business case. Third, a recent decision from the Dutch government is to build houses without a gas connection, as already explained earlier (Overheid, 2019). This demands new political decision from municipalities about how to provide heat for these new buildings. Fourth, there is an already ongoing change of creating increasingly stricter regulations in order to become CO_2 neutral (RVO, 2019). This provides an incentive for increasing the sustainability of sources of district heating in order to update the requirements made in the demand of heating. Fifth, a new Heat law is currently being created (VEMW, 2019). Although it is not completely clear what the content of this law will be, it is suggested that municipalities are provided with a central role in controlling heating. This already results in a pressure for municipalities to influence heating options and heating sources. Sixth, currently there is a new regional policy being implemented, which is called the Regional Energy Strategy (RES) (Nationaal Programma RES, 2019). Relevant to the Amernet, the RES is focusing on how to add sustainable sources to the heat infrastructure (Heat visions). It does so not only for district heating, but for every type of

heating. Although the Heat visions will not be finished soon, the Amernet and the Heat visions (will) mutually influence each other. Coordination between them is vital in order to avoid conflicting policies between the Heat visions on the one hand and the steering board of the Amernet on the other hand.

Text box 1: Institutional context of the Amernet

4.3. The stakeholders in the Amernet

In table 3, the stakeholders influencing the sustainability of the Amernet can be found. The respondents are identified by attending several meetings of the focus group that was created out of the agreement between the stakeholders who signed the agreement of envisioned changes (ISSUU, 2019). The stakeholders can roughly be structured according to supply, coordination and demand.

Stakeholders	*Type of actor*
RWE (CHP plant) *Initiators of new heat sources* *Ennatuurlijk (grid operator and heat supplier)*	Suppliers
Housing corporations *Private owners* *Companies*	Consumers
Municipalities *Province Noord-Brabant* *Dutch government*	Coordinators

table 3: stakeholders in the district heating network Amernet

The suppliers are RWE, initiators for new heat sources and to some extent Ennatuurlijk. RWE is the owner of the current heat source in the Amernet: the coal plant at Geertruidenberg. In addition, the initiators for new heat sources are stakeholder. They want to add sustainable sources to the Amernet. These stakeholders are very diverse, because their motivations differ. For example, this can be company initiatives, a government initiative or a civilian initiative. Besides motivation, the source may differ, as can be found in table 2. Ennatuurlijk can be viewed as a heat supplier, but of second-order. Ennatuurlijk is the grid operator and sells the heat to the consumers. In this role, Ennatuurlijk is a key operator in the chain of supply to demand. Ennatuurlijk is responsible for delivering heat to the consumers and has therefore an interest in connecting to heat sources (first-order heat suppliers) that meet the demand of the system and of the consumers.

There are consumers involved as stakeholders in the Amernet. These stakeholders are everyone who owns a building and has a heat demand. A big group within these stakeholders are housing corporations. Housing corporations that have connections to the Amernet are Laurentius, Alwel, WonenBreburg, Tiwos and TBV Wonen. Housing corporations are providing social housing, which is low-rental housing. Therefore, housing corporations have an interest in the energy prices their renters have to pay. Besides, housing corporations have agreed to contribute to a sustainable future in a voluntary agreement with the Dutch government (De Woningstichting, 2019). Both of these factors have to be met in order for a housing corporation to connect houses to the Amernet. The goal of enlarging the Amernet is easier with housing corporations than with individual private owners due to lower investment costs per household, which leads to the additional benefits of economies of scale. There is another group of consumers: the private owners connected to the Amernet. This group is diverse. Some want to be connected to district heating, but most private owners do not like the decreasing options of choice that are involved once connected to the district heating network. In the

same line of thought, private owners who are not yet connected to the Amernet are often less willing to connect to the Amernet than housing corporations. Also companies are consuming heat from the Amernet. They can perform a double function, producing heat for the Amernet and consume heat from the Amernet. For example, this double function exists for the glasshouse owners in Made.

Finally, there are coordinating parties involved in the Amernet. The first group are the municipalities. As stated earlier, they have the goal to create a sustainable form of heating. The question is if this can be done by district heating. They are an important actor in adding sustainable sources to district heating, both because of their interest in sustainable sources and of the spatial and environmental permits they have to provide in order to be able to build these new heat sources. Second, the province Noord-Brabant is an involved stakeholder in the Amernet. They are issuing environmental permits (part of these permits is impact on nitrogen levels). Besides, they are often asked to bear financial risks. Financial help is often asked from the national government as well, the third coordinating stakeholder. Currently, the Dutch government is heavily involved in changing the way buildings are heated. A new Heat law is created. The new Heat law can help or constrain the development of connecting sustainable sources to the Amernet.

4.4. Data sampling

In order to identify barriers and opportunities in institutional design for adding sustainable sources to Amernet, semi-structured interviews have been held with representatives of these stakeholders. These are interviews wherein the questions that need answering are pre-determined, but the way of questioning is more free (Longhurst, 2003). The order is less strict and follow-up questions for clarification or deepening of the provided information can be asked. This approach fits well if the research question is in-depth, as is the case in this research. The pre-determined questions are noted in appendix 1. A standardised format of questions is chosen. This helps in discovering similarities and differences in the data. Table 4 visualizes which interview question can be related to which research question. Interview questions 1-3 are questions aimed at identifying the position of the stakeholder regarding the Amernet and its goal to become more sustainable. Determining the position of the stakeholder helps to analyse the answers of interview questions 4-9. Question 10 is a control question and concludes the interview.

Interview question	Research question
1	-
2	-
3	-
4	1
5	1
6	1
7	2
8	3
9	3
10	-

table 4: relevance of interview question for answering the research question

In total, 12 semi-structured interviews have been taken to collect data. These interviews were held in November and December in 2019 and lasted between 30 and 80 minutes. The location of interviews and the way they were conducted were arranged and done in the most convenient way for the stakeholder. Seven interviews which were held at the office of the stakeholder, three interviews were held at the office of Royal Haskoning DHV and two interviews were conducted by phone. These interviews were, after consultation, recorded and transcribed. When asked by the respondents, the transcriptions were again checked by these respondents. Afterwards, the transcriptions were coded using PESTEL, as will be explained in the end of this chapter.

Overall, each of the stakeholders involved in the identified institutional design is represented. From the coordinating stakeholders, representatives of the ministry of Economy and Climate, of the province Noord-Brabant and representatives from the municipalities of Tilburg, Breda, Drimmelen and Geertruidenberg are interviewed. The municipalities Breda, Tilburg and Drimmelen were chosen

because of the initiatives for new sources of heat present in these municipalities. The municipality Geertruidenberg is chosen because of the presence of the CHP plant in this municipality, which already provides heat. In total, six coordinating stakeholders are interviewed.

From the consumers, an employee who represents the housing corporations of Tilburg and Breda (under the umbrella organisation AWLTT) and a citizen of Breda who is involved in an energy initiative cooperation were interviewed. The consumers are an important stakeholder in the overall institutional framework. However, they have more influence on enlarging the amount of connections of the Amernet than on adding sustainable heat sources to the Amernet. Therefore, consumers are not that much represented in this research. Two respondents are sufficient to identify what drives consumers in the current institutional design when sustainable heat sources are added to the Amernet. In total, two consumers were interviewed

The following supplying stakeholders were interviewed. Next to RWE and Ennatuurlijk, new initiatives were represented in the sample of interviewees. The last group consists of stakeholders who try to establish and connect a new sustainable heat source to the Amernet. These were sometimes represented by stakeholders from other groups who had been involved in the new initiative. The earlier mentioned new biomass plant is represented by a glasshouse owner. The solar thermal project is represented by the municipality of Breda and the citizen of Breda (both are earlier mentioned) and the geothermal initiative by Ennatuurlijk (an explanation can be found under the envisioned changes in the Amernet). In total, six suppliers were interviewed. For the solar thermal project, the interviewees had a double function being both representative of consumers or coordinating stakeholders and of the solar thermal project. The geothermal initiative was represented by another employee of Ennatuurlijk than the representative of Ennatuurlijk. There exists no double function here.

4.5. PESTEL

The PESTEL method is used to analyse the opportunities, barriers, and windows of opportunity. Yüksel (2012) identifies PESTEL as an analytical evaluation tool consisting of six factors. These are the political, economic, social, technical, ecological and legal factors, the first letters of each providing the method its name. They provide focus wherein the institutional framework and institutional changes can be structured better.

The political factor incorporates efforts and obstructions of all governmental layers. The economic factor incorporates financing, the ability to make a working business case. The social factor incorporates cultural aspects and is about the efforts and obstructions created by the civil society. The technical factor incorporates the capability of technologies. The ecological factor incorporates all environmental concerns. Finally, the legal factor incorporates rules and regulations. Important to notice: the PESTEL method can incorporate formal and informal rules. The legal factor is concerned with formal rules, but the other factors can incorporate informal rules as well. For example, social rules are mostly informal.

Yüksel (2012) identifies several advantages of using the PESTEL method. One of these is that it helps identifying important variables. Identifying variables important to existing district heating networks is what this study tries to achieve, so this method is suitable. Several scientific articles underline the usefulness of labelling by factors to investigate barriers in district heating (Colmenar-Santos et al., 2015; Oberlack, 2017). These articles do not necessarily use the PESTEL method, but they use the focus on different factors in order to structure their search for barriers. Next to identifying important variables, the PESTEL method is advantageous for structuring the answers to the research question.

Combining the need to structure institutional approaches analytically and the fit of the PESTEL method with this research, the PESTEL method is regarded as a proper evaluation tool in this study. In chapter 5, the results will be provided by splitting up each sub-question using PESTEL. The last part of this chapter checks if more focus has to be created in the use of PESTEL for this research. Maybe some dimensions deserve extra attention in the interview guide, because these dimensions are the main obstacles or solutions to adding sustainable sources to district heating.

4.6. Creating focus

To identify if some dimensions need more attention than others, phase 1 of this research has been undertaken. In this phase, four experts in district heating were asked which dimensions they deemed more important in enlarging the district heating network and which dimensions they deemed more important in adding sustainable sources. The investigation in enlarging district heating network is included because this is a huge contextual factor in the Amernet. Adding sustainable sources is included because this is the topic of this study. Importance is measured in two ways: problems existing in this dimension, or solutions that can be found in this dimension.

The questions and a more detailed explanation of the format are noted in appendix 2. The questions were first tested with two experts to check if they were well understood by experts in the field. Afterwards, a workshop is done with three experts focusing on strategic management in district heating. They were asked to put the dimensions in an order of importance and provide motivations on why they gave this ranking. These motivations were written down on post its and attached to the paper of this dimension. These three experts proved able to agree on one ranking. Afterwards, another expert (a technical expert and project manager in district heating) was asked the same to verify if the results from the first workshop could be underlined by experts in the field with another background. Due to time reasons, enlarging district heating and adding sustainable sources were combined. The results of these two workshops are visualized in appendix 3 and table 5. The results of these two workshops are input for data collection, as well as for data analysis of the interviews with the stakeholders.

The ranking in table 5 is made by the experts. However, whereas double rankings were made, a 1-6 scale was maintained in the table (Note: this is not the case in the results, appendix 3). Double rankings both got the higher ranking, but counting below these dimensions is restored on a 1-6 scale. Table 5 already indicates that some dimensions are more important than others. The political dimension is

	1st workshop: enlarging district heating		*1st workshop: adding sustainable sources*		*2nd workshop: enlarging district heating and adding sustainable sources*	
	Problems	**Solutions**	**Problems**	**Solutions**	**Problems**	**Solutions**
Politics	3	2	2	1	4	1
Economy	1	1	1	2	2	2
Social	5	5	3	4	1	3
Technology	1	4	6	4	3	4
Ecological	6	6	5	6	6	6
Legal	4	2	4	2	5	5

table 5: ranking of perceived problems and solutions per dimension, based on a workshop with experts in district heating. A low ranking (1 = low) means a higher amount of problems or solutions can be found in adding sustainable sources to existing district heating networks in this dimension compared to other dimensions. A high ranking (6 = high) means no or a less amount of problems or solutions can be found in adding sustainable sources to existing district heating systems in this dimension compared to other dimensions.

perceived as a solution for adding sustainable sources to existing district heating networks (both 1). The economic dimension is perceived to contain problems as well as solutions to add sustainable sources to existing district heating systems (1 or 2). The social dimension contains more problems to add sustainable sources to existing district heating systems than that it contains solutions (3 or 1 versus 4 and 3). The technological dimension is perceived as moderate important in adding sustainable sources to existing district heating, although it is perceived to contain a lot of problems in enlarging district heating networks. The results on the ecological dimension are clear. This dimension does not contain a lot of problems or solutions in adding sustainable sources to district heating (5 or 6). The results on the importance of the legal dimension seems to be disputable, because the first workshop gives a higher ranking to the problems and especially solutions in this dimension than the second workshop (4 and 2 versus 5 and 5).

The motivations provide more insight into the importance of the dimensions (appendix 3). First, the social dimension is identified as a dimension that contain problems in adding sustainable sources to district heating, because of difficulties with civilian support. The social dimension does not contain solutions to adding sustainable sources in existing district heating systems, because this dimension has to deal with slow-moving cultural perceptions. Second, next to the social dimension, the economic dimension is seen as a dimension which contains problems in adding sustainable heat sources to district heating, because of difficulties in creating a solid business case for several types of sustainable sources, like geothermal and solar thermal. In addition, the economic dimension contains solutions in adding sustainable sources to existing district heating systems, because a solid business case is an important driver for change. However, this has sometimes to be stimulated by the political dimension. Third, the political dimension has to provide solutions according to the experts. This is already done by the political system to a certain extent by regulations. The political dimension is moving due to formal law changes. The political system can issue permits and offer risk assurance to help business cases of initiatives to create new sustainable sources to district heating. Especially the political dimension highlights the difficulty in dividing per dimension, because the political dimension directly influences the economic and legal dimension. Fourth, the legal dimension had inconclusive results. The first workshop saw a lot of solutions existing in this dimension, but these solutions had to be implemented by the political dimension. In the second workshop this process was completely put in the ranking of the political system, as appendix 3 shows in the motivations on the solutions that can be provided in the political dimension. Fifth, the ecological dimension does not have an important role in either problems or solutions in adding sustainable sources to existing district heating systems. This is explained well in the first workshop: ecology is the ultimate goal why there has to be invested in district heating systems, but has no internal solution for the change itself. Sixth, the problems in the technological dimension stem from interrelationships, especially with the economic dimension. Technological difficulties can often be overcome by a more expensive alternative, whereas economic possibilities often define which technologies can be implemented. Besides, sustainable sources have more technical complications, like heat storage.

All in all, the data analysis will focus on the political, economic, social, technological, and legal dimension. All these dimensions contain important solutions or problems, or they have an interrelated influence on each other, or both. These dimensions will be addressed in the data collection (questions about these dimensions will be asked to the respondents) and in the data analysis (data analysis will be structured according to these dimensions). The ecological dimension will not be a part of this study. Therefore, the PESTEL analysis has become the SPELT analysis.

4.7. Research strategy

Chapter 4 is summarised in figure 4. To answer the research questions a lot of data is obtained. The data sampling and its justifications are provided in the light green part. Figure 4 shows how the data sampling is build up. The rectangles represent theory and secondary data. The circles represent empirical data obtained in this research in order to provide a better foundation to the research. First, it is explained how a case study is a good way to answer the research question. Second, this study addresses how the Amernet is a good case for answering the research question. Third, the Amernet has an array of stakeholders. Twelve respondents are chosen from the main stakeholders that are identified. These respondents are identified by attending and observing focus group meetings. These 12 stakeholders were assumed to represent the current institutional framework, bringing together different institutional perspectives.

The choice for semi-structured interviews is based on the research question. Besides, the research question and sub-questions are the basis for the interview questions, as provided in appendix 1. The method for data analysis is described on the right side in figure 4 (the blue part). To include only the relevant dimensions of the PESTEL method, an expert session was held to identify the relevant dimensions of PESTEL in terms of opportunities or barriers in adding sustainable sources to existing district heating networks. The ecological dimension is found to be not relevant, resulting in a SPELT analysis: in the interview questions is not asked about the ecological dimension. In addition, data analysis does not include the ecological dimension. With the input of the SPELT analysis and the stakeholders, semi-structured interviews were held to identify opportunities, barriers, and windows of opportunity in adding sustainable heat sources to existing district heating networks. The data sampling (light green) and the data analysis (blue) will result in research answers (visualized in dark green in figure 4).

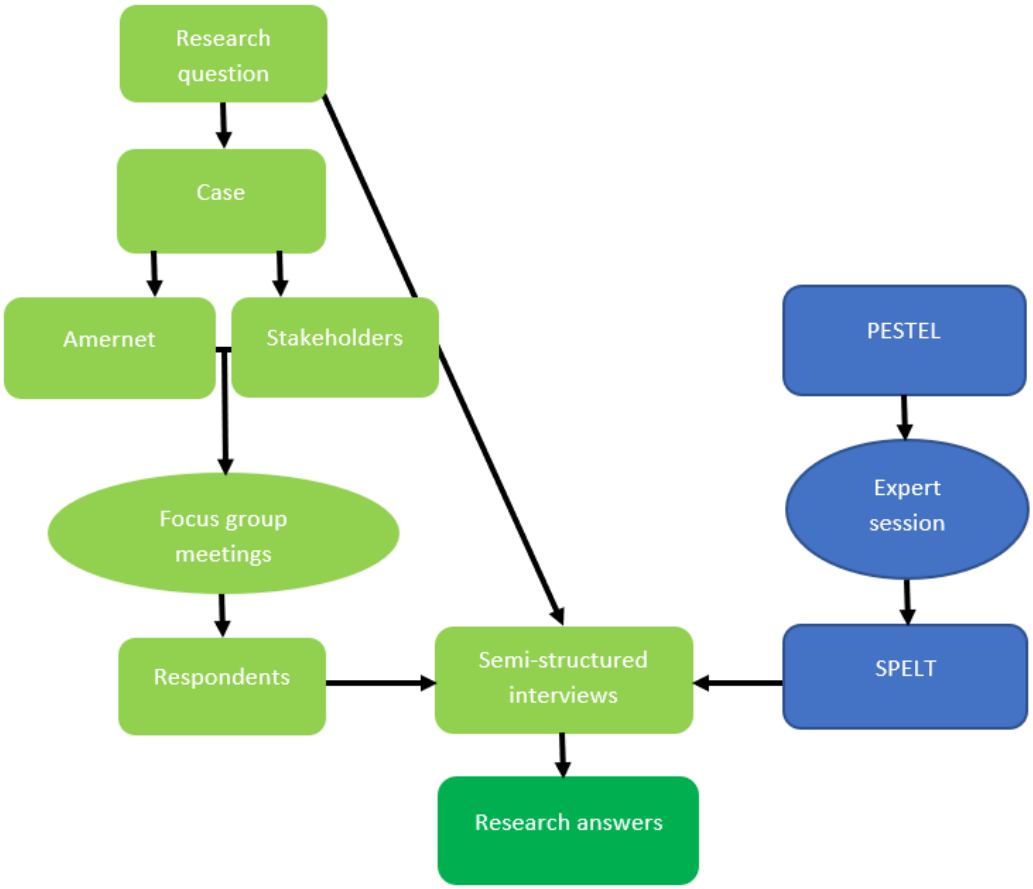

figure 4: build-up of research strategy

5. Data analysis and results

5.1. General

This chapter provides a data analysis as well as the results of this data analysis. First, general remarks will be provided on the quality of the data. Second, the choices made in data analysis will be explained. Afterwards, the data will be analysed. These will be structured according to opportunities, barriers, and windows of opportunity with subdivision in SPELT perspective. Each section (opportunities, barriers, and windows of opportunity) will end with an overview of the main results.

The quality of the data differs in ability and intention per respondent. The reason for this is twofold. First, not every respondent is well-informed on adding sustainable heat sources to the Amernet. Especially less populated municipalities (Drimmelen and Geertruidenberg) did provide less information on opportunities and barriers, because the respondents did not know (many) opportunities or barriers. Second, also the pro-activity of the respondents regarding the topic differed. A more pro-active attitude often resulted in more information on what could be windows of opportunity.

Sometimes the data contains contradictory information between respondents. This is not often the case, but two main contradictory stories exist. First, the CHP plant in Geertruidenberg is often seen as a barrier, because it produces heat with biomass. However, there are also respondents (also of governmental organisations) who state that Geertruidenberg is the most efficient plant in the Netherlands or that biomass can be a good certified sustainable resource. Another contradicting storyline is the success of the program up till now. Most respondents are negative on the process. However, especially Ennatuurlijk is stating that the goals set for 2024 are most likely going to be met.

The data also differed per source. Different sustainable heat sources especially have different barriers. Geothermal sources have far more barriers than biomass. Besides, the barriers they face are different. Biomass has more social barriers, whereas geothermal sources have more economical and technical barriers.

Third, often other processes (like enlarging the Amernet and increasing energy efficiency) were also mentioned by respondents. These processes are interrelated with the possibility of adding sustainable sources, but are only valid to include in this study up to the point that this interrelation exists.

5.2. Decisions regarding data analysis

The usefulness of SPELT analysis proved to be high. The method is all-including, because all information could be labelled. The only way in which information could not be labelled is that in mentioning opportunities often real projects were answered, like waste-heat in Moerdijk or the transition to hydrogen fuel of the CHP plant in Geertruidenberg. These real projects were often not specifiable to a dimension of SPELT, because they can be part of every dimension.

Although, the applicability of SPELT is high, there are several problems encountered in the data analysis. First, there is a thorough interrelation between dimensions of SPELT. This makes it difficult to analyse data in one dimension without considering the data of another dimension. Often, stories are told that involve multiple dimensions. When this is the case, the end point of the story (directly linking to adding sustainable heat sources) determines in which dimension the story is presented in this study. The interrelation will often be present in the data analysis. However, the complexity in relations is sometimes that high that not every relation could be explained in this study.

Second, there is an interrelation in the data with other processes within the Amernet. The goal of adding sustainable sources as explained in this study is often underlined by the respondents. "*We got a sustainability goal*" (Ennatuurlijk – geothermal). Also, the increasing efficiency in the Amernet by

adding heat sources is mentioned by Ennatuurlijk as well as municipality Tilburg. However, adding sustainable heat sources to the Amernet is often mentioned in combination with enlarging the Amernet. This happens partly due to the overlap these goals have on each other. When this connection is not present, the information provided in the interview about enlarging the Amernet will not be mentioned in this study, because this is not the topic of this study.

Third, it was sometimes unclear to which interview question respondents referred. Opportunities, barriers, and windows of opportunity were mixed, as can be pointed out by this statement of the respondent from the housing corporation: "barriers can also be viewed as chances". Therefore, interpretations are made by the researcher on where to place the described process. This interpretation is based on the division between opportunities, barriers, and windows of opportunity as is shown by the arrows in figure 2 (section 3.4). This interpretation is made based on the data of November and December 2019. Due to the changing institutional design, the division can change as well.

Fourth, policies are chosen to be included in the political dimension. Policies are heavily interrelated with political decision-making and therefore these two are combined. There are often references to policies present in the data.

5.3. Opportunities

Social

There are opportunities in the social dimension. First of all, the existence of a platform in which the adding of sustainable heat sources can be discussed is considered an important opportunity. There are several platforms available, but the platform mentioned the most is the program team of the Amernet, which is often called platform or steering group.

"*What is going well? That is that we have a constant platform wherein we can have these discussions*." (Housing corporation)

"*I think that in the last steering group meeting we have made steps to communicate a joint message to the people around us*." (Province)

Another social opportunity is the high public support for an energy transition. The foundation of the energy transition lies in a believe that climate change is happening and therefore sustainable heat sources should be found and used. The problems with earthquakes in the Groningen natural gas field only add to the idea of leaving natural gas behind and aim for sustainable heat sources, because this increases public support for moving away from natural gas as a heat source.

"*And there is a public opinion. We have to do something with natural gas. This cannot continue, for example because of Groningen*." (Municipality Tilburg)

This support can also result in social participation if ways are established in which civilians can participate. One key condition which has to be met, is that there should be formed consensus on which heat sources should replace natural gas. This is currently not clear, undermining public support and participation. This is not easy achievable, as will also be mentioned under political barriers.

Political

There are considered to be two interrelated political opportunities. First, there is a lot of political effort in finding alternatives to natural gas heating. This is mainly stimulated by the national government, who forces a political vision (heat transition plan) of no natural gas by putting speed on creating a new Heat law:

"*In spring 2020 it will be consulted [the new Heat law]. Then everybody can react. And then we also want to go to the Raad van State [judicial adviser] in 2020."* (Ministry of Economy and Climate)

"*We have to get off the gas grid. The Heat law 2.0 will stimulate this heavily.*" (Municipality Breda)

Next to this, often is mentioned that there exists political will to move in this topic. This is for example mentioned by the municipality Breda and Ennatuurlijk:

"*Yes, absolutely. We were a frontrunner in signing the intention agreement [of the Amernet program]."* (Municipality Breda)

"*The province is much more active in Brabant [than other provinces], they want to feel involved in the development.*" (geothermal – Ennatuurlijk)

Economic

There are several economic opportunities. The most important economic opportunity is the availability of the so-called SDE subsidy (=SDE+ subsidy). This subsidy is available for renewable resources and is the main reason why sustainable heat sources can have a balanced business case, wherein costs do not outweigh the benefits.

"*As long as the SDE subsidy is available, I think the costs can be mitigated.*" (Province)

"*The SDE+ subsidy is of course the reason why renewable energy is made in the Netherlands…. the lifeline.*" (RWE)

Other economic opportunities were also mentioned in the interviews. First of all, the financial feasibility of sustainable heat sources increases by the economies of scale that are always present in district heating networks. There is a greater and easier market for a heat source, because connections to buildings are already made. Second, investment in a geothermal heat source is made possible by a cooperation of private and public parties. This is also seen as an opportunity. Third, there is an increase in transparency provided in business case contracts by Ennatuurlijk. This increases investment security. Although this suggests that not all is well, this is seen as an opportunity which emerging opportunity (Housing corporation).

Legal

Next to economic opportunities, there might be two legal opportunities in adding sustainable heat sources to the Amernet. These opportunities stem from the already moving legal framework. First of all, a new Heat law will be created by the ministry of Economy and Climate: Heat law 2.0. This new Heat law will solve hindrances in the development of district heating. This creates an incentive in the development of sustainable heat sources to the Amernet.

"*Heat law 1.0 is now being implemented and we work on Heat law 2.0, which tries to coordinate the whole market structure.*" (Ministry of Economy and Climate)

Besides the Heat laws, ambition is often turned into legal obligations. Municipalities are asked by the Dutch government to create Heat visions, which should be formalised in 2021. Also other stakeholders contribute by putting forward legal goals by their own, for example by signing the intention agreement of the Amernet. Part of this is the commitment to adding sustainable heat sources (30 MW in 2024). Sometimes, stakeholder commitment is also enforced by law, as becomes clear in the following statement:

"*The offer we made is 70% CO_2 reduction. This will become part of the Heat law.*" (Ennatuurlijk)

Technical

There is also a technical opportunity for adding sustainable heat sources. This opportunity stems from the existence of sufficient technology to create new sustainable heat sources. En vice versa, adding sustainable heat sources also provides an opportunity for the existing technology. Existing technology can be tested and improved by implementing and testing new projects.

"*It is really necessary to have such developments [geothermal and sun thermal testing projects]. In this way, you can connect multiple sources to the Amernet.*" (Ministry of Economy and Climate)

"*I think it is a really good thing that we look at new technologies, for example the sun thermal project in Breda.*" (Province)

The existence of these technologies contributes to the addition of sustainable heat sources to the Amernet.

Summary

To conclude, every dimension contains at least some opportunities. In table 6, the opportunities in adding sustainable heat sources to the Amernet can be found. Three opportunities are mentioned by the majority of respondents (underlined in table 6). These are the presence of a cooperation platform as a social opportunity, the existence of the SDE subsidy as an economic opportunity and the upcoming new Heat law as a legal opportunity.

Dimension	*Opportunities*
Social	-the presence of a cooperation platform -public support for energy transition
Political	-the positive intention in the political system
Economic	-SDE subsidy -increasing transparency -economies of scale
Legal	-new Heat law -ambition turned into legal obligations
Technical	-existence of technology

table 6: Opportunities in adding sustainable heat sources

5.4. Barriers

Social

There are identified three social barriers that prevent the addition of sustainable heat sources to district heating. The first social barrier is that there is a lack of trust between stakeholders, especially between Ennatuurlijk and the other stakeholders. There is distrust on three levels. First, there is no full transparency provided in the business case of Ennatuurlijk, as claimed by the housing corporation: "*I do not think that Ennatuurlijk will provide full insight and show their cards, that they let everybody look into the total business case of the network*". Second, there is a widespread feeling that Ennatuurlijk has not the appropriate position to fulfil a public service (heating is seen as a public service), leading to statements like: "*[Ennatuurlijk] is a grid operator and a heat supplier. This cannot remain together in the future*" (Citizen). Also being a private party is seen as a barrier: "*I do not want to speak ill. But they are a private party. Therefore, they are always looking for a feasible business case. The conversation is different*" (Municipality Breda). Third, there is a more general distrust against district heating by consumers, because it creates a dependency on the heat supplier: "*Then, civilians do not have a choice anymore. So, there will be established district heating in their district. But support for connecting to district heating is important, because success is difficult when there is much public*

resistance" (Ministry of Economy and Climate). All of these factors decrease the credibility of the Amernet and are therefore counterproductive in adding new sustainable heat sources to the Amernet.

This distrust results in an inability to identify which roles everyone has to play in adding sustainable heat sources, questioning the position of Ennatuurlijk as well as the possibility of public participation.

"*First, a company is going to think through how it should be done and afterwards they ask civilians if they want to join. That is exactly the wrong order."* (Citizen)

"*Municipalities tend to point to Ennatuurlijk. Ennatuurlijk points back to municipalities or housing corporations. So the question is: who dares to take the first step*?" (Province)

There are two other social barriers. First, the lack of support for biomass is frequently mentioned. Biomass has currently a negative publicity. This is frustrating the addition of sustainable heat sources, especially because the most developed projects often use biomass in the context of the Amernet. This discussion is about the sustainability of the origin of biomass. Therefore, it is unclear if biomass heating should be implemented. The stakeholders have opposing positions in this discussion. Second, the position in the program of the Amernet is sometimes also unclear. Less populated municipalities (Drimmelen and Geertruidenberg) questioned whether they were involved enough. This is no direct barrier, but might be a threat to the development of sustainable heat sources. Their support is often needed, because additional heat sources are often developed in less populated municipalities, due to the fact that there is more space to build there.

<u>Political</u>

One often mentioned political barrier is the uncertainty on how to proceed. The mission is clear: get off natural gas. However, there is no clear direction as there is an array of options to choose from. Combining this uncertainty with a focus on constructing a Heat vision in the RES (obligatory and should be finished in 2021), sometimes results in a waiting attitude towards the development of district heating. This effect is enhanced by the lack of capacity in the municipalities to handle all the workload related to energy at once.

"*Well, if the energy transition is to be successful, the role of the [municipal] government should be more pushing*." (Citizen)

"*In our perspective the [municipal] government should dare more. They are leaning back. Of course they are still searching in this trajectory. However, if they want to proceed, they should put more effort in*." (Province)

"*There is not yet a masterplan heat. We are working on starting the creation of a Heat vision.*" (Municipality Tilburg)

A second political barrier is the lack of space for the creation of sustainable heat sources. The cities of Breda and Tilburg are stressing that there is not enough space within their own borders to provide heat for the consumers. Also, for the Amer region as a whole, parties stress the intense spatial consequences from the addition of enough sustainable heat sources to fully support the Amernet.

"*The municipality Breda and the municipality Tilburg have not enough space to realise sustainable sources. The question is: to which extent can you ask from the surrounding region to produce heat for you."* (Municipality Breda)

"*In the end, the dilemma of energy transition is: what to do with the limited space that we have."* (Ennatuurlijk)

A last political barrier is the political fear to make unpopular decisions. This is stressed by anecdotes of municipal politicians who had to leave their positions, and by anecdotes about suboptimal solutions. This generic issue is also applicable when adding sustainable heat sources. For example, the glasshouse owner tells about the non-existing connection of the Amernet with a waste burner. The waste is burned anyhow, only this heat source is not added due to political sensitivity. This is an example of a suboptimal solution.

Economic

A first economic barrier, which is especially feared by municipalities, is: too high energy costs. There is a need for socialization of energy costs. Socialising costs is something which is done in the Netherlands for electricity and natural gas. It entails that energy costs are organised in such a way that there is not much difference between energy prices per household. Therefore, socialization is a redistribution of costs. For now, the level of socialising costs like with electricity and natural gas does not exist. This is probably also not possible, because not everybody can be connected to district heating. Therefore, a new system has to be invented in order to counter energy poverty (Municipality Tilburg).

"*One person has to buy a heat pump of €15.000,- and the other gets a district heating connection of €5.000,-. One person gets a lower energy bill, the other a higher energy bill. How are you going to organise that?"* (Municipality Tilburg)

This barrier is not directly related to the creation of sustainable heat sources, but it involves the decision to choose for a district heating network or to move away from a district heating network. This would make the question of adding sustainable heat sources irrelevant.

Another economic barrier is the difficulty to make a beneficial business case for sustainable heat sources. Especially for geothermal sources this is difficult, due to high investment costs. These costs mainly arise from the knowledge gap that exists concerning the underground. This stresses the need for extra research, costing several millions of euros (geothermal – Ennatuurlijk).

There is also a barrier in the small financial profit space that is present in sustainable heat sources. Sustainable sources are still more expensive than fossil sources, which makes it more difficult to develop sustainable heat sources. This is especially important for the addition of sustainable heat sources which cannot often be used due to a low demand, because the SDE subsidy does not apply to temporarily producing heat sources.

"*You cannot apply for SDE subsidy on that part. It is not structured in that way. The SDE subsidy is structured on base load units [not units producing for peak load]."* (Ennatuurlijk)

Legal

There is one legal barrier identified. This is related to the social barrier of distrust towards Ennatuurlijk for being a private party. The district heating operator has to be a private party, due to legislation called the Splitting law (Splitsingswet) (Overheid, 2014). This law has made it obligatory that grid operators of district heating are not state-owned. As long as this legal barrier is in place, the social barrier of distrust cannot be lifted by installing a public party.

"*Ennatuurlijk exists as a consequence of the Splitting law of the ministry. They said: no other activities any more than gas and electricity. District heating has to become a market activity. They have to be moved away from gas and electricity."* (Municipality Tilburg)

Other legislation procedures were not seen as a barrier. Legislative problems regarding nitrogen and PFAS (were mentioned in relation to slowing down the procedure. However, these processes were argued to be temporary, and due to lack of permanence they were not seen as a barrier in itself.

Technical

There are two interrelated technical problems. The most important one is the need to use a lower temperature in the Amernet. Many sustainable heat sources need a low temperature to be able to deliver optimal heat supply to district heating, like geothermal and sun thermal sources. This is exemplified by the respondent with an expertise in geothermal sources:

"*Geothermal sources produce a low temperature and the higher this temperature comes back, the higher the temperature goes back into the earth and the less you use the capital that you have invested*." (geothermal – Ennatuurlijk)

Another respondent stresses that the lowering of the temperature in the Amernet does not get enough attention:

"*We are already in a development towards a lower temperature, but this has to go faster*." (Province)

However, this results in a related technical problem. Interventions are needed to adjust buildings to a lower temperature:

"*In the end, a lot needs to be changed in the houses. There is looked a lot at the sustainability of the Amernet …… On the other side you see the consumer, I do not know if he realises how important it is what he is going to do in the future*." (geothermal – Ennatuurlijk)

Summary

To conclude, all identified barriers can be found in table 7. The following barriers are identified by the majority of the respondents (underlined in table 7). First, lack of trust and public support for biomass are important social barriers. The delay in political decisions is an important political barrier. This is divided in two perspectives. One perspective indicating that political decisions are not yet known and will be formulated by creating Heat visions. A second perspective stresses the need of the political arena to take action and start moving (especially towards municipalities). The last often mentioned barrier is the need to lower the temperature (technical barrier).

Dimension	*Barrier*
Social	-lack of trust -lack of public support for biomass -position in program unclear for less populated municipalities
Political	-waiting for political decisions -space is scarce -sometimes forces unpopular decision making
Economic	-the need for socialization of energy costs -sustainable heat sources more expensive than fossil heat sources
Legal	-splitting law privatizing district heating operators
Technical	-a lower temperature is needed -The influence of isolation is not known to consumer

table 7: barriers in adding sustainable heat sources

5.5. Windows of opportunity

Social

Two social windows of opportunity can be identified, which partly solves the social barriers as indicated above. First, social participation can be seen as a window of opportunity. Social participation does add resources to the development of sustainable heat sources. Furthermore, it adds public support to the transition, which is identified as an important social barrier.

Interviewer: "*It has to be a collective ownership*?" Respondent: "*Yes, maybe not of district heating itself, but of sources connected to the Amernet.*" (Citizen)

Second, another social opportunity is the framing of biomass discussions by creating stories. This is exemplified by two respondents:

"*It is especially important to tell your story pro-actively*." (RWE)

"*I think we have made steps in bringing forward a joint message [including biomass].*" (Province)

This does not mean that the biomass discussion is solved by creating a story. In the end, time is needed to form a coherent opinion that can combine both sides, according to the respondent of RWE.

Another possible window of opportunity is the creation of demonstration projects, according to the Ministry of Economy and Climate. This creates understanding of what creating a sustainable district heating network involves, and therefore create public support.

Political

The creation of the Heat vision plan can be considered a barrier. However, the Heat vision plan itself can be considered a window of opportunity. Especially municipalities often point out that everything will become clearer when the Heat vision plan is made. The Heat vision plan is only finished in 2021 (as part of the Regional Energy Strategy), but can then function as a pushing platform for change. This counters the threat of unclarity of direction (political barrier).

"*This will be worked out and get a place in the regional energy strategy.*" (Municipality Tilburg)

"*Yes, out of the heat transition plan shall come forth ….. which choices we have to make*." (Municipality Geertruidenberg)

Economic

There are three economic windows of opportunity. First, in the near future (somewhere in 2020) the SDE subsidy will become applicable to waste-heat, giving a boost to this kind of sustainable heat sources (Ministry of Economy and Climate). Second, isolation programs can be developed in municipalities, like in the municipality of Geertruidenberg. The isolation program arranges a collective purchase of isolation, making it cheaper for each individual, based on economies of scale. The third economic window of opportunity is the economies of scale when housing corporations offer houses to connect to district heating. This is discussed in a cooperation between housing corporations, grid operators and the governments. This is profitable for grid operators, providing room for further investments.

Legal

The creation of the Heat law 2.0 is mentioned as an opportunity, but also as a window of opportunity. This is probably due to the fact that the Heat law 2.0 is in development. It is not in existence yet. The Heat law 2.0 can address the market structure of district heating as well as ways to socialise the costs. Therefore, it can solve social barriers as well as economic barriers.

"*I think there has to be made another market structure. Probably they are already working on that in the Heat law 2.0."* (Municipality Breda)

Another legal window of opportunity is the certification of biomass. This can help in making biomass trustworthy, depending on the sustainability criteria used for the certification of biomass.

Technical

A technical window of opportunity is the creation of smart networks (Ennatuurlijk). The smarter the network, the less energy is spilled and the lower the peak demand is relative to the base demand. This makes district heating more efficient. In this way, heat sources can produce a more stable flow of heat. A window of opportunity in reducing peak demand can be found connecting the following two statements:

"*Back then, we were awarded if we used heat from 11 till 6 instead of midday, to reduce the peak capacity of the Amer plant*." (Glasshouse owner)

"*You have to think of smart things to make the system more efficient, to provide opportunities to buffer heat or make agreements with consumers to consume heat at another time.*" (Ennatuurlijk)

This is a specific example of available space to make an agreement here on the time planning of consuming heat in order to make the system smarter. Besides, next to Ennatuurlijk, several respondents stress the capabilities of buffering in making district heating smarter.

Summary

To conclude, table 8 shows the windows of opportunity in adding sustainable heat sources to the Amernet. The windows of opportunity mentioned by the majority of respondents are underlined in table 8. First, the Heat vision plan as a political window of opportunity is often mentioned. Second, the Heat law 2.0 is often mentioned as a legal window of opportunity. Both these windows of opportunity were also mentioned as normal opportunities. Third, the need for a smart network is present in the data.

Dimension	*Window of opportunity*
Social	-social participation -telling stories
Political	-Heat vision plan
Economic	-SDE changes -isolation programs -housing corporations offering houses to connect
Legal	-Heat law 2.0 -certification of biomass
Technical	-smart network

table 8: windows of opportunity in adding sustainable heat sources.

The results will be discussed in the next chapter in order to show what the results mean for adding sustainable heat sources to existing district heating networks. The sort of influence of each of the identified opportunities, barriers, and windows of opportunity on the addition of sustainable heat sources will be assessed. Sub-conclusions on each of the sub-questions will be formulated. Afterwards, the main research question will be answered based on these sub-conclusions. Finally, a reflection will be provided on the applicability of the conclusion on other cases and on the context in which the conclusion is to be understood.

6. Discussion and conclusion

6.1. Opportunities

A distinction can be made based on what the mentioned opportunities by respondents mean for the addition of sustainable heat sources to the Amernet. The separation is made between intentions, possibility and co-benefits.

First of all, there are opportunities which stress positive intentions in adding sustainable heat sources. These are the presence of a cooperation platform, the positive intention in the political system, ambitions turned into legal obligations and the public support for an energy transition. They are all contributing to the possibility to come to an agreement in realising additional sustainable heat sources. The cooperation platform is the most specific opportunity. The cooperation platform is intentionally erected to add sustainable heat sources to the Amernet by bringing stakeholders together. The positive intentions in the political system, ambitions turned into legal obligations and the public support for an energy transition are broader than the addition of sustainable heat sources and are often focusing on the whole energy transition. This is probably the reason why the cooperation platform is mentioned more often as an opportunity. The public support for an energy transition to move from natural gas to sustainable sources is an underlying argument for the existence of the other positive intentions. This link is especially strong between political intentions and public support, because the political arena tries to represent the public.

Second, there are opportunities which are stressing the direct possibility to add sustainable heat sources to the Amernet. The SDE subsidy, the presence of technology and economies of scale are part of this group. The SDE subsidy can be considered a big opportunity in adding sustainable heat sources to the Amernet. This is argued in the interviews from two perspectives. First, the SDE subsidy will result in a feasible business case. Second, it is mentioned several times that fossil sources are cheaper than sustainable sources currently and that this counterforce needs to be mitigated. The SDE subsidy increases the possibility of a feasible business case for a sustainable heat source. Therefore, it is helpful to the addition of sustainable heat sources to the Amernet. The presence of technological know-how is another opportunity in this respect. Although it is sometimes stressed that most technologies are not fully evolved, there seems to be enough technological know-how to set-up pilots. Third, economies of scale inherently present in district heating help to add sustainable heat sources to the Amernet. Existing district heating networks provide a consumer pool which helps sustainable heat sources to deliver their heat to consumers without high transportation costs. To conclude, adding sustainable heat sources connected to the Amernet is possible.

Third, there is an opportunity mentioned, which stresses the indirect possibility of adding sustainable heat sources, by means of a co-benefit structure: increasing transparency. Increasing transparency is an indirect support for adding sustainable heat sources to the Amernet. The increasing transparency builds trust. This trust is needed to add sustainable heat sources, because stakeholders have to work together in the implementation of these sources.

One opportunity mentioned by respondents will not be considered to be an opportunity. These are the new Heat law and increasing transparency. The new Heat law is also mentioned as a window of opportunity. This seems to be the appropriate place for the Heat law, because this law is not finished yet, and the content can still change. This is not yet an existing opportunity in adding sustainable heat sources to the Amernet (the law is not implemented yet), but a window of opportunity. Opportunities have to be present already to be an opportunity (as defined in section 3.3.6.).

To round up, sub-question 1 will be answered. Sub-question 1 is:

"What are opportunities for adding sustainable heat sources to existing district heating networks in the current institutional framework?"

There are four opportunities identifying positive intentions to add sustainable heat sources to the Amernet: the presence of a cooperation platform, good political intentions, legal pressure and a public support for the energy transition. There are three opportunities that increase the possibility of implementation of sustainable heat sources: the SDE subsidy, the presence of technology and economies of scale. Finally, there is one indirect opportunity that can have co-benefits for the addition of sustainable heat sources: increasing transparency.

The applicability of these opportunities on other district heating networks will most likely differ, although this is not researched directly in this study. The presence of a cooperation platform, good political intentions and increasing transparency might not be present in other district heating networks, as these seem to be very context-specific on a local level. Legal pressure and the SDE subsidy are opportunities in a Dutch context, so these opportunities will be present for all district heating networks in the Netherlands. Public support for the energy transition, the presence of technology and economies of scale are likely to be present as opportunities on an international level.

6.2. Barriers

There are identified four different kind of barriers in adding sustainable heat sources to the Amernet. These are: direct barriers in the realisation of sustainable heat sources, barriers in how to organize district heating, barriers in knowledge and threats to the development of sustainable heat sources for the Amernet.

First, there are four direct barriers: scarce space, the need for a lower temperature, the lack of public support for biomass and the need for unpopular decisions. Scarce space is applicable to the development of all types of sustainable heat sources to the Amernet. Of course this factor favours the heat sources that occupy less space or use already existing sources (waste-heat). The need for a lower temperature is another barrier for many sustainable heat sources. Only biomass and CHP can directly deliver high temperatures and can cope well with higher return temperatures. Most waste-heat and geothermal sources do not and neither do sun thermal sources. The other mentioned sources in section 2.3 need lower return temperatures in order to be able to deliver heat to the Amernet. There are also barriers for specific sources. For example, the current lack of support for biomass only influences the addition of biomass heat sources to the Amernet. This also applies to the need for unpopular decision-making. Biomass and waste-heat from the burning of waste are politically unwanted sources. If these sources should be wanted is something that will not be addressed in this study. However, it is clear that this issue is a barrier in adding these sources to the Amernet.

Second, there are three barriers addressing how to organise district heating. These are lack of trust, the splitting law and the need for socialization of energy costs. These barriers do indirectly influence the implementation of new heat sources, because they influence the appeal of district heating. A low appeal will lead to less investments in district heating and a search for alternatives to district heating. The barriers in this category are interrelated. Trust is a first barrier in this category. There is no trust between stakeholders, especially towards the grid operator Ennatuurlijk. This is partly due to the fact that no full transparency is provided. However, a deeper reason behind this lack of trust seems to be that Ennatuurlijk is a private party which makes profit. This brings us to the second barrier: the Splitsingswet (Overheid 2014). This law makes it obligatory that grid operators of district heating are not state-owned. So, the grid operator has to be a private party by law. The third barrier also addresses trust, but focuses more on a lack of trust in the current system: the need for socialization of energy costs. There are no socializing measures to counter high energy costs of district heating yet. For natural

gas and electricity, costs are made more equal by redistribution. This is done by force of law. This does not apply to district heating. Complete socialization is probably not possible, but an effort is asked from the Dutch government. Especially municipalities are afraid that no socialising system leads to excesses in costs and energy poverty.

Third, there are two barriers based on lack of information. For example, lack of information is apparent in the waiting for political decision. This is mostly seen on municipal level. The municipalities are working on the Heat vision plan, which has to provide information on which districts use which heating source. When municipalities are asked on what to do, they often mention that they are waiting on the results of the Heat vision plan. The fact that these results are not available yet, slows down political decision-making. Next to this, the importance of isolation to the sustainability of district heating is unknown to consumers. Often, consumers do not know what their influence on district heating is at all. In this way, temperature of district heating need to be higher, which again influences the entrance of sustainable heat sources (as explained in the paragraph of direct barriers).

There are also two barriers mentioned, which can better be seen as threats. These are not yet barriers, but they can evolve into a barrier. First, less populated municipalities do not feel involved in the program of the Amernet (the program tries to implement sustainable heat sources). When this is not addressed enough, there can be a decreased willingness to contribute to this program. This is particularly important in light of scarce space. Every space to implement new sustainable heat sources is needed and less populated municipalities have more available space to realise these heat sources. Second, fossil heat sources are cheaper than sustainable heat sources. This is often mentioned as a barrier. However, there is also often mentioned that the SDE subsidy does help in diminishing this difference. Therefore, this barrier is only a threat if changes are made in the SDE subsidy.

To round up sub-question 2 will be answered. Sub-question 2 is:

"What are barriers for adding sustainable heat sources to existing district heating networks in the current institutional framework?"

There are four direct barriers: scarce space, the need for a lower temperature, the lack of public support for biomass and the need for unpopular decisions. There are three barriers in the organization of district heating: lack of trust, the splitting law and a need for socialization of energy costs. There are two information barriers: waiting for political decisions and the lack of knowledge of consumers in how they influence district heating.

There are also two threats identified: the lesser involvement of less populated municipalities and the price difference between fossil heat sources and sustainable heat sources. These are not an answer to the sub-question, because they cannot be considered barriers yet.

Again, the applicability of these barriers to other district heating networks will most likely vary. Lack of trust and the need for a lower temperature are different for each district heating network, though not many low temperature district heating networks exist yet. Scarce space, the lack of public support for biomass, the splitting law and waiting for political decisions seem to be applicable to all Dutch district heating networks, and might also be applicable outside the Dutch context. The need for a socialization of energy costs might be universal, but is probably mentioned because the Netherlands has a socialization system for electricity and natural gas. The need for unpopular decisions and the lack of knowledge of consumers in how they influence district heating are likely to be applicable to district heating networks across the world.

6.3. To counter barriers

There are three ways mentioned by respondents in which barriers can be countered. There are small windows of opportunity to help counter barriers, there are big windows of opportunity to help counter barriers and there are windows of opportunity which can be made but result in a dilemma.

First, there are four small windows of opportunity: telling stories, certification of biomass, isolation programs and housing corporations offering houses to connect. Small windows of opportunity are labelled 'small', because they are a partial answer to a barrier. Telling stories is often mentioned in the biomass discussion. If one perspective gets all the attention, creating a second story with another perspective can be helpful. This does not eliminate the first story, but it can create nuance. The certification of biomass might help to support a more positive perspective on biomass. Both these windows of opportunity will help in the addition of biomass as a heat source. Also isolation programs are helpful. This does not have to consume a lot of resources. In the municipality Geertruidenberg, the isolation program shares information about how to isolate your house and offers a collective sale, which makes isolation cheaper. This will move more people towards isolation, though not everybody is likely to cooperate. Housing corporations offering houses to connect is a window of opportunity that mitigates the threat that fossil heat sources are cheaper than sustainable heat sources. Enlarging the Amernet (which is a contemporary ongoing process) increases the demand for heat. Therefore, it does increase pressure on realising sustainable heat sources. Besides, it leaves opportunities to investment in sustainable heat sources, because this can be included in the contract.

Second, there are two big windows of opportunity: SDE changes and the Heat vision plan. Big windows of opportunity are labelled 'big', because they can fully overcome a barrier. The Dutch government will make SDE changes in the near future. The SDE makes a more favourable business case. In this way, it has a high positive influence on the realisation of sustainable heat sources. Coming SDE changes are going to include waste-heat sources, resulting in a big incentive in the development of this kind of sustainable heat sources (which waste-heat sources are assumed to be part of). This will especially help in the competition of waste-heat sources with fossil heat sources. Next to this, the development of the Heat vision plan can slow down the process for now, but can become a window of opportunity in the future. If the Heat vision plan is created, a vision has been made on which district should use which form of heat. This largely solves the unclarity related to the direction of the energy transition. Therefore, it is an incentive to the development of district heating, at least for the parts which have been appointed to district heating.

There are also three windows of opportunity which do solve barriers, but contain dilemmas in themselves. First, social participation is often mentioned as a window of opportunity. Social participation would help at developing sustainable heat sources directly as well as improve public support and increase trust towards this development. However, also mentioned by respondents is the technical difficulty of developing sustainable heat sources into an existing district heating grid. There is a tension between the involvement of civilians versus the needed skill to translate ideas into a district heating system. Second, the Heat law 2.0 is a window of opportunity (as argued under opportunities). The Heat law 2.0 will address issues like ownership of district heating, market structure and could also address the socialization of costs. There is no easy right or wrong answer for these issues. Should district heating be privately owned or state-owned? And by whom? Should costs be socialized or to what extent should costs be socialized? However, the creation of Heat law 2.0 is a window of opportunity to address these barriers. Third, the creation of a smart network is a window of opportunity. Consumption differs over time due to increased demand when it is cold and increased demand depending on the time of the day. A smart network tries to balance consumption by shaving the peak. Shaving the peak entails that district heating does not have to function on full capacity and

can lower the temperature in the network. However, who should start shaving the peak? The grid operator or consumers? This is a dilemma which can be solved by further research in order to use this window of opportunity.

To round up, sub-question 3 will be answered. Sub-question 3 is:

"How should be the current institutional framework be changed to overcome the barriers resulting from the current institutional framework?"

Table 9 gives an overview on countering barriers. All barriers are listed and behind them the windows of opportunity which can (partly) solve this barrier. The threats are included for a more complete overview of the results, though they cannot be considered barriers at this moment. Table 9 is the answer to the third research question. There are two limitations to this answer. First, not every window of opportunity is a panacea. This is especially the case for the small windows of opportunity. Second, not every barrier has a response by a window of opportunity. Therefore, it should be investigated how these barriers can be circumvented or dissolved. In this research, no answer is found to these barriers. Therefore, no suggestions can be made on how to change the institutional framework to overcome these barriers.

Barriers	**Windows of opportunity**
Lack of trust	Social participation
Lack of public support for biomass	Social participation / Telling stories / Certification of biomass
Waiting for political decisions	Heat vision plan
Space is scarce	
Sometimes forces unpopular decision making	
The need for socialization of energy costs	Heat law 2.0
Splitting law privatizing district heating operators	Heat law 2.0
A lower temperature is needed	Isolation programs / Smart network
The influence of isolation is not known to consumer	Isolation programs
Threats	
Position in program unclear for less populated municipalities	
Sustainable heat sources more expensive than fossil heat sources	SDE changes / Housing corporations offering houses to connect

table 9: barriers/threats and which windows of opportunity can counter them.

The applicability of windows of opportunity to other district heating networks is high. Every window of opportunity is a response to a barrier (as defined in section 3.3.6). If this barrier is present, the window of opportunity will always be (part of) a response to that barrier.

There are two counterarguments to this general applicability. First, the windows of opportunity mentioned are sometimes country-specific (like Heat vision plan, Heat law 2.0 and SDE changes). However, also these windows of opportunity can be formed in other countries (although probably named differently). Second, some windows of opportunity are dependent on culture. Social participation and telling stories are sometimes not needed due to other organisation structures. However, in that situation the barriers that these windows of opportunity address will also not be present as a barrier.

6.4. Conclusion

With the identification of opportunities, barriers, and windows of opportunity, the main research question can be answered. The main research question is:

"How should the current institutional framework be changed to overcome the barriers in adding sustainable heat sources to existing district heating networks?"

There are several ways in which a current institutional framework can be changed to overcome barriers in adding sustainable heat sources to existing district heating. Windows of opportunity are identified, which counter identified barriers. They are visualized in table 9. There is not one window of opportunity which is going to solve all barriers present in adding sustainable heat sources to existing district heating networks. A combination of the identified windows of opportunity have to be used. Specific attention has to be provided to the big windows of opportunity. These windows of opportunity can fully overcome certain barriers. This also applies to the windows of opportunity which result in a dilemma. These dilemmas should be solved in order to enhance the addition of sustainable heat sources to existing district heating infrastructure. Small windows of opportunity are additional measures which help in the addition of sustainable heat sources.

Just as important is to keep the institutional framework intact at parts of existing opportunities in adding sustainable heat sources to existing district heating networks. Especially the SDE subsidy is very helpful in creating a beneficial business case for sustainable heat sources. When the current institutional framework changes, it is important to keep the existing opportunities.

These opportunities, barriers, and windows of opportunity are applicable to waste-heat, biomass, sun thermal, CHP and geothermal heat sources. These heat sources are identified as the main possible heat sources of district heating at the moment, based on academic sources. This study provides insight in how to add sustainable heat sources to existing district heating networks. Therefore, it adds to the existing academic debate which focuses on how to increase sustainability in existing district heating networks as identified in section 2.3.

6.5. Reflection

In interpreting the conclusion, the following limitations of this research should be taken into account. First, as already mentioned in the sub-conclusions, the applicability of the results to all existing district heating networks diverges due to the context-specificity of the case Amernet. The use of one case is used to find variables influencing the addition of sustainable heat sources. This does not mean that every variable is present in other district heating networks or that no other variables can be found in other district heating networks. Suggestions have been made on how applicable the opportunities, barriers or windows of opportunity are to other district heating networks besides the Amernet.

Second, the data used is based on perspectives of respondents. The statements of the respondents are not tested on absolute truth. However, not often are contradicting stories told between respondents, indicating that the statements of respondents often do correspond with reality.

Third, in this research is assumed that waste-heat, CHP, biomass, geothermal and sun thermal sources are sustainable heat sources. However, the sustainability of biomass and certain types of waste-heat are questionable. This is not further deepened in this study, but could be done in future research.

6.6. Link to planning theory

This research is based on normative assumptions, as can be seen in the basis on perspectives and the assumption of sustainability. This normativity has added value. First, adding sustainable heat sources itself is normative. This is deemed necessary in current academic as well as current societal debates.

This research adds to this goal. Second, this research identifies many variables which are deemed important in adding sustainable heat sources to existing district heating networks. Therefore, this research contributes to planning theory by identifying what barriers should be solved and this research makes suggestions how these barriers can be solved by windows of opportunity. This can be input for further analysis on cooperation frameworks. The general applicability of the identified variables must be further investigated, but this is a start in researching these variables.

Two suggestions for further research in planning will be made in this study. First, a stakeholder decision framework should be developed. This research identifies which changes can be made to address a certain barrier, but not how these changes should be implemented. Besides, the dilemmas in the windows of opportunity still need to be worked out. How to implement these changes should be examined. Research in planning can help develop this stakeholder decision framework. Second, best practices in the organisation of adding sustainable heat sources to existing district heating should be investigated. Lessons may be learned in how to overcome the mentioned barriers in this study, solving the issue on how to change an institutional framework to allow for the addition of sustainable heat sources to existing district heating networks. Planning research should focus on how best practices in existing district heating networks can be implemented elsewhere.

Furthermore, also in the broader academic world scientific discourse about the sustainability of several types of heat sources should continue. Clarity on sustainability will contribute to the addition of sustainable heat sources to existing district heating.

When the suggested research is successfully done and added to this study, adding sustainable heat sources to existing district heating networks will accelerate. This will contribute to the sustainability of district heating systems. Then, it can play a part in an energy system of the future.

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Appendix 1: Interview guide

Allereerst worden de respondenten welkom geheten. Er wordt uitgelegd wat het onderzoek inhoudt: het onderzoeken van barrières en kansen in het toevoegen van duurzame bronnen aan bestaande warmtenetten. Hierbij wordt verteld dat het Amernet als casus wordt gebruikt. Vervolgens wordt er uitgelegd wat er met het interview gebeurt in dit onderzoek: deze wordt getranscribeerd en gecodeerd en daarna wordt deze vergeleken op overeenkomsten en verschillen tussen resultaten van de interviews.

Er wordt medegedeeld dat dit gesprek wordt opgenomen. In geval van bezwaar, zullen uitkomsten van het interview worden genoteerd. Er wordt aangegeven dat hun privacy wordt gewaarborgd en ze niet herleid kunnen worden in het onderzoek.

1. Kunt u kort vertellen wat uw functie is bij uw organisatie? Wat is vanuit uw functie de relatie met het (verduurzamen van) het warmtenet?
2. Welke doelen streeft uw organisatie na met of via het Amernet?
    a. Verduurzamen, financieel en/of betrouwbare warmtevoorziening
    b. Gebonden/niet per se gebonden aan het Amernet
3. Kunt u zich vinden in het idee dat er nieuwe duurzame bronnen worden ontwikkeld om in te voeden op het Amernet. Vindt u dit belangrijk, en waarom (niet)?

Vervolgens wordt de vertaalslag gemaakt door te introduceren dat er binnen het Amernet de ambitie is om het net uit te breiden met duurzame bronnen.

4. **Wat ziet u op dit moment als kansen in het verduurzamen van het Amernet? (Hierbij wordt gelet en eventueel gestuurd op de verschillende dimensies van SPELT)**
5. Wat is uw bijdrage/de bijdrage van uw organisatie aan de verduurzaming van het Amernet?
6. Wie hebt u nodig om uw bijdrage aan de verduurzaming van het Amernet te kunnen leveren?
7. **Wat ziet u als barrières in het verduurzamen van het Amernet? (Hierbij wordt gelet en eventueel gestuurd op de verschillende dimensies van SPELT)**
8. **Heeft u ook ideeën over hoe deze barrières in het verduurzamen van het Amernet kunnen worden weggenomen? (OPTIONEEL, wanneer vraag 7 positief beantwoord is)**
9. Welke bijdrage kan u/uw organisatie leveren aan het wegnemen van deze barrières?

De respondent wordt bedankt voor de tijd die hij heeft geïnvesteerd in het onderzoek. Ook wordt hem of haar gevraagd of hij/zij interesse heeft in de uitkomsten van het onderzoek. Dan zullen die te zijner tijd gedeeld worden met de respondent.

10. Heeft u nog informatie over het verduurzamen van het Amernet die ik als onderzoeker niet mag vergeten?

Appendix 2: Format and questions workshop experts

Politiek, Economisch, Ecologisch, Technisch, Juridisch & Sociaal

Er bestaan 6 A4tjes met elk 1 dimensie. Die moeten in volgorde worden gelegd op de schaal aangegeven bij de vraag. De vraag is een rangorde te geven die in principe van 1 (groot) naar 6 (klein) loopt. Er mag echter aan verschillende dimensies dezelfde rang worden gegeven. Hierbij worden de redenen hiervoor in post-its op het A4 met desbetreffende dimensie geplakt.

Eerst wordt uitgelegd wat onder elke dimensie verstaan wordt. Daarna wordt ook uitgelegd hoe de vragen zijn opgebouwd om overlap in de beantwoording van de vragen te voorkomen.

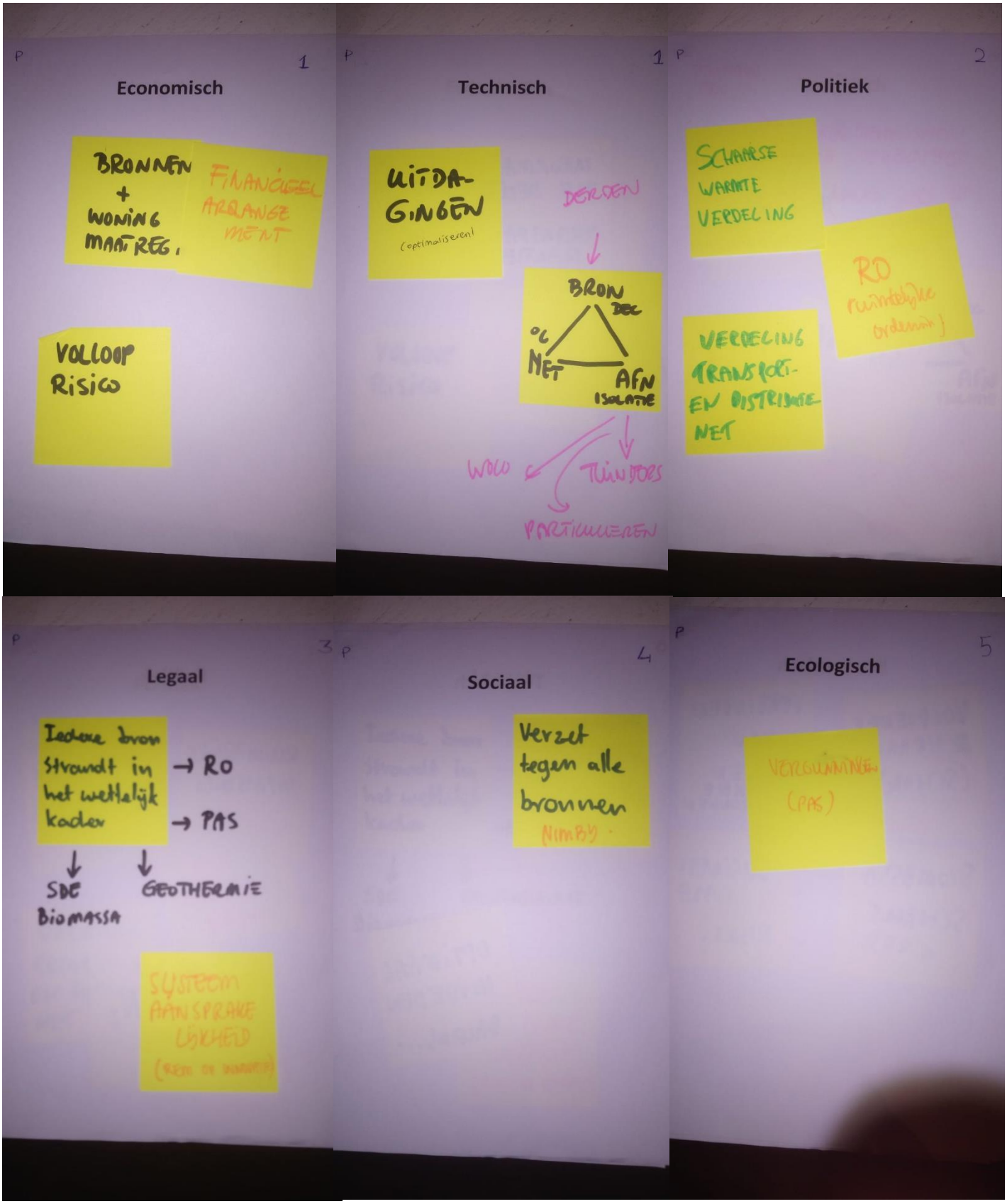
- ➔ In welke dimensie zijn de grootste problemen voor warmtenetten die willen uitbreiden?
- ➔ In welke dimensie ligt volgens u de oplossing voor de problemen in het uitbreiden van bestaande warmtenetten?
- ➔ In welke dimensie zijn de grootste problemen voor het *toevoegen van bronnen* op bestaande warmtenetten?
- ➔ In welke dimensie ligt volgens u de oplossing voor de problemen in het toevoegen van bronnen op bestaande warmtenetten?

- ➔ Zijn er in uw opinie problemen bij warmtenetten die niet in deze discussie geïncorporeerd konden worden?

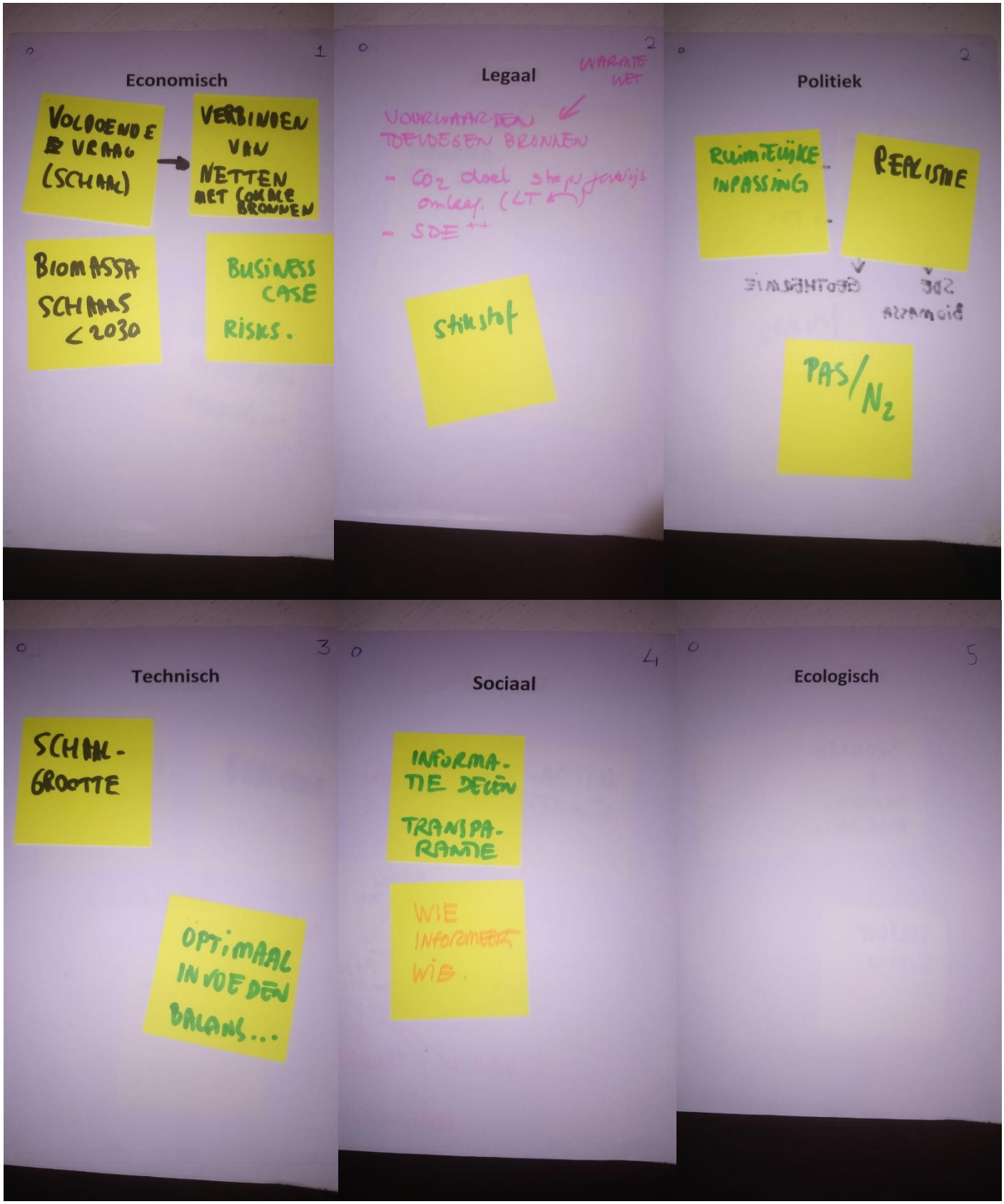
Appendix 3: Results workshop experts

Results workshop 1: Enlarging district heating

Problems

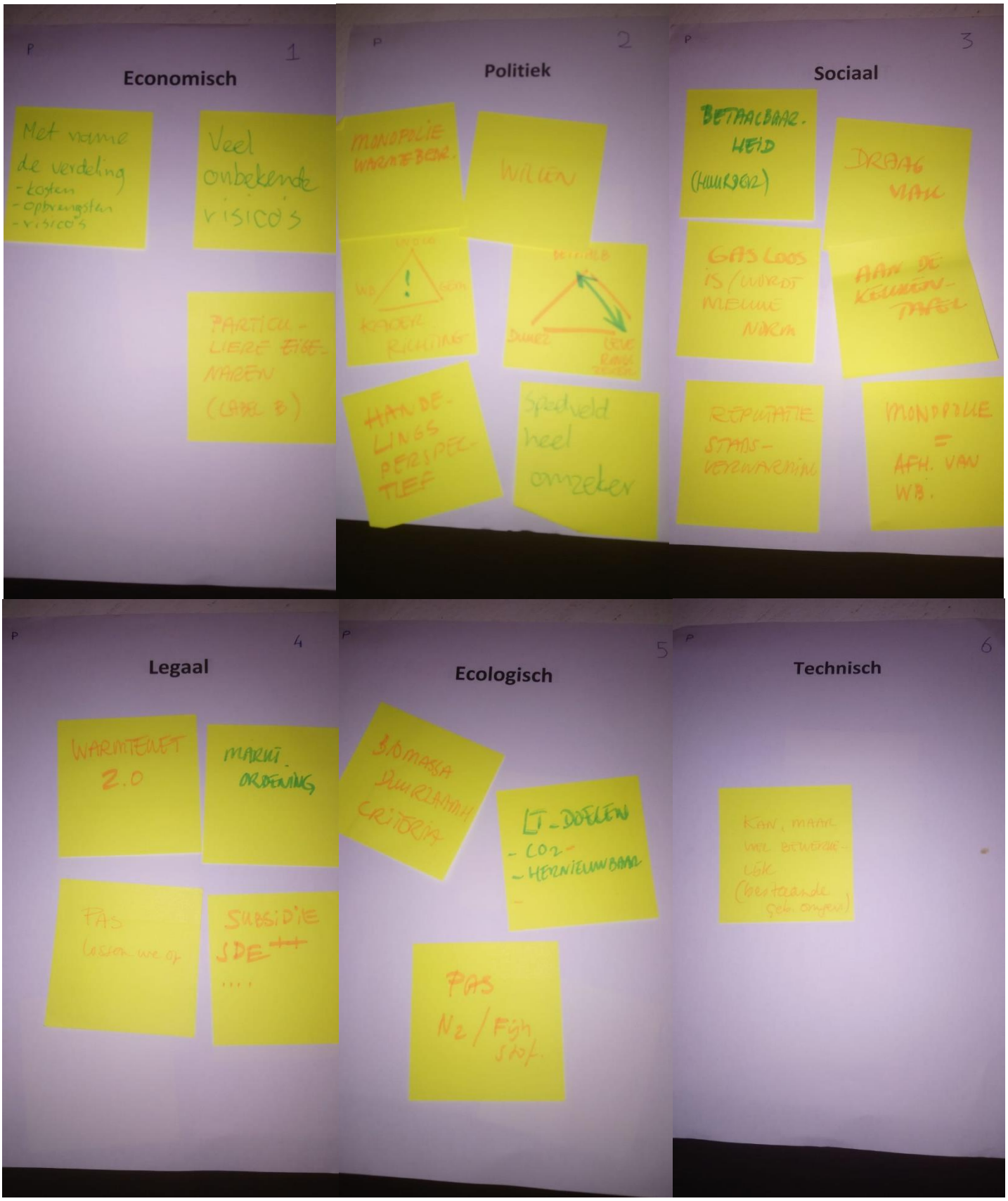


Solutions

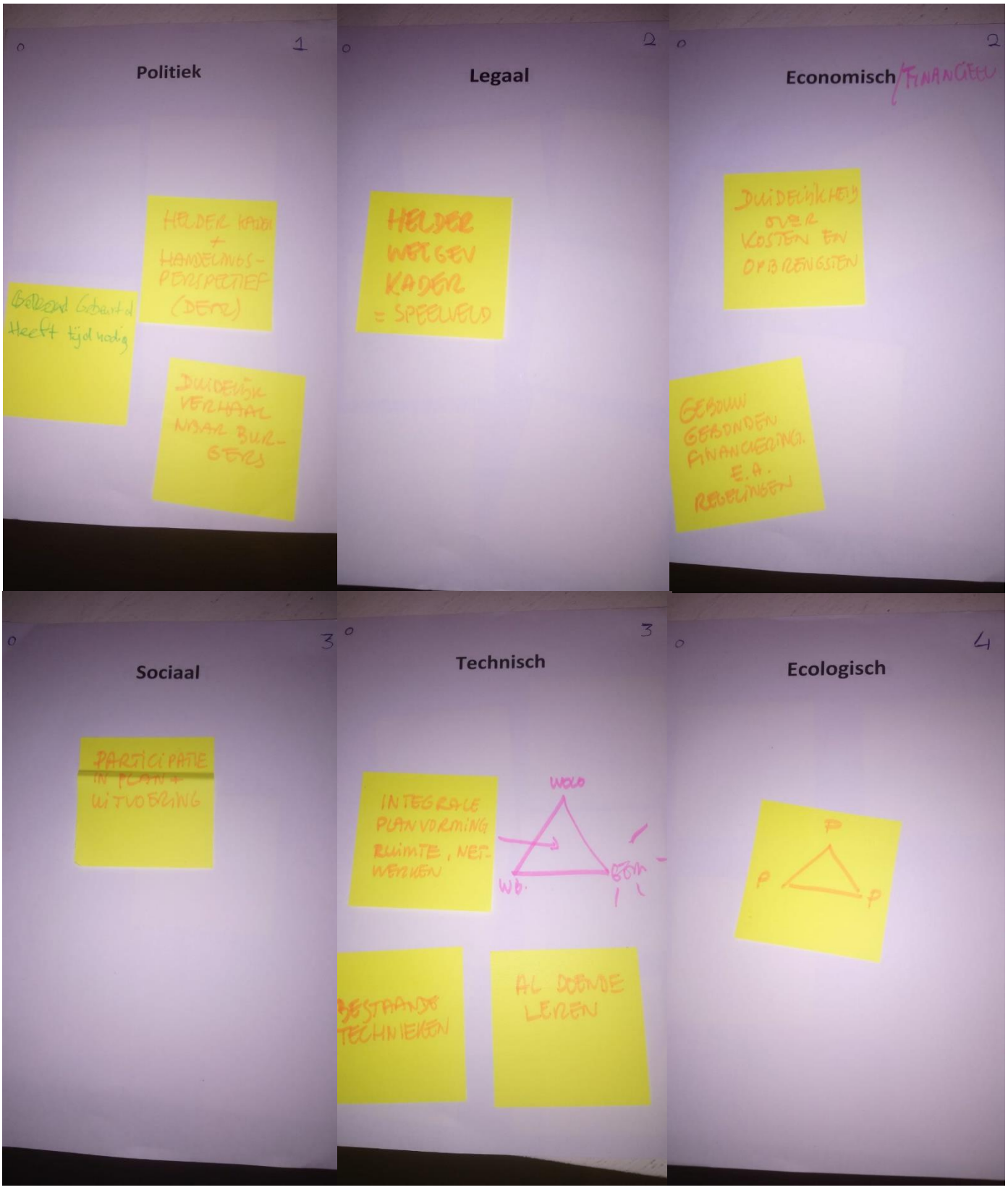

1
Economisch
VOLDOENDE VRAAG (SCHAAL)
VERBINDEN VAN NETTEN MET COMMERCIELE BRONNEN
BIOMASSA SCHAARS < 2030
BUSINESS CASE RISKS.
2
Legaal
WARMTE WET
VOORWAARDEN TOEVOEGEN BRONNEN
- CO_2 doel stapsgewijs omlaag. (LT
- SDE++
stikstof
2
Politiek
RUIMTELIJKE INPASSING
REALISME
PAS/N_2
3
Technisch
SCHAAL-GROOTTE
OPTIMAAL INVOEDEN BALANS...
4
Sociaal
INFORMATIE DELEN
TRANSPARANTIE
WIE INFORMEERT WIE.
5
Ecologisch

Results workshop 1: Adding sustainable sources to district heating

Problems

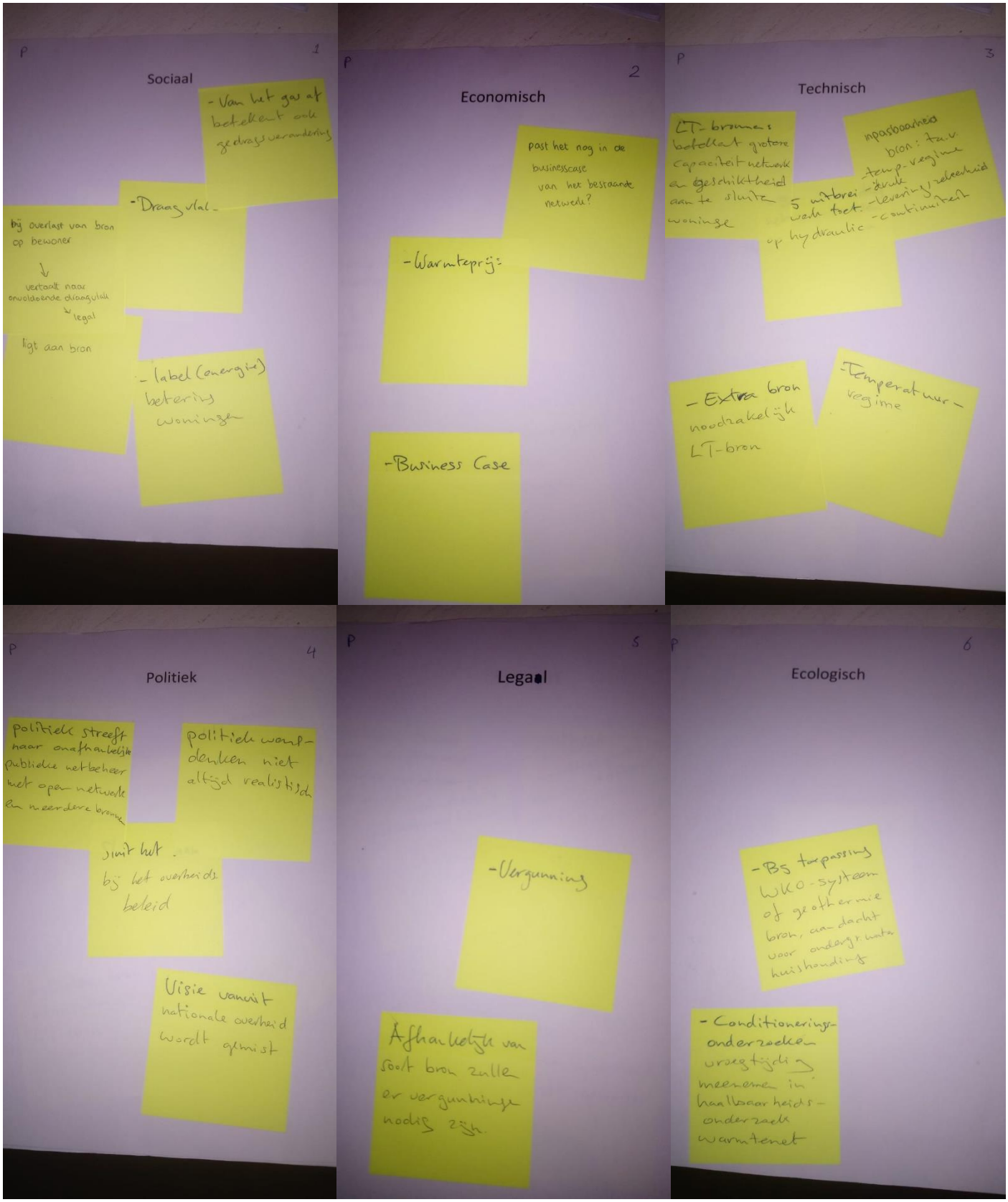


Solutions

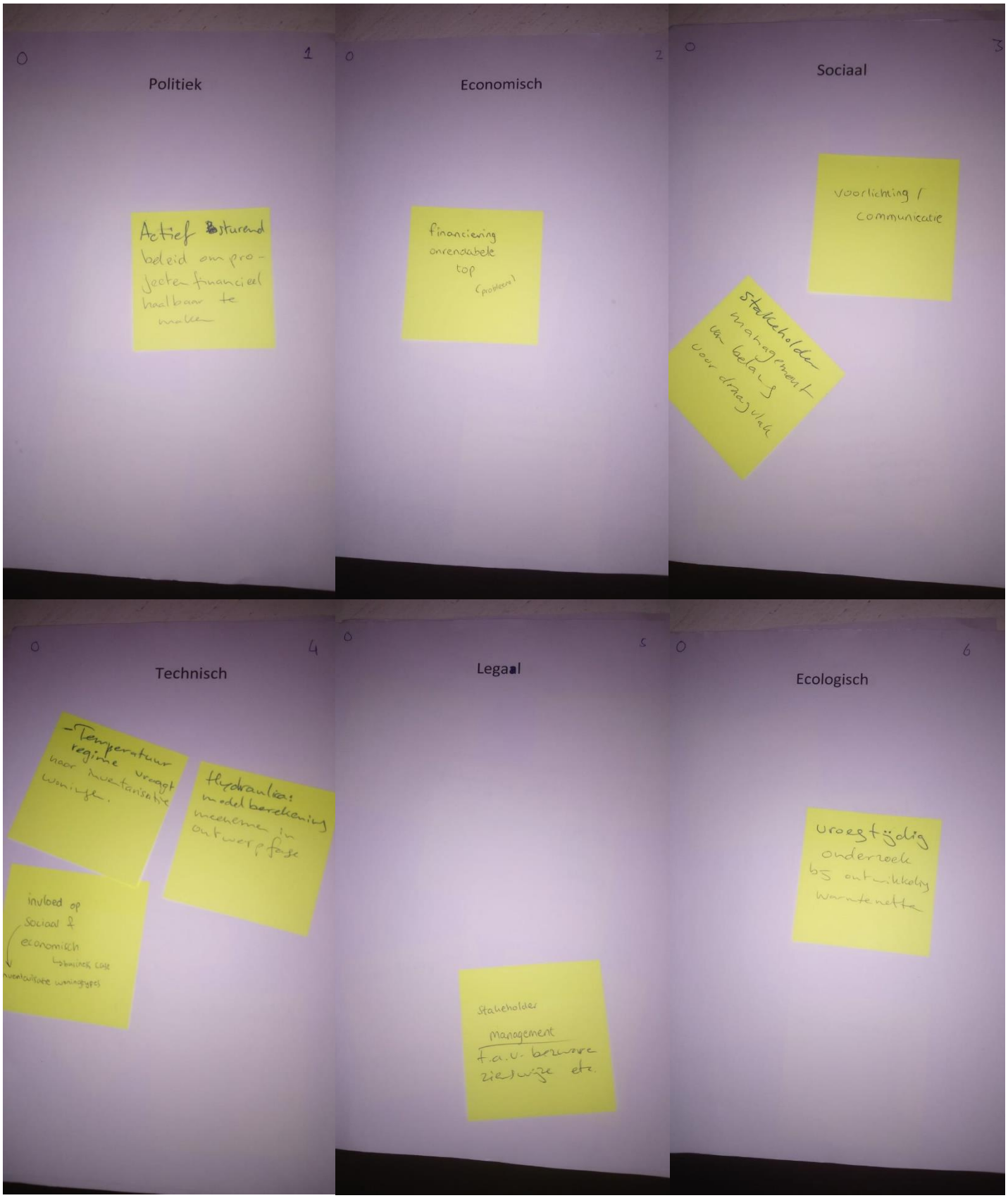

1
Politiek
HELDER KADER + HANDELINGS-PERSPECTIEF (DERO)
DUIDELIJK VERHAAL NAAR BUR-GERS
2
Legaal
HELDER WETGEV KADER = SPEELVELD
2
Economisch/FINANCIEEL
DUIDELIJKHEID OVER KOSTEN EN OPBRENGSTEN
GEBOUW GEBONDEN FINANCIERING E.A. REGELINGEN
3
Sociaal
PARTICIPATIE
3
Technisch
INTEGRALE PLANVORMING RUIMTE, NET-WERKEN
WOLO
WB.
BESTAANDE TECHNIEKEN
AL DOENDE LEREN
4
Ecologisch
P
P
P

Workshop 2: Adding sustainable sources to district heating and/or enlarging district heating networks

Problems



Solutions


Politiek
Actief sturend beleid om projecten financieel haalbaar te maken
Economisch
financiering onrendabele top (projecteer)
Sociaal
voorlichting / communicatie
Stakeholder management
Technisch
-Temperatuur regime vraagt naar kwantitatieve woningen.
hydraulica: modelberekening meenemen in ontwerpfase
invloed op sociaal & economisch
Legaal
Stakeholder management
Ecologisch
Vroegtijdig onderzoek bij ontwikkeling