Heat transition Groningen

A transition from natural gas towards sustainable heat in the built environment

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Colophon

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Abstract

Due to increasing concerns about fossil fuels use and because of the closing down of the Groningen gas field, our energy system requires a transition away from natural gas use. By 2050, the natural gas demand used for cooking, space heating or water heating will have to be substituted by alternatives. Substitutes like renewable gasses, heat networks, and electrical heating will play a big role in fulfilling future heat demands. In this transition towards sustainable heat system all kinds of challenges arise. Balancing the electricity grid due to increased electrical heating, increasing renewable gas production, implementing heat storage and motivating home owners to take energy saving measures are amongst the challenges of the heat transition. The province of Groningen will be taken as a case study in order to determine the challenges and opportunities that arise, but also the approach, when changing this heat system based on natural gas towards sustainable heat.

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1. Introduction

Energy is one of the most important conditions of modern day's society. Without energy there is no growth, development and survival will be much harder (Proedrou, 2012). The global energy mix contains of mostly coal, oil, natural gas, and renewables. With the energy transition towards renewable energy, countries are focusing on their big goals in this transition. The Dutch government has already set goals in regards to becoming energy neutral. These national goals are directed to provinces and municipalities. This transition means a shift towards carbon dioxide poor energy sources and cleaner technologies, thus the shift away from coal, oil and naturalgas towards sustainable energy.

A big challenge in the way the energy is converted lies in the use of natural gas, which is mainly used for heating of spaces. Natural gas is seen as one of the less polluting fossil fuels and therefore it will still continue to play an important role in fulfilling the energy demands as long as it can be extracted against reasonable societal costs (Ministerie van Economische zaken, 2016). But recently the societal costs began to rise as society began to give a lot more resistance against the gas extraction because of the extraction-induced earthquakes ocurring in the province of Groningen. According to the Ministry of Economic affairs (2016) continuation of the gas extraction in the future will depend on the speed and the direction of the energy transition, which is very much depending on technological developments in cleaner energy sources, but also depends on politicians and how they deal with vested interests in fossil fuels (Proedrou, 2012).

Becoming independ of natural gas is especially important for the province of Groningen because of the earthquakes induced by the extraction of gas from the Groningen gasfield. Groningen could be used as an example for other provinces in becoming independent of natural gas, thereby solving the problems Groningen has dealt with for several years. Therefore the outcomes of this study could also be of societal relevance for the province of Groningen. A start has already been made and concrete steps are on the way to realise this goal. For example, the municipality of the city Groningen has made a first plan of action in becoming independent of natural gas by the year 2035 (Noorman & van Noordenburg, 2016).

The main consumers of gas are the residential and service sector buildings that use gas for heating spaces (IPO, 2016). They account for approximately 50% of gas consumption. The second largest consumer is the industry, which accounts for 35% of gas consumption. In the industry gas in used mainly for production processes, a large share of this consumption from the industry comes from the chemical industry. The third largest consumers are electricity companies with a share of approximately 15%, which use gas in a process for electricity production. The focus in this study is mainly on residential and service sector buildings.

1.1 The Dutch history of natural gas

Before the discovery of the Groningen gasfield, only small gasfields in the provinces Drenthe and Overijssel were in use, were gas was being extracted. In 1959 the gasfield beneath the province of Groningen was discovered, it is considered as the biggest gasfield in western Europe (van Geuns & de Jong, 2017). The total volume is estimated around 2800 billion m3 of gas, enough to fulfill the demand for the Netherlands for more than 60 years (van der Voort & Vanclay, 2015). Ever since it has made a big impact for the Netherlands. For more than half a century the Netherlands was self-sufficient because of this energy source. Besides that, gas exportation has been an important revenue stream for the Dutch government, from 1965 untill 2016 the government made about 281 billion euros revenues of the gas exportation (van Geuns & de Jong, 2017).

After several tens of years of gas extraction, extraction-induced earthquakes arose around the beginning of the 21th century (Vlek, 2018). These earthquakes became more heavier during the years and are causing significant damage to buildings and structures in the area (NOS, 2018). For example in the summer of 2012 a 3.6 on the Richter scale earthquake was measured (van der Voort & Vanclay, 2015), and this is only one of the many earthquakes that had happened over time. As a result of these extraction-induced earthquakes becoming heavier, public resistance and media attention began to grow over the course of the years, placing it higher on the political agenda. At first several studies were undertaken which led to the publication of reports confirming that the earthquakes were extraction-induced and were likely to become heavier.

The public resistance led into a collection of lawsuits and negotiations between the public and the state which has led to certain limits on how much gas to be extracted. The last decision of the government has led to a maximum extraction of 19,4 billion cubic metres of gas in the year of 2019 and furthermore to an agreement of zero extraction by the year of 2030 (NOS, 2018). This decision combined with an energy transition happening requires the Netherlands to reduce their dependency of gas and find ways to fullfill this demand for natural gas with the use of other energy sources. With this research I will walk through the process of changing our heat system for the built environment, from heat based on natural gas towards other, sustainable forms of heat. Thereby identifying challenges, opportunities and determining a suitable approach to this complex issue.

1.2 Geo-political relations

Countries in the EU are highly dependent upon the importation of natural gas, about two-third of the overall gas consumption is being imported in 2011 (Proedrou, 2012). Also with the recent decisions in the Netherlands with regards to limiting gas extraction, we are becoming more dependent upon the importation. Most of the gas that is imported is coming from Russia but also from other regions like Norway, North Africa and the Middle East (Hill, 2013).

Becoming less dependent upon natural gas can bring several advantages in regard to geo-political relations. First of all a shift from natural gas towards other, more sustainable energy sources would mean less dependency upon importation from countries outside the EU which often have an unstable governance structure en have monopolistic positions in the gas market (Proedrou, 2012). This monopolistic position also gives these gas-exporting states a lot of influence in global politics. Being less dependent on these countries thus would mean a higher energy security and might give the EU more political power. An example is given by Flouri et al. (2015) who explain that since gas production in European states have declined, the import dependence is estimated on 85% in year 2030. They emphasize this number with the geo-political conflicts in 2015 which caused interruptions of the importation of natural gas to EU states and threatened the gas supply in EU states. Therefore a switch from natural gas towards sustainable heat would not only improve our energy security but also make EU states benefit with more influence in global politics due to less dependency upon other countries with unstable governance structures.

1.3 Demarcation of the research area

This study focuses on the energy transition towards more sustainable forms of energy conversion. We speak of energy conversion because when following the first law of thermodynamics, energy cannot be produced nor can it be lost, only a conversion is possible (van Kann, 2015).This transition concerns a fundamental change in the way that the energy system is organized. This transition is a very broad topic, that can be divided into multiple subsystems within the energy system. Within this energy system, the heat system can be regarded as a subsystem. Within this subsystem we can also see an energy transition happening, because natural gas has to be replaced by other sources of energy in order to meet the goals of the energy transition set by our national government. In this research I focus on this subsystem because heat is a big part of our total energy consumption in the Netherlands. As explained before the share of natural gas usage is around 50% for residential and service sector buildings. The focus is therefore on the built environment containing housing, bussiness and other service buildings that demand natural gas for heating. Heating purposes are for example for showering, warm tap water, cooking, and heating spaces. The focus in this study is on the latter because this requires most of the natural gas demand.

In this study I have also chosen to carry out a case study for the province of Groningen. This method is chosen because every area requires different solutions, therefore it is impossible to find specific results without a case study. A case study might yield information on how to manage a transition in one area, which might help in developing an approach for other areas, but the specific heat sources that have most potential might vary between areas. The choice for the province of Groningen is, as mentioned before mostly because of the high societal relevance for Groningen to become independent of natural gas use for space heating. Therefore the province of Groningen might become an interesting best practice case. In this case study I will research the potential for different heat sources/techniques and the approach that is taken by different actors.

1.4 Research questions

Due to the increasing concerns about fossil fuels that are used for the purpose of energy conversion, an energy transition is needed to go towards an energy system with cleaner ways of energy conversion. And with the recent societal resistance because of the events surrounding the gas extraction fields in Groningen, a shift away from natural gas would be benificial for the Netherlands and could be an opportunity for Groningen to solve the problems. It would also mean that we could become less dependent on states that have a monopolistic position in the gas market thus benefit our energy security. It is therefore interesting to take the province of Groningen as a case study to find out how this demand for natural gas could be replaced by energy that is converted in ways that are cleaner and experience less societal resistance as the result of the environmental degradation they cause. Therefore the goal of this study is: to research how to achieve a transition from a heat supply based on natural gas, towards a sustainable heat supply for the built environment in the province of Groningen. Thereby the following research question is formulated:

"How can the province of Groningen achieve a transition from a heat supply based on natural gas towards a sustainable heat supply in the built environment?"

In order to answer this question the following sub-questions are formulated:

- What are the important concepts and theories regarding an (energy) transition?
- What approach is suitable in the transition to sustainable heat for the built environment?
- What sources and techniques can replace the demand for natural gas?
- What steps have already been taken in Groningen to become independent of natural gas?
- What are the barriers and opportunities for certain alternatives for natural gas in Groningen?
- Which alternative heat sources are most applicable in Groningen?
- What other challenges occur in the transition towards sustainable heat?

1.5 Outline

The introduction in chapter 1 is followed by the methodology containing the explanation of research methods and the different steps taken. A theoretical frameworks is discussed in chapter 3 that is followed by an application of one of the important concepts, Trias thermica in chapter 4. The document analysis is presented in chapter 5 with results for the case of Groningen. In chapter 6 the results of the different data collection methods are presented and the subquestions are answered. This study ends with an concluding chapter in which the main question is answered.

2. Methodology

This chapter will elaborate on the different steps taken in the research process and will motivate the choices for the different methods of data collection and data analysis. In short the research process is divided into four different steps. For three out of the four steps I have decided to appoint certain research questions in order to come to an answer to the main question. The different steps in the research process can be divided in: 1: Background research, 2: Literature study, 3: Case study, containing a document and a map analysis & 4: Interviews. In the process I am using an iterative research design, meaning that I sometimes switch back and forth from different parts. One advantage of this approach is that during the study new insights can be added, so whenever the research question is changed, data collection and data analysis methods can be adjusted accordingly as well (Kerssens-van Drongelen, 2001). Figure 1 below represents a visual presentation of the research design.

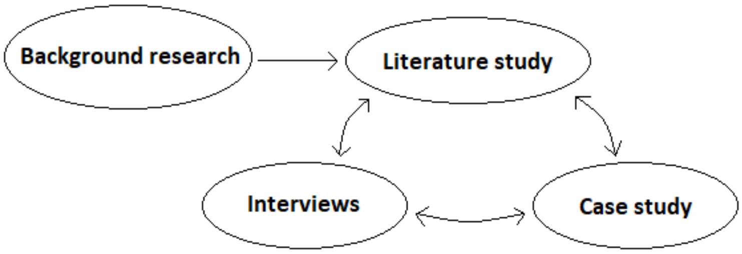


Figure 1: Visualisation of research design

2.1 Background research

Doing the background research is the first step in the research process. In this step I will focus on determining the aim of the research, the research topic and its scope along with the main question and some subquestions. Within this step the research proposal is determined which is followed by the processing of this information in an introduction chapter.

2.2 Literature study

The second step in the research design is the literature study. The aim of the literature study is to find important concepts and theories regarding the topic. After gaining insight in the most important theories and concepts, a conceptual model is determined. This model will act as a framework for answering the research question. This literature study thus aims at understanding the different relevant concepts and theories with regards to a transition from natural gas towards sustainable heat in the built environment and to use these theories in answering the main research question. After the most important theories and concepts are discussed, the next chapter aims at applying the Trias thermica concept. This chapter ends with a comparison of the different heat sources in the form of a table. For the literature study the following subquestions are formulated:

- What are the important concepts and theories regarding an (energy) transition?
- What approach is suitable in the transition to sustainable heat for the built environment?
- What sources and techniques can replace the demand for natural gas?
- What are the barriers and opportunities for certain alternatives for natural gas in Groningen?

For this literature study scientific articles are used that have been found by using different search engines like: Google scholar, Smartcat, and Science direct. Articles were searched by using some of the following key words: “Heat transition”, “Energy transition”, “Transition management”, “Transition management model”, “natural gas independency”, “Alternative heating”, “sustainable heating”, “Trias energetica”. Articles that were published before the year 2000 were avoided. Also relevant articles were used from different courses during my studies, for example articles from de Roo.

2.3 Case study

The second step in the research process is to carry out a case study of the province of Groningen. The choice for a case study and the location of the case study is motivated in section 1.3. This case study consists of two data gathering methods, a document analysis and a map analysis, that are put together in chapter five. The aim of the case study is to gain insight into the approach that is taken to achieve a transition towards sustainable heat production for our case study in the province in Groningen. It also adds to the literature study by exploring if the barriers and opportunities on certain alternatives and techniques found in chapter four, also apply for our specific case in the province of Groningen. Also the different heat sources and techniques are judged by their applicability for our specific case of Groningen, which is presented in the form of a table in chapter five. For this step in the research process the following subquestions are formulated:

- What steps have already been taken for Groningen to become independent of natural gas?
- What approach is suitable in the transition to sustainable heat for the built environment?
- What are the barriers and opportunities for certain alternatives for natural gas in Groningen?
- Which alternative heat sources are most applicable in Groningen?

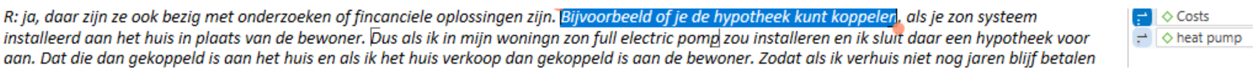
For the document analysis, relevant policy documents from for example: governmental bodies, advisory companies, and scientist were used. These documents were searched using different search engines like Google, Google Scholar, and Smartcat, using some of the following (Dutch) key words: “Warmteplan Groningen”, “Warmte transitie Groningen”, “Energie transitie Groningen”, “Aardgasloos Groningen”, “Biogas potentie”, “Geothermie Groningen”, “Aardgasvrij wonen”, “Waterstof Groningen”. A text analysis was done to filter relevant information out of the selected documents, by highlighting sentences that were relevant to the subquestions and summarising them at the end. For the document analysis the following documents were selected:

- Gemeente Groningen. (2016). *Groningen aardgasloos 2035.* Groningen: Gemeente Groningen.
- Gemeente Groningen. (2018). *Routekaart Groningen CO2-netraal 2035.* Groningen: Gemeente Groningen.
- Lieshout, van. M. & Schepers, B. (2011). Nationale routekaart restwarmte. Delft: IPO.
- Lysias. (2018). *Eindrapport raadsonderzoek geothermie Groningen*
- Moraga, J. L. & Mulder, M. (2018). Electrification of heating and transport: a scenario analysis for the Netherlands up to 2050. *Policy Papers*. No2.
- Provincie Groningen. (2016). *Warmteplan Groningen.*
- Provincie Groningen. (2016). *Vol ambitie op weg naar transitie.*
- RVO. (2018). Verkenning tool aardgasvrije bestaande woningen. Utrecht: RVO
- Schepers, B.L. (2017). *Optimal use of biogas from waste streams: An assessment of the potential of biogas from digestion in the EU beyond 2020.* Delft: CE.
- Van Wijk, A. & Hellinga, C. TU Delft. (2018). *Waterstof de sleutel voor de energietransitie.* TU Delft.

Besides the document analysis, the other data gathering method that is used for the case study is a map analysis to identify the potential for different alternatives to space heating on natural gas. These two maps were found in the process of the literature study. Both maps are containing input in the form of different layers of spatial information on potential for alternative heat sources. By selecting the right layers, the output is a map with a visual representation of the potential for an alternative heat source/technique. The following maps were used: Provincie Groningen. (2019). Warmtekansenkaart Groningen. & Nationaal Expertise Centrum Warmte. (2018). Warmte Atlas.

2.4 Interviews

The third step in the research design are the interviews. This data collection method is chosen for several reasons. Firstly it can shed light on topics that have not been mentioned or underexposed in this thesis, by using a semi structured style in which respondents can divert from the questions asked. Therefore it will also discuss one of the subquestions "*What other challenges occur in the transition towards sustainable heat?*". It also adds experts experiences and therefore can provide a better understanding for certain approaches that are taken. Especially with this topic interviews are relevant because it could thus provide insights into the motives for certain approaches, for example why heat pumps are chosen over district heating in some areas by policymakers. Thirdly it is important to not only use secondary data obtained and analysed through a literature study and document analysis, but also add primary data thus making the research more reliable. Interviews can also yield a lot of primary data in a short amount of time (Kallio et al., 2016). I have chosen to conduct the interviews as semi-structured because this leaves room for the interviewee to divert from the questions that are asked. In this way the interviewee can mention relevant information, during or after the questions, that have been underexposed in this thesis. A semi structured interview thus makes the interview more flexible and allow for question to be brought up during the interview (Kallio et al., 2016). Some questions or themes have therefore been prepared upfront, while some of them have been made up during the interview. All of the interviews are recorded with the permission of the respondents, and typed out, leaving irrelevant parts out and making it one readable dialogue. The interviews are transcribed in Dutch, for the results the citations have been translated as literally as possible to English. In order to analyse the transcripts of the interviews, the transcripts have been provided with coding so that the interviews can be analysed in a structured way. This mechanism is helpful to distinguish relevant parts out of the interview transcripts by providing parts of text with labels (Cope, 2010). For this analysis the program ATLAS.ti has been used, an example of this analysis is provided in the image below. The transcripts of the interviews can be found in the appendices.



Example of coding process in ATLAS.ti

I have chosen to select respondents after the literature and document analysis because this would clarify which topics need further explanation. The date of preference for the interviews were as soon as possible, but were also depending upon the respondents. Also I have chosen to try and interview experts from the most important organisations, so that a variety of the different perspectives are taken in to account. Preferably interviews are carried out in person, at the office location of the interviewee so that they feel most comfortable. Due to busy schedules interviews were not always possible to be carried out in person, therefore sometimes a list of questions was sent via email to the interviewees and one interview was conducted through the telephone.

Respondent	Organisation	Role	Date	Form of interview
#R1	RUG – Faculty of Economics & Business	CEER Researcher sustainable heat	05-12-2018	In person
#R2	Kloosterman Biogas	Owner	12-12-2018	In person
#R3	Municipality Loppersum	Policy advisor environment and sustainability	25-2-2019	Via email
#R4	Enexis Group	Strategic advisor energy transition	27-02-2019	Via telephone
#R5	Rijksdienst voor ondernemend Nederland	Program advisor sustainable energy	04-04-2019	Via Email

Table 1: List of interviewees

3. Theory & concepts

This chapter will discuss the most important theories and concepts in regards to the main question. Firstly the institutional design of heat markets will be explained in order to gain more understanding on how the heat market is organised between different actors. This is followed by the explanation of transition management theory in order to understand how a transition works. After this the approach to the heat transition will be explained by using the framework of planning oriented action and the concept of Trias thermica. Following up with an elaboration of the Trias thermica steps.

3.1 Institutional design heat markets

Since 2004 the energy market is liberalized meaning that the energy market is open for competition between different energy companies. The consumer has a free choice to choose for an energy supplier, in contrast to before where the consumer was bound to an energy supplier depending on the location. Energy suppliers arrange the contracts and payments with the consumers, often they are also energy supplier themselves. The network company is responsible for the local gas distribution network and is therefore location bound. The government has the role of regulator and supervisor on the energy market. They can influence the market by setting taxes therefore play an important role in the heat transition as they can influence the prices of gas. Through taxation on gas the central government tries to decrease gas usage and stimulate renewable energy sources. Energy suppliers thus have an important role in supplying sustainable heat for the consumer, in which network companies play the role of transporting this heat to the consumer. The central government can make it more attractive for people or energy suppliers to switch to renewables through for example pricing of natural gas.

Through laws and regulations the government acts as regulator. The governmental organisation: the ACM, monitors the compliance to the regulations. An important law is the 'Gaswet' that obligates network companies to provide houses with a connection to the gas-grid. It also defines other rules and tasks where network companies and energy companies have to abide to. Since the first of July 2018 this law has been adjusted in order to discourage natural gas use for heating buildings and houses. The obligation to connect new houses and buildings to the gas grid has been dropped. Also the adjustment of this law allows to forbid a connection to the gas-grid in areas where other options like DH networks are available (Rijksoverheid, 2018). The obligation to connect existing housing thus remains.

Through competition the supply price of gas is regulated for consumers. This is different for heat networks because they often have one heat supplier in that area, making it hard for other suppliers to make profit here and therefore they have a monopolistic position. Because of this the 'Warmtewet' is founded in 2014. This law protects the consumer against high prices of heat. This is done through the principle that this heat may not cost more than the costs of heating the same house with natural gas, the NMDA (Niet meer dan anders) principle (CE Delft, 2009). Therefore this law has a direct relation with the pricing of natural gas. If prices of gas rise, district heating becomes more profitable for energy suppliers because they can charge a higher price for the supply of heat. Taxation on gas therefore is an important instrument for the central government to stimulate DH networks but also to provide incentives for consumers to find alternative ways of heating.

In short, energy suppliers, consumers, network companies and governments are important actors in the heat market. The governments act as a regulators for energy suppliers and consumers. Therefore the government can promote sustainable heat by pricing through laws and regulations. Network companies have the task of distribution and are therefore also important in establishing heat networks.

3.2 Transition management

In the whole energy sector a transition is required towards more sustainable forms of energy supply in order to reach climate goals set by the national government and avoid further environmental degradation. This also counts is the subsystem of heat supply. A transition itself can be described as a process of structural change or the move from one dynamic equilibrium towards another one with a long time span (25-50 years)(Loorbach, 2010). Transition management can be regarded as an approach in which the aim is to instigate long-term structural changes in a major societal sub-system (Meadowcraft, 2009). With transition management a situation in such a major societal sub-system can be guided towards a desired situation by guiding this transition carefully with governance processes. Transition management can therefore be used to offer a perspective in which this transition can be accelerated and managed carefully towards the right direction (Loorbach, 2010). An important challenge is addressed when using transition management on this issue, namely breaking out of a lock in situation, described as path dependency. Path dependency is created by certain policy choices which make it necessary to continue in developing along a chosen path. Big investments are made for making this path possible and it is very hard because of these vested interest and investments to break out of this situation (Martin & Sunley, 2006). Transition management addresses this issue by focusing on system improvement and system innovation while taking sustainable development as an important focus (Meadowcraft, 2009). Thus applying a transition management strategy would require to focus on these elements of improvement and innovation. The transition management framework developed by Loorbach (2010) consists of four different types of activities used to coordinate a transition: strategic, tactical, operational and reflexive activities. This would mean that in order to break out of a lock in situation like heating the built environment on natural gas, different type of actions on different scale levels are important.

Strategic

For strategic activities it is important to think big, activities such as developing a vision and to set long-term goals are important. Within these strategic activities it is important to develop a culture for the transition (Loorbach, 2010). In this culture the activities are important that can bring people together with the same ideas. Norms and values, the idea of sustainability and the societal relevance are aspects that belong to this culture. It is therefore important to mobilise frontrunners with different views on the transition so that a collective agreement is made on the future development and that a sense of urgency is created (Geels & Schot, 2007; Loorbach, 2010).

Tactical

With the activities on tactical level is meant the activities that relate to the organisation of a system. This contains the elements of how a system is structured, such as rules, regulations, policies and networks (Loorbach, 2010). These activities are aimed at reaching the long-term goals that are formulated on the strategic level by developing policies that are aimed at concrete measures. These tactical activities generally take 5-15 years and are often hindered by fragmentation in governance structures (Loorbach, 2010). This highlights the importance of the formation of coalitions and networks on the tactical level.

Operational

The central focus of this level of activities is on innovation. This focus on innovation is carried out in the form of experiments and action associated with short-time frames. This innovation often happens with a collaboration between a small group of actors. Through the process of success and failure these niches are creating opportunities to be scaled up and provide a valuable contribution to the transition (Kemp et al. 2007).

Reflexive
These activities express the value of constant monitoring, and evaluating of policies and changes within the system. These activities happen on different scale levels from individual to collective activities in institutions. The aim is to constantly learn by doing and prevent certain situations where we become too path-dependent (Loorbach, 2010).

These activities on different levels are linked with each other so that a transition is steered and accelerated in the right direction. Geels & Schot (2007) explain this multi-level model by three steps: The first step is that these innovating experiments on the micro level improve by the process of doing-by-learning, then changes in the macro level put pressure on the existing regime which causes that this existing system will destabilise and create opportunities to scale up these niche innovations at the micro level.

The multi-stage transition model is used by van der Brugge et al. (2005) for explaining the transition in water management and can provide some useful insights in explaining the status quo of the transition towards gas independency. The model (Figure 1) consists of four stages. The pre-development phase is characterized by little visible change on the system level but lots of experimentation on the micro level with innovative technologies. The take-off phase is reached when certain initiatives take place that defines a new way of thinking, there is also a lot of experimentation in this phase which could lead to new technologies being scaled up. Along with the acceleration phase, these two phases both contain high levels of change on the sub-system. After the acceleration phase a new dynamic equilibrium is reached, this phase is characterized by stability (van der Brugge et al. 2005).

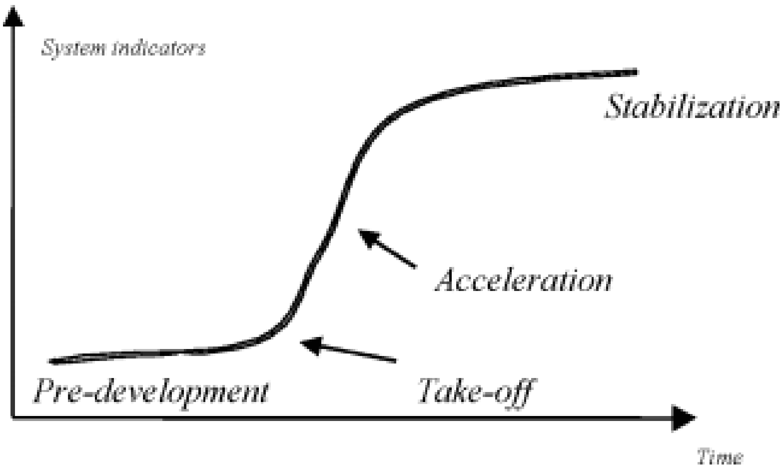


Figure 2. Multi-stage transition management model. (Van der Brugge et al. (2015))

The transition towards gas independency in Groningen is in an early phase. It varies between different sectors how much progress is made and how far in the transition they actually are. There is a lot of experimentation with new technologies that can substitute gas as an energy source. But it still concerns minor visible changes in the system level. An example of this experimentation that is being scaled up is a project in the Eemshaven which produces hydrogen from electricity, which could act as a substitute for natural gas and could act as an energy source for running one of its turbines (RTV Noord, 2018). The companies recently started building an infrastructure for delivering the hydrogen produced with green electricity to other companies in the industrial area (Groningen Seaports, 2018). This shows that in the industrial sector especially hydrogen is in an take-off phase because of the large scale it is deployed in this project.

Most of the visible changes seem to occur in the industrial and residential sector. The industrial sector tries to reduce gas consumption by replacing the demand, with hydrogen for example. The residential sector aims to reduce the demand for gas used for heating houses. The substitutes for gas in the residential sector are very different, ranging from electric heating to the use of bio-gas. Heat pumps is for example a technique that is increasingly becoming popular. Overall the heat transition could be placed in the take-off phase the best. This is because there are macro trends happening that are changing the way people look at the environment and ways of energy production, but also because of experimentation on the micro level. This takes place in the form of several different pilots for sustainable heat for example.

3.3 Area-specific - decentralised approach

There are a lot of stakeholders involved in the transition to a gas independent energy sector. Probably one of the most important is the municipality since they have been given the role of director by the central government, meaning they are responsible for making plans on the local level (RVO, 2017). They are considered best suitable for making decisions on the built environment on the local level, not only because of their knowledge on the local scale but also their relations with important stakeholders (RVO, 2017). Centralised goals are set by national governments, which are translated from global agreements such as the Paris Agreement which are then translated downwards to lower governmental bodies like the EU and then individual countries. This makes it a multi-level governance approach in which a good combination of this centralised and decentralised approach is necessary according to Brandoni & Polonara (2012). They argue that combining both can help in choosing the best alternatives for sources of energy production for specific areas in conformity with the higher scale level goals. Local governments also play an important role in transitioning to a renewable energy system because they can act as regulators by for example developing restrictions and provide permits with requirements relating to sustainable goals. They are able to work on a tactical and operational level in the built environment, which are important levels for managing transitions. De Roo (2004) also recognises that the central approach is insufficient for solving complex local issues. He argues that with the new ROM approach (Ruimtelijke ordening & Milieu- aanpak) in spatial planning which focuses on sustainable development there are opportunities to solve multiple complex issues through a participative approach with a focus on the polluting environment.

With regards to this decentralisation happening where local governments gain more responsibility, de Roo (2004) developed a framework for planning oriented action. Within this framework planning issues can be placed somewhere in the spectrum by judging the issue by its goals and relating to its actors (De Roo, 2004), see figure 2. With this model the rules of decentralisation are very simple and it links effectiveness and efficiency to an approach that should be taken. On the basis of this model there are three elements that determine the approach that should be taken. The first element relates to the goals of the planning issue, this represents the vertical axis of the figure. On the top of the axis there is one single and determined goal, on the bottom there are multiple contained and dependent goals. The second element relates to actors, as to who are involved in the problem, is it one central actor, like the central government or are there multiple actors that organise around the problem? This places a central guidance on the left of the figure and a more participative interaction on the right. The third element relates to how these goals can be reached and this represents the diagonal line in the spectrum. This line also represents the process of decentralisation, with on the top left corner representing one generic policy as opposite to the bottom right corner, which represents an area specific approach used by local governments. When looking from the point of local governments, the transition to a gas independent energy sector is placed somewhere in the grey area marked in the figure, which fits the area-specific policy best to approach this issue. This is because the transition concerns multiple energy related goals and involves a large scale of actors. This thus leaves the municipalities and provinces to approach this issue in collaboration with other important actors, for example in the residential sector to collaborate with housing associations and residents or in the industrial sector to cooperate with other industrial companies and energy suppliers. Overall in the heat transition there are multiple areas in the figure depending on from which actor you look at. Although the local government plays a big role, when considering all actors, an area specific policy is not suitable. This would rather become a multi-level governance approach where different actors place on different sides of this figure.

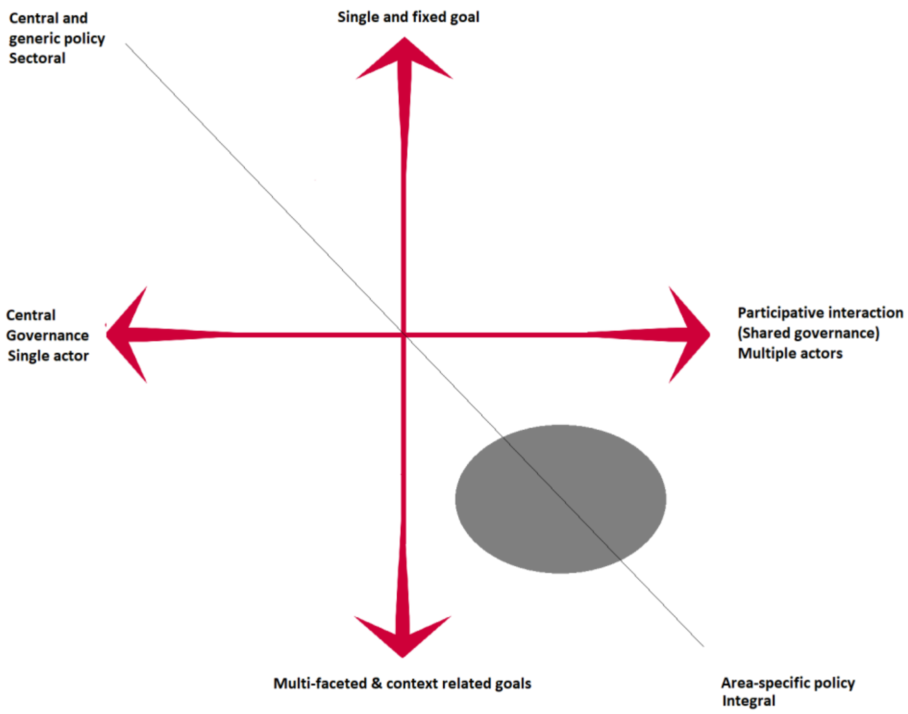


Figure 3. Framework for planning oriented approaches. (Based on: De Roo, 2004 & De Roo, 2003).

The central government has the role to set the boundaries and to determine the policy in general, for example by providing certain documents which provide general policy with a long-term perspective with certain agreements on the short and middle-long term (SER, 2013). This report, called: "Energieakkoord voor duurzame groei", contains agreements on the approach that should be taken by lower governmental bodies like provinces. One approach also mentioned is this report is the Trias energetica, which will be explained in the next section. Lower governmental bodies like provinces and municipalities get to choose their own approach on this issue within the boundaries set in this report. As mentioned before an area-specific approach is most fitting for decentral governments. The city of Groningen takes on such an area-specific approach in developing district heat networks. This approach is taken due to the fact that it is not feasible to focus on the level of a whole city but better to focus on a level where chances for the development of such a heat network and customers are present (Gemeente Groningen, 2012).

3.4 Trias thermica

The goals of the national energy agreement mentioned in the section are based upon the concept of the Trias Energetica. This is an important concept that helps in giving an approach for transitioning towards a more sustainable energy system. The general steps of this concept are as following ((IPO, 2015),(van Beuzekom et al, 2016)):

- Reduce the energy demand by increasing energy efficiency
- Use renewable energy
- If necessary use cleanest fossil fuel source

In the national energy agreement the first two steps can be recognized when looking at the goals that provinces have agreed to on the short/middle long term (IPO, 2015). These goals are an energy saving of on average 1,5% per year; or 100 petajoule savings by 2020 and an increase in the share of renewable energy from 4,5% in 2013 to 14% by 2020 and 16% by 2023.

Due to the focus on natural gas usage for heating in this study, this concept needs to be adjusted to the Trias thermica so that its application is more useful in this study (figure 3). This concept was first mentioned by advisory company Overmorgen, but the applicability is low because it was made for a specific case study. Therefore I have reformed the concept to increase applicability for this study. The first step then contains: reducing the demand for heat. This step requires end-users to commit to heat saving measures in their buildings. But as the costs of saving measures increase as there is more savings achieved, alternatives become cheaper than saving measure (Hansen et al., 2016). Therefore, the second step is using substituting natural gas usage by renewable energy. The third step is using the cleanest available alternative if there is no renewable alternative. The first step requires end-users to commit to heat saving measures like isolating their homes while the second and third step refer to the way heat is produced and distributed geographically. In the next section, ways to implement heat reducing measures will be discussed. After this section the available substitutes concerning step two and three will be discussed.

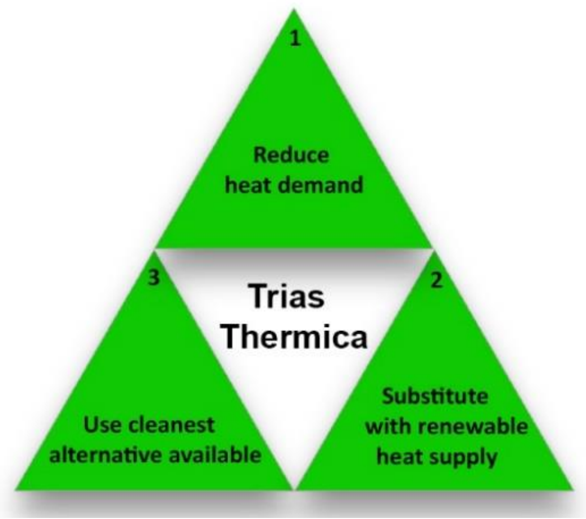


Figure 3. Trias thermica.

3.5 Conceptual model

Figure 4 displays the conceptual model of this research. This conceptual model displays a visual representation on the most important theories and concepts in this study. In the rectangle above the transition is displayed. Starting at the left site of the figure, the transition management theory is displayed along with the different scale levels from the transition. The black line next to the box indicates the switch from theory to approach. Next to the Tactical agenda there is an arrow that relates this lower scale level to the approach in the right side. The approach consists of two sections, the Trias thermica and the framework of planning oriented action. The Trias thermica relates to the approach on a scale level of a neighbourhood/individual building. It is a very important concept in this study because it displays a practical approach to solving the problem of heating buildings on natural gas. The framework of planning oriented action is part of the approach, as discussed before the heat transition requires a multi-level governance approach, for example different levels of governments have different approaches. The central government sets regulations and fixed goals and therefore places on a different side of the framework than the local government. Because sustainable heat solutions are mostly implemented on the lower (local) scale level, by lower levels of government, an arrow is drawn to display the importance of this area specific approach from the framework.

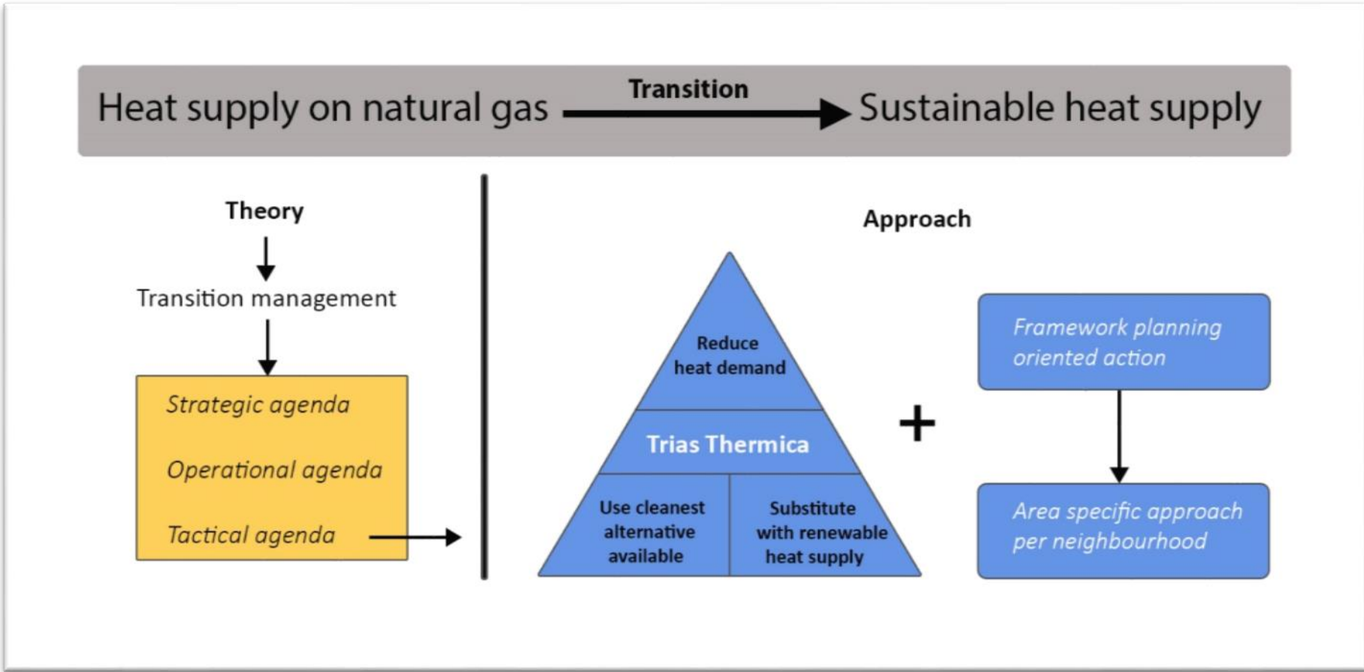


Figure 1: Conceptual model

4. Applying Trias thermica

This chapter aims at applying the three steps of the Trias thermica. When applying the Trias thermica it becomes clear what interventions are possible regarding the first step, reducing the heat demand. Regarding the second and third step, this chapter will show what the alternatives to heating the built environment on natural gas are. Also the barriers and opportunities for these different energy sources/techniques will be discussed.

4.1 Reducing the demand

Following the first step of the concept Trias thermica, part of this strategy is reducing the demand for heat in the built environment. The more the heat demand is reduced, the less heat has to be produced. As mentioned before the goal for the Netherlands is an energy saving of 1,5% per year. Since the average age of the Dutch building stock increases and about one million buildings reach an age of 50 years, these buildings do not meet the modern day requirements with regards to energy efficiency (Mulder et al. 2015). The replacement and refurbishment of the building stock could therefore significantly contribute to this goal of energy savings, because the largest share of household energy consumption lies in the demand for heat.

There are essentially two approaches that could be taken in order to reduce the heat demand. The first is improvement of the thermal efficiency of buildings, by renovating and the second is replacing thermal inefficient buildings. Regarding the first approach. especially older buildings are not thermal efficient, therefore a higher thermal efficiency could be achieved by cost-efficient measures such as improving insulation, upgrading windows and upgrading boilers (Roberts, 2008). In practice programs focus mostly on this approach due to lower costs and less nuisance. But according to Mulder et al. (2015) instead of this approach, an approach focused on replacing would yield higher results as the maximum potential for energy savings would increase from 32.4% to 47.1%. Although this approach is more costly, other arguments for this approach are beside a lower energy demand, an increase in the value of the buildings and job creation in the building sector (Mulder et al. 2015).

The second approach of replacing buildings with new energy efficient buildings reduces the energy demand because the government has set strict regulations with regards to new buildings, where energy neutrality becomes the focus. An example of this approach is the concept “Nul op de meter” which focuses on houses that are energy-efficient, so that all consumed energy could be generated by the house alone on a yearly base (Jacobs et al. 2015). In practice the first approach is not that promising as it seems, Hoppe & Faber (2011) identify barriers that hinder the implementation of taking energy saving measures. For private building owners there is no obligation and too little incentives for taking action.

Other important actors are housing associations, they own a big part of the building stock and therefore are important players when it comes to reducing the energy demand of buildings. It is important to take on an participative approach when it comes to renovating/replacing buildings because of the involvement of a large scale of stakeholders. In practice agreements are negotiated with corporations and other actors like finance corporations and the building sector to increase the energy efficiency, measured by the energy label, of their buildings stock (Schilder et al., 2016). For companies that are located in existing buildings, recently a law came in place that says: Businesses that use more than 25.000 m3 of gas and are settled in lower class energy efficiency buildings are recently obliged to take energy saving measures if these measures have a rate of return of investment costs of 5 years (RVO, 2018).

4.2 Substitutes for natural gas

In the process of becoming independent on natural gas it is important to first assess all the relevant alternatives to natural gas usage. What we do know is that there is not one solution here, a mix of alternative energy sources have to fulfil the demand for natural gas. In this mix it is important to look for the energy source which has the most potential on-site, in this task decentralised governments play a big role, as explained earlier. In this subchapter sustainable alternatives for natural gas used for heating are considered which can be used later on to determine where the demand could be substituted with which alternative. Therefore the focus is on making the demand for heat by residential and service sector buildings more sustainable by replacing the demand for gas with a mix of sustainable alternatives

Natural gas usage in the built environment is mainly used for the heating of spaces such as housing and businesses. Indirect natural gas usage comes from electricity that is produced by gas-driven power plants. When considering alternatives for the built environments there are 3 routes that can be taken to substitute the demand for natural gas used for heating. The first solution is an individual solution, such as a heat pump. This solution requires home and business owners to invest in their own energy conversion unit if they want the lowest costs and emission, for example solar panels, that provide electricity to power the electric heat pumps (Lund et al. 2010). Another option would be using the existing gas-grid to distribute biogas or hydrogen as a heat source. These solutions are more common among rural areas associated with a lower building density and for the second option buildings with higher heat demands such as farms or older houses.

The other solution is district heating (DH), or in Dutch "stadsverwarming" it is a collective solution in which residential and commercial buildings are connected with a network which stores and transports heat in the form water to the buildings, in which heat is produced from a central location (Ghafghazi et al., 2011; Soltero et al. 2018). DH networks are divided in high and low temperature networks. High temperature networks are more common in existing buildings because they can be connected to existing radiators that heat spaces. Low temperature heat networks are more common in new construction buildings because they are more isolated and therefore require lower temperature heat. High-temperature DH networks are therefore more common in big cities due to the large share existing buildings requiring higher temperatures of heat to be used by their radiators (Odijmond, 2017).

The advantage of a heat distribution network is that different sources can be connected. And collective systems could be cheaper due to the scale effects when comparing them to individual solutions (Daniëls, 2011). With a centralized heat source, it also allows a more effective control over pollutants compared to individual gas boilers (Soltero et al. 2018). Another advantage is that due to the large possibilities with regards to the source of energy production, there is a potential to use waste or low-grade biomass as a source of heat production (Morandin et al., 2014).

Although the advantage of district heating is that the heat can be generated through different (renewable) sources, only around 15% of the heat from the big heat distribution networks (over 150 TJ) is actually generated by renewable energy sources, mostly biomass from household waste (Menkveld et al., 2017). Most of the demand for heat in district heating networks comes from coal or natural gas power stations. Also, with the smaller heat distribution networks the main source of heat is a WKK-installation powered by natural gas (Menkveld et al., 2017). It thus seems that there is potential in making the source of the heat more sustainable. Van Beuzekom et al. (2016) show for example that biogas on the local scale is a good alternative to make the source of small district heating networks more sustainable. It is projected that with renewable sources district heating networks have the potential to fulfil 60-75% of the national low-temperature heat demand that is used for heating spaces. This potential is translated to around one third to one fourth of the national energy demand in 2050 (Hoogervorst, 2017). Which means that district heating could contribute significantly to the goals regarding sustainable heat.

Another barrier for the success for district heating is the extra infrastructure costs that it brings with it, this makes the costs of district heating upfront very high. Within an existing neighbourhood there is a higher demand for heat then a newly built neighbourhood because of the lower energy efficiency of the houses. But within existing neighbourhoods there is also a gas connection in place for heating so there are costs for removing the gas connection and then there is the problem that most of the existing houses use gas for cooking (van Beuzekom et al. 2016). Because of the more energy-efficient housing in newly built neighbourhoods, this makes district heating less profitable there. But on the other hand, initial costs of the infrastructure are cheaper because there is no gas connection that needs to be removed. Therefore, district heating in existing neighbourhoods is more profitable but the upfront costs of the infrastructure are higher. In district heating networks spatial variables like distance from the source to the end-user and density of housing also play a big role because the temperature of the water in DH networks decreases over distance (van Kann, 2015). But also, density has to be large enough in order for a DH network to be profitable. For municipalities this leaves a consideration on where to create a network for district heating and whether to create it at all. This consideration for district heating is further investigated in the following part of this study.

4.3 Heat sources and techniques

There are different ways on how to supply a DH network with heat. The potential for DH networks is thus very much depending on the availability of a heat source in the local context. Therefore, in the following sections different heat sources are discussed that can substitute natural gas used for heating, either in the form of a DH network, through the gas grid, or as an individual heat production system. Firstly I will discuss the different heat sources/techniques that are commonly distributed throughout a DH network, following with heat sources that can be distributed through the gas grid and lastly I will discuss the individual heat generation units and thermal storage. Every heat source/technique will shortly be introduced and explained, following with an explanation of barriers and opportunities, also every heat sources is complemented with an example from practice.

4.3.1 Excess heat

Industrial companies produce a large amount of heat in their production processes, in DH networks the demand for heat could be fulfilled with excess heat coming from industrial companies. According to Morandin et al. (2014) the potential is high for using industrial excess heat in cold climate countries which require a high demand for space heating during a large part of the year. Of course this does require industry which is producing excess heat close to densely populated areas. If this is the case then there is a possibility to use this excess heat for space heating through a DH network.

Although this seems promising using excess heat also has some barriers which limits its applicability. Depending on the type of industrial company there is the risk of an interruption of the flow of the available excess heat. Then there is also a competition between exporting this heat through a DH network or internally using this heat again to save energy (Morandin et al., 2014). For the producers of industrial excess heat, it is often easier to dump the excess heat water then to provide it for DH networks. This is because there are certain demands for delivering to the DH network, such as temperature and pressure, this requires industrial companies to invest in additional installations that prepare the excess heat for transport which brings additional costs. Nevertheless this excess heat could be used to make a profitable business case. In addition to this there are certain restriction with regards to pricing, the price for this heat is based on gas-prices so that consumers are protected against high market prices (Hoogervorst, 2017). This limits the profitability for industrial companies that provide excess heat for DH networks.

But when comparing this heat source for DH with the individual situation in which gas is burnt in a boiler, using excess heat for DH is way more efficient (van Kann, 2015).

In an ideal situation this excess heat is produced climate neutral so that it contributes even more to a climate neutral energy system (Hoogervorst, 2017). Due to this potential it is important to make use of this excess heat in order to make the overall heat supply more sustainable for housing and businesses. Therefore, it is important that these barriers are addressed so that industrial companies can be stimulated to provide (climate neutral) excess heat to DH networks. Hoogervorst (2017) provided examples of incentives for industrial companies, for example by setting more restrictions to dumping excess heat water or broadening of the definition of energy saving so that excess heat counts as energy savings.

Excess heat
In Maastricht, excess heat is used in a district heating network to fulfil the heat demand of service sector and residential buildings. From the chimney of a factory where paper is produced, heat is won back and transported to the energy production unit of Essent. Where an installation with boilers for energy security and heat storage is used to distribute the heat. This process had some implementation risks because the factory had difficulties to ensure supply for the long-term. Also the investment costs are high and therefore the payback period for this project is around 30 years. (RVO, 2019)

Box 1: Application Excess heat source

4.3.2 Geothermal heat

This renewable heat source exploits heat secured as steam or hot water in the earth's crust. The potential for geo-thermal heat in the Netherlands begins from depths of 500 metres and around 1 km in the Netherlands where low-temperature heat (40-50'C) can be used for district heating in buildings with a low heat demand and ranges to around 4 km with temperatures over 100'C (EBN, 2018). But when referring to geo-thermal heat, a lot of the times geo-thermal heat from shallow aquifers combined with heat pumps to heat the low-temperature water is also included in the definition, this system is called a ground source heat pumps and is already discussed earlier.

This source of heat has potential for the industry, greenhouses, bathing and swimming and buildings in a DH network. Around 83% of the geothermal energy used for space heating in 2005 is used in DH networks and by 2015 this number has increased to 89% (Hepbasli, 2010; Lund & Boyd, 2015). The downside of using geo-thermal heat is that it is often capital expensive to install and in a DH network it often requires additional equipment installed to ensure a constant energy flow. For example heat pumps are used when the temperature of the water is too low, or a tank storage is required to meet the maximum load delivered (Lund, 2010). Geo-thermal energy is also depending on geological conditions, this brings a higher risk in the phase of exploration, thus requiring test drills to confirm its potential on site (Kyriakis et al. 2016). The plus side is that the operating costs after installing is generally very low and that the price of the heat is very constant compared to fluctuating fossil fuel costs (Lund, 2010). And due to the fact that this heat source is not dependent on weather conditions, it makes geo-thermal energy a relatively stable source of renewable energy after it is installed (Kyriakis et al. 2016). Among the countries with the largest increase in the use of geothermal energy, the Netherlands was in the top five (Lund et al., 2005). Although this heat source is getting increasingly popular in the Netherlands, for the province of Groningen this heat source might not be able to exploit in Groningen. This due to the fact that a license is needed in order to drill below 500 metres of depth

(Rijksoverheid, 2018). This license was not granted to the municipality of Groningen because of the high-risk of earthquakes occurring (Veenstra, 2018).

Geothermal heat
In Neustadt, Germany a geothermal heating plant extracts hot water from deep hydrothermal reservoirs in the ground. This hot water is extracted at depths around 1 to 3 kilometres containing heat up to 120 'C. This heat is distributed in a district heating network combined with a gas-boiler for meeting the peak demand (Seibt et al., 2005). The advantage is that sustainable heat is produced for a long time span. The barrier in this project were the high investment costs due to the construction of the DH network and the geothermal and heat production units (Lund, 2005)

Box 2: Application geothermal heat

4.3.3 Biomass combustion

Biomass is a collective name used for all organic material that stems from plants. This organic material contains energy that is released through combustion (McKendry, 2002). The process of combusting organic material is not to be confused with the process of producing biogas, where organic material is not combusted but fermented. Biomass can be used collectively for combustion in which water is heated to distribute it throughout DH networks or can be used individually in biomass boilers. Most of the biomass that is combusted in the Netherlands is 'woody biomass', in the form of waste wood from households and municipalities and imported biomass. It is mainly combusted in coal-combustion plants to increase the share of sustainable produced electricity (PBL, 2014). Excess heat from this process can then be used in DH networks to increase the share of sustainable produced heat.

The principle of using biomass as a sustainable source for energy production is that when biomass is harvested, new biomass is planted. This is important because when it is combusted CO2 is released but when new biomass is planted this CO2 that is released is compensated by the absorption of new biomass (McKendry, 2002). McKendry (2002) mentions that this source is not as sustainable as is promised because of the time lag between the release of the CO2 and the absorption of the same amount of CO2. He thus points to the consumption of biomass and failure of replacement programmes for biomass.

Biomass combustion thus seems like a good solution to make the heat supply sustainable at first. But it requires a constant input of biomass which cannot be produced sustainable on a large scale locally, as exemplified in the case of Ede below. Therefore biomass is depending on importation from other countries and their pricing (PBL, 2014). Abbassi & Abbassi (2010) mention that due to this dependence on importation of biomass, transportation costs also make this source more expensive and less sustainable along with the time-lag of CO2 that is released and absorbed. They also mention that on the short term it can cause high emissions of air pollutants and can bring detrimental effects due to the nitrogen compounds that are released (Abbasi & Abassi, 2010). Despite these negative aspects, when following the trias thermica this source could be used to substitute the natural gas demand when other renewable options are not available. Biomass combustion could be a good alternative for heat production because there is a local biomass waste stream available which could provide heat for a DH network.

Biomass combustion
In the city of Ede in the Netherlands the demand for natural gas in the residential sector is partly substituted through a DH network with a biomass combustion source (Edestad, 2017). Woody biomass from municipal rest streams are used as an input for combustion. But in a study it was concluded that locally there was not enough bio-mass available and that it threatens the bio-diversity in the region if local wood is used (Edestad, 2018).

Box 3: Application biomass combustion

4.3.4 Waste incineration

Residual municipal solid waste can be used as an energy source in municipal waste incineration plants (MWIP). Heat and electricity can be harvested from burning this residual municipal waste (Panepinto & Zanetti, 2018). Waste incineration is used mainly for DH networks, industrial processes and heating of greenhouses. The gross amount of heat produced from these MWIP in the Netherlands is increased by 49% from 2012 to 2016, in which since 2012 an significant increase is shown in the amount of waste that is imported (Rijkswaterstaat, 2017). About half of the waste that is burned is from a biogenic origin which makes half of the energy produced from waste renewable energy (Gerdes, 2016). Gerdes (2016) explains that due to the circular economy in which recycling will become important in the future, these MWIP reduce in number and this source of renewable heat and energy production will thus become less favourable in the future.

Although this energy source is initially used for burning the excess waste volume, it started to become an alternative for fossil fuels. The downside of these MWIP's are that they have a detrimental effect on the environment because they pollute toxic substances and greenhouse gas emissions (Morris, 2005). For this reason these MWIP's need to gain a certain permit and meet certain standards with regards to energy efficiency (Persson & Münster, 2016). The plus-side is that it is an alternative to landfilling of waste and therefore avoids the disposal of emissions and reduces the overall energy demand. Persson & Münster (2016) explain that the potential for heat recovery from municipal solid waste is very much depending on the presence of DH network present in the area to increase the overall efficiency of the waste-to-energy method so that residual heat from this process has the opportunity to be distributed.

MWIP's have some advantages over landfill disposal of waste but still have to deal with negative environmental aspects. In the long term this way of heat production might also not be feasible because more favourable ways of municipal waste disposal like recycling are expected to increase. Like biomass combustion this energy source is not completely renewable but could nevertheless contribute to the substitution of natural gas used for heat production when other renewable options are not available. It is then important to use the local municipal waste stream in order to make this method of heat production as clean as possible, so that emissions from transporting this waste is avoided.

Energy from waste
In Delfzijl, EEW Energy from Waste B.V. imports municipal waste as a resource in their energy production unit. This process could be regarded as CO2 neutral due to the high amount of biogenic material in the waste. This waste is burnt and the installations retreat as much harmful gasses as possible to reduce the environmental impact. Heat from this process is used in a district heating network to heat residential and commercial buildings (Groningen Seaports, 2013).

Box 4: Application energy from waste

4.3.5 Biogas

This source of energy can be produced using two main input sources. The first is from waste of crops and the second source is using animal manure (Weiland, 2010; Holm-Nielsen et al. 2009). Therefore it uses input sources that would often be wasted. These waste streams are fermented in a large containers where bio-gas is produced and the waste from the process can be used again once treated properly as fertilizers, which makes this process very efficient (Weiland, 2010). Although bio-gas is mainly used in the Netherlands in these large-scale production units, it is also possible to produce it on a household level.

Bio-gas is mainly used by power plants which produce combined heat and power (CHP), as a fuel in the transport sector or for the use in a natural gas-grid (Weiland, 2010). Compared with other substitute energy sources for natural gas, bio-gas has the benefit that it can be distributed to the consumer throughout the existing gas infrastructure networks if it is properly prepared first (van de Walle, 2014). Therefore certain investment costs related to the distribution network are avoided. When using animal manure as an input source, it reduces environmental degradation as a result of air and water pollution from the animal manure (Holm-Nielsen, 2009). The local availability of these waste streams usually from agricultural activities and the benefits it brings with regards to the environment, waste reduction, agriculture and health makes this source of energy production to be considered as a good alternative for natural gas extraction on the local scale. Bond & Templeton (2011) investigate the potential for biogas technology and find that certain aspects hinder the implementation of this technology. They name upfront costs of bio-gas installations as one of the reasons, the high construction costs of these installations often hinder the implementation for smaller scale agricultural businesses. Other reasons can be that it requires a labour-intensive operation and maintenance and that these installations usually have a limited lifespan of around twenty years (Bond & Templeton, 2011; Gebrezgabher et al. 2010).

According to Gebrezgabher et al. (2010) some of these barriers that hinder the implementation of bio-gas plants, could be addressed in politics. They name the renewable policy that should provide an incentive for producing bio-gas, but in fact deliver uncertainty with regards to receiving subsidies. Due to this uncertainty, bio-gas plants require to be very cost-efficiënt because the high investment and operation costs limit the potential.

Biogas

An example of the application of biogas is the production of biogas from a sewage treatment plant in Leeuwarden. A biogas installation is used to produce biogas from the organic sludge from the sewage treatment plant, combined with gas-boilers to provide energy security. Around 20% biogas is then used in a CHP installation to provide heat and energy for a retirement home 500 meters away, 60% is used by the sewage treatment plant itself and around 20% is not used because of a limited demand in the summer period (RVO, 2016). This example shows that sewage treatment plants are a good example for producing biogas with limited financial risks, the payback period was around 10 years. The process could be optimized by storing this 20% heat during summer period to use it in the winter.

Box 5: Application Biogas

4.3.6 Power-to-Gas

This technology makes use of a surplus of power to convert this to gas. The process uses renewable electricity surpluses combined with H2 obtained from electrolysis and CO or CO2 to produce CH4, known as a substitute for natural gas (Syngas) (Götz et al. 2016). This technology has a wide range of application: is it used as a technology to store surpluses of electricity, fuel for transport, raw material for industry and for distribution through the existing gas-grid, mostly for mixing with natural gas to reduce the gas demand (Gahleitner, 2013; Götz et al., 2016).

Although hydrogen has some properties similar to natural gas, it might not be possible to use the gas-grid to export hydrogen alone and use this for heating. Some adjustments to existing installations for the consumption of hydrogen might need to be made, Dodds et al. (2015) name for example replacing gas-boilers or adjustments to burners used for cooking. But on the plus-side the existing gas infrastructure network can be used to transport the hydrogen, possibly not one on one but it is already used to mix with natural gas to reduce the gas demand and there are possibilities to convert the gas-grid into an hydrogen grid (Dodd et al. 2015). Because the existing gas-grid could be used to distribute hydrogen, some high upfront investment costs could be saved. It could also be used in existing DH networks that have an CHP energy source (Dodd et al. 2015). The downside of this technology is that the production process is quite costly because of the low efficiencies of the electrolysis process and high storage costs (Götz et al., 2016).

So although this is a quite immature and costly technology, it has a high potential to reduce the natural gas-demand used for heating buildings. Due to our existing heat supply sector hydrogen has the potential to replace the gas demand throughout the distributing gas-grid. The gas-grid could be converted in the future so that pure hydrogen could be distributed, but it could also already be mixed with natural gas to reduce the demand. In the short term it could also be used in DH networks with CHP to replace natural gas demand. According to Dodd et al. (2015) this technology is depending on research and innovation to mature enough to be used on a larger scale for heating in residential and commercial buildings. Future options seem promising but are very much dependent on decreasing the high costs of the production process. Everts (2015) named several important measures to make the P2G technology more feasible. These measures for governments are in general: provision of subsidies, exemption from the energy tax and exemption of network costs. Other measures are more dependent on the development of the technology, such as efficiency improvements and the sale of residual energy flows.

As mentioned earlier, Groningen already has ambitions of using hydrogen for a wide range of applications to develop a green hydrogen economy. According to van Wijk (2017) Groningen has the expertise and infrastructure due to decades of natural gas production and also has a strategic location because the availability of large scale renewable electricity from Nordic countries and the presence of the chemical industry, which recently expanded the hydrogen infrastructure network. It would also provide an opportunity to be a leading province in this technology and therefore provide long-term economic possibilities for export (van Wijk, 2017). He also emphasises the importance of the challenge to scale up the hydrogen production in order to reduce costs of hydrogen production to make it less competitive with fossil fuel prices.

Power-to-Gas

As mentioned earlier, Groningen already has ambitions of using hydrogen for a wide range of applications to develop a green hydrogen economy. According to van Wijk (2017) Groningen has the expertise and infrastructure due to decades of natural gas production and also has a strategic location because the availability of large scale renewable electricity from Nordic countries and the presence of the chemical industry, which recently expanded the hydrogen infrastructure network. It would also provide an opportunity to be a leading province in this technology and therefore provide long-term economic possibilities for export (van Wijk, 2017). He also emphasises the importance of the challenge to scale up the hydrogen production in order to reduce costs of hydrogen production to make it less competitive with fossil fuel prices.

Box 6: Application Power-to-Gas

4.3.7 Heat pumps

There are different heat pumps that can replace the need for a gas boiler. Heat pumps use electricity to convert low heat out of the air, soil or water to higher temperature heat for heat purposes (van de Walle, 2014). It is important that these heat pumps are connected to an energy source that produces decarbonised energy in order to get the lowest CO2 emissions. Therefore individual heat pumps are often combined with solar panels on the roof of buildings. Costs and potential of heat pumps in DH systems are depending upon electricity availability and related pricing of electricity. Werner (2017) argues that in an energy system with high electricity surpluses, electricity prices will decrease and therefore create good market conditions for heat pumps and the other way around for biomass and natural gas. Increasing electricity supply might therefore decrease natural gas use and stimulate the use of heat pumps. Heat pumps used in DH networks require different heat sources compared to individual solutions. Individual heat sources are for example groundwater or just air. While heat sources commonly used for heat pumps in DH networks in Europe are for example: sewage water and geothermal water (David et al., 2017). While heat sources vary in DH networks with heat pumps, the heat source is also a variable determining the costs and potentials of heat pumps.

Disadvantages of heat pumps are that they require higher upfront investments and have long payback periods (Wang, 2018). It also requires a huge amount of decarbonised electricity in order to use them in a DH network with the lowest CO2 emissions and therefore it requires more investments. For houses that require a higher heat demand such as older buildings and farms heating spaces with heat pumps are regarded as a very costly option because heat pumps are most efficient when heating at low temperature (van de Walle, 2017). These buildings first need to be isolated further which makes heat pumps less feasible in some areas (van Wijk, 2017). For these houses a hybrid solution, where a heat pump is combined with a gas boiler, would be a better option. The heat pump can then fulfil most of the demand, but on some colder days where the heat pump has not enough power, the gas boiler can help in meeting a higher demand (Klein et al., 2014). In this way a significant reduction of natural gas usage is gained.

But using the heat pumps in a DH network could result in benefits arising from economies of scale (Wang, 2018). Then these heat pumps are becoming cheaper when they are used in the larger DH networks. And due to the dependence on electricity availability and related pricing, heat pumps in DH networks would be most cost-efficient if they are used in large scale DH networks and where electricity surpluses are available so that they are more cost-efficient than other energy sources. With regards to the source of heat for heat pumps in DH networks, a study by David et al. (2017) shows that using sewage water has the highest benefits because it is a long-term and stable source containing high temperatures and is in close proximity to urban areas. Therefore they name sewage connexions, and sewage water treatment companies as ideal locations for heat pumps using sewage water in a DH networks (Hartman & Bloemendal, 2015).

Heat pumps
A good example of heating residential buildings with heat pumps is the concept of 'Nul op de meter' where buildings are energy-neutral through improving the thermal efficiency and producing their own electricity. In Delfzijl this concept is applied to existing buildings, first they are isolated and made earthquake resistant, then heat pumps are placed that are powered by solar panels. This approach is regarded as costly and is made possible due to subsidies from the central government (Hierverwarmt, 2018).

Box 7: Application heat pumps

4.3.8 Solar thermal heat

This energy source is an individual alternative to fulfil heat demands with gas boilers and makes use of incoming solar radiation to capture this energy uses it to heat water. Because solar energy is used any environmental pollution is avoided and there is a reliable energy source (Kalogirou, 2004). Highest heat production from solar thermal panels occur in the summer, while in the winter the production is very low. The demand of heat is also not matched with the production of solar thermal panels and due to these factors solar thermal panels are often used in a system combined with heat pumps or gas boilers to meet the required heat demand. A buffer tank for hot water is also part of the installation so that the peak demand for heat could be met (Goovaerts et al. 2014).

Solar thermal heating in combination with heat pumps could be very costly when the heat demand of a building is high. Therefore this solution works better with low temperature heating, like in new, energy efficient buildings. For existing buildings it requires to invest in making houses more energy efficient first to make this option more cost-efficient. The investment costs for existing housing is therefore often too high to choose this option (van Wijk, 2017). In the Netherlands these (combined) solar thermal configurations are stimulated by beneficial support policies in order to stimulate the implementation (van de Walle, 2014).

Solar thermal
In Almere solar thermal collectors are used collectively to produce heat for residential buildings. In total there are 520 solar collectors that produce around 10% of the total heat demand of the district. This solar thermal project required six million investment costs and is for 1,4 million euro subsidised. The investment costs are therefore a downside of the project accompanied with the amount of space required for installing the solar collectors (Bongaerts, 2018).

Box 8: Application Solar thermal

4.3.9 Thermal storage

Thermal storage is a technique that can help in making buildings more energy-efficient. This thermal storage uses layers in the ground to store hot and cold water. In the summer the cold water is used too cool the building, the used water for cooling gets hotter and is stored in a ground layer again. This warm water stored in the ground can then be used during winter time in combination with a heat pump to provide a more cost efficient way of using the heat pump (RVO, 2011) . The downside of this technique is that heat losses occur during storage of hot water in the ground (Hesaraki et al., 2015). Also this technique requires investment costs that are related to a return rate of around 10 years and is harder to install in existing buildings (RVO, 2011).

4.4 Comparison heat sources and techniques

The different heat sources and techniques discussed above can all be found structured in the table below. They are compared on their opportunities and barriers and judged on their environmental impact. This environmental impact could be seen as an indicator for sustainability while it judges the sources and techniques on their emissions and effects on the surrounding area.

Source/technique	Environmental impact	Opportunities	Barriers
Electrical heating	Low *	High applicability, Also works in hybrid forms	Increases electricity demand, Upfront investment costs,
Biogas	Low **	Use existing gas grid, No extensive isolation requirements	Expensive production process, Requires stable input source, Upfront investment costs
Hydrogen	Low - Medium *	Use existing gas grid, No extensive isolation requirements	Expensive & inefficient process, Immature technique
Excess heat	Low - Medium ***	Use reststreams more efficiently	Requires stable excess heat source, High density buildings in proximity
Geo-thermal heat	Low	Low environmental impact, High temperature heat	Requires sufficient geological conditions High density buildings in proximity
Solar thermal heat	Low	Low environmental impact	Low yields especially in winter, Need to combine with heat pump
Biomass combustion	Medium	Use reststreams more efficiently	Requires stable input woody biomass, High environmental impact to area High density buildings in proximity
Waste incineration	Medium - High	Use reststreams more efficiently	High environmental impact High density buildings in proximity

	Conditions
*	if source of electricity is not from fossil fuels
**	if source of biomass is not too distant, otherwise transport increases CO_2 emissions
***	if source of heat is not from fossil fuels, environmental impact decreases

Table 2: Comparison heat sources/techniques

5. Case study

This chapter focuses on the transition from natural gas towards sustainable heat in the province of Groningen. The aim of this chapter is to gain insight into the approach that is taken by governmental bodies. Also based on the information from the previous chapter, the potential for the different alternatives to natural gas are discussed for the province of Groningen. The outcome is another table in which the applicability of different heat sources and techniques for the province of Groningen is compared. This case study uses a document analysis and an map analysis for gathering the data. The map analysis will play a big role in determining the potential for the different alternatives for the province of Groningen and the document analysis will help in examining the approach and the policies regarding this heat transition.

5.1 The approach

From the analysis of the documents from the province and the municipality it is shown that a similar approach is taken by the province and municipality of Groningen as described in the literature study. Due to the complexity of the problem the approach is focused on participating with multiple actors. This relates to the right side of the spectrum of figure 2 from the literature study. Important actors are different governmental bodies, like municipalities, the province, the central government, housing associations, inhabitants but also institutions that are established to advise and lead the transition, like Green Deal.

From the reports from the municipality and the province it stands out that the province of Groningen has set ambitious sustainable energy goals. For example 21% sustainable energy by the year 2020 and 60% by the year of 2035 in the province. The municipality of Groningen has actually set a more ambitious target of 100% renewable heat by 2035. There is a realisation that sustainable heat can contribute significantly in reaching these goals. The approach of the province to reach these goals is through combining these projects with other goals like the renovation of housing in the earthquake area in east Groningen. In this way the province of Groningen aims to integrate these goals to solve multiple problems at the same time. The integration of these goals relate to the vertical line in the spectrum of figure 2.

The earthquake area requires renovations of buildings and housing to make these more resistant to earthquakes occurring in the area. Due to the sustainable energy goals this is seen as an opportunity to renovate these houses and make them energy neutral. From the central government funds have been made available to initiate these projects. In this way this area will act as some sort of a testing ground for making houses energy neutral and independent of natural gas for space heating. In these projects important concepts are used for energy neutrality in the residential sector. For example the implementation of the concept of “Nul op de meter” housing. As mentioned before this is a proven concept in which houses fulfil their own energy demand mostly through electrical heating and solar power generation. This concept shows a similar approach to the Trias thermica, discussed in the literature study. First the heat demand is reduced through better isolating these houses and secondly the heat supply is fulfilled with heat pumps in combination with solar panels, thus substituting the demand for natural gas with renewable heat.

Elements of the transition management framework are clearly recognizable in the approach that is taken. In the report “Vol ambitie op weg naar transitie” by the province of Groningen the ambitions, visions and approach of the province are explained for the energy transition as a whole. In this document a transition management approach is taken that focuses on innovation and reflexive learning activities. This focus is implemented by a collaboration between the northern provinces, where Energy Valley is established to promote innovation through collaboration with businesses. From this document it is also shown that the province will continue an exemplary role as its sets ambitions energy goals for their own organisation.

In East Groningen some efforts have already been made, mainly due to the urgency for renovating housing there. This makes integrating this goal with sustainable energy goals more cost-efficient. In other areas in the province a similar approach following Trias thermica will be taken. The aim is to renovate existing housing so that the demand is reduced and then fulfil this lower heat demand with sustainable heat production. For new housing the approach is to build energy neutral. Depending on local conditions renewable sources of heat production are chosen. A neighbourhood approach/focus is taken on this issue. In general, in places with a low population/building density heat demand will mostly be fulfilled through individual heat production. In urban areas the focus will be on collective systems where DH networks distribute heat produced preferably from sustainable sources. With these DH networks the approach is to find multiple sources that can be connected so that energy security is guaranteed. This approach seems logical when looking at the barriers and opportunities from different heat sources, heat sources requiring high building density are all distributed through a DH network.

From the analysis of the documents from the province and municipality it is shown that there are several roles that these governmental bodies are fulfilling. As mentioned before there is an exemplary role that is carried out by setting ambitious targets for their own organisation. For example the effort to make all buildings from the province energy neutral. Another role for the province but also municipalities is that they aim to stimulate, support, connect (local) initiatives that carry out sustainable energy projects. The province of Groningen has established a fund where these initiatives can request financial assistance. Also local energy initiatives are supported by the so called “vliegende brigade” an advisory body for these initiatives, established by the province. But also opportunities are mapped by the province and municipalities in Groningen for starting such initiatives. This approach that focuses on local initiatives is very important because these projects have more support from the local community due to their involvement, but also assist municipalities because they lack the resources to take on this issue their selves. Governmental bodies also cooperate with businesses. This cooperation mostly focuses on bigger projects with companies. For example the municipality of Groningen cooperated with five main consumers in the area to implement a thermal storage that has reduced the heat demand of these buildings. Another measure that has been implemented is the opening of energy booths at municipalities. These booths have an advisory role, for example inhabitant can go to these booths to be advised on individual sustainable options for their houses.

In short the province takes on an approach aimed at three main points: energy saving, sustainability, and a changing energy system through innovation. There is a clear focus on innovation and learning as the earthquake area will act as a learning case for the rest of the province due to the societal relevance here. With sustainable energy, their focus is mainly on wind and biomass-initiatives until 2020. Along with this, large scale projects like solar projects and DH networks are the focus. Through the use of (local) initiatives innovation will be stimulated and smaller municipalities with the lack of available resources will be assisted in reaching their goals. The third main point relates to a changing energy system in which other forms of energy substitute natural gas. Therefore an effort will be made to promote the development of new gasses like biogas or hydrogen. They also mention a future approach will be based on ‘Evidence based policy’, which is policy that is developed based on successful projects. Thus future policy will be based on the upscaling of successful projects.

The municipality of Groningen show in their report “Groningen aardgasloos 2035” and the report “Routekaart Groningen CO2 neutraal 2035” that their approach focuses geothermal energy and to create open DH networks with geothermal energy and multiple other sources. The construction of DH network is stimulated by the establishment of WarmteStad, a cooperation between the local water company in Groningen and the municipality. The aim is to generate the heat in the area itself through various sources that can also be combined. Also the focus is on a continuation of the development of a thermal ground storage policy. Thermal ground storage has successfully been implemented and therefore they continue to promote and develop a good organisation for this system. Along with a focus on renewable gasses that can be used for high quality energy demand, for example production processes and CHP generation in large buildings. For housing excess heat from the burning of renewable gasses can then be used. The use of heat pumps will also be stimulated. In the report from Gemeente Groningen (2018), it is mentioned that the heat supply by 2035 will be fulfilled with roughly 35% heat through DH networks along with 50% heat pumps, solar boilers will also play a role for 50% of the houses. To realise this increase in electrical heating they aim at increasing the amount of solar panels on roofs along with large scale solar and wind parks outside the municipality, along with a reduction of the heat demand from housing.

5.2 The barriers and opportunities

Through the text analysis of the documents complemented by the map analysis, the different sources and techniques for replacing natural gas in the built environment in Groningen have been analysed. The barriers and opportunities from table 2 in chapter 4 have been evaluated for the Groningen and the different sources and techniques are judged on their applicability in the province of Groningen.

5.2.1 Geothermal heat

As mentioned in the section before, one of the main points in the approaches for the municipality of Groningen to become independent of natural gas relies on the use of geothermal heat that is distributed via a DH network. In the report from “Groningen aardgasloos 2035” they mention that earthquakes occurring in Groningen could create a risk for the future of geothermal energy in Groningen. By now we know that the geothermal project from Warmtestad in the city of Groningen has come to an end. The end report on the process for this project has been published and is analysed in order to determine the barrier for geothermal energy in Groningen. The number one barrier that have caused the project to fail are indeed higher project risks among others due to the occurrences of earthquakes and a changing policy context. However this project has failed, geothermal heat can still play a role as a substitute for natural gas in Groningen, because of the availability of geothermal heat in the ground. For future efforts on geothermal energy, the location choice, the project management and stakeholders play a crucial role in the success for these projects. Specific recommendations that are mentioned in the report for future efforts on geothermal heat projects are: a more comprehensive stakeholder analysis, locations that are less affected by earthquake related risks and to involve organisations that are regarded as central and robust operators by the ministry. In the province of Groningen this would mean a location choice more in the west side of the province. Most potential for deep geothermal heat would then lie in the brown area displayed in Figure 5.

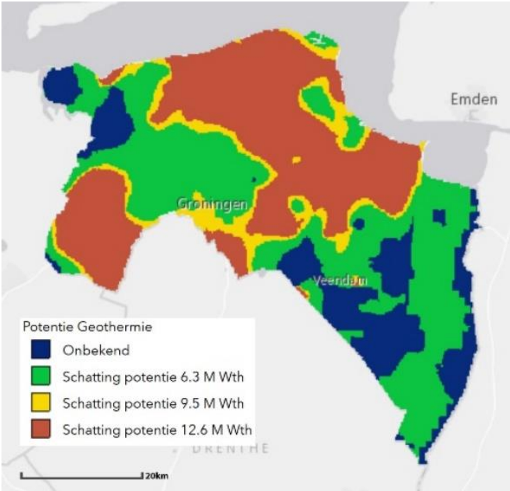


Figure 5: Potential geothermal Heat (Provincie Groningen, 2019)

5.2.2 Renewable gasses

The province will focus on the promotion of biogas initiatives until 2020, the re-using of waste streams complements the circular economy approach Groningen focuses on. The report from the CE Delft discusses the potential of biogas in the EU beyond 2020. In the report two scenarios are discussed for biogas, one in which biogas is used locally for mainly CHP use or other processes that require high quality energy. The second focuses on upgrading biogas for injection in the natural gas grid. Mentioned before, the municipality of Groningen focuses in their report “Groningen aardgasloos 2035” on the first approach. But also a focus on the second approach is mentioned because for the inner city of Groningen renewable gasses can play a role in the heat transition. This is because measures that require adjustments to buildings, especially monumental buildings are harder to realize here.

The main barriers for biogas production mentioned in the report are related to the costs. The investment costs are high and subsidies are mainly granted to big and high efficiency projects, therefore hindering the implementation of small scale less efficient projects. It is hard to make a business case for smaller scale projects due to changing contexts. For example: every new cabinet starts their own strategies and funding schemes and therefore long-term security for these projects are endangered. The development of stable and reliable support schemes on a national level for small scale projects can help in making biogas production more feasible. Public and private support schemes like Green Deal are ways that can help in making business cases for smaller scale projects. However producing biogas has some evident barriers, due to the large area of agricultural land in Groningen, the potential for biogas is high in some of the municipalities. A visual representation of this potential is displayed in Figure 6.

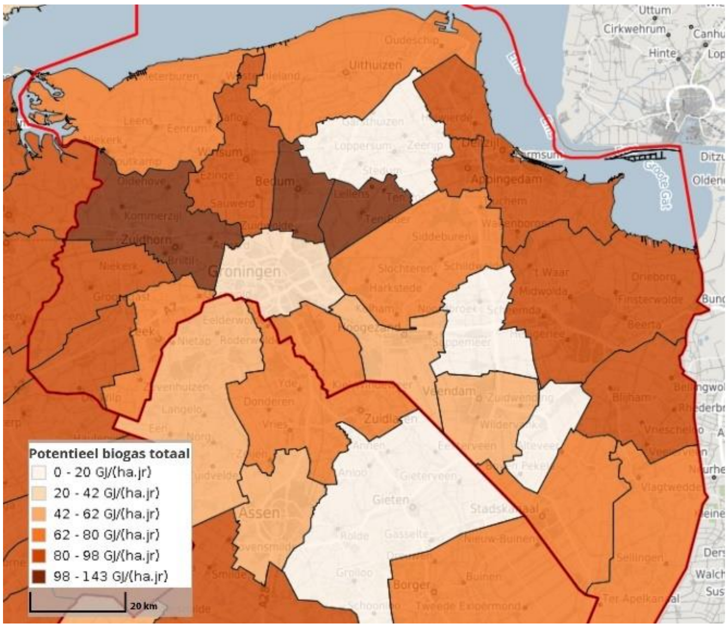
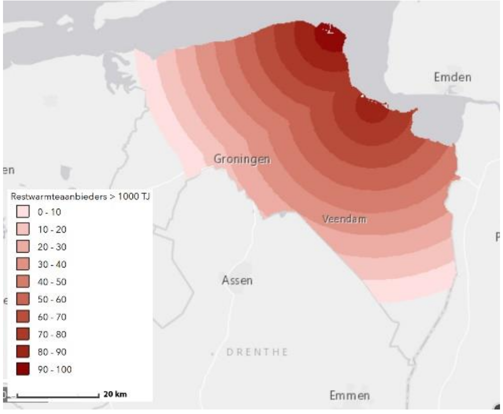


Figure 6: Potential biogas in Groningen 1 (*Nationaal Expertise Centrum Warmte, 2018)*

Next to biogas, there will also be a focus on hydrogen as a renewable gas. Hydrogen will be used for similar purposes as biogas, mainly industrial processes or used as a substitute in gas-fired power plants. In the built environment it can also be used to inject in the natural gas grid as a substitute for natural gas. The focus of hydrogen does not seem on space heating, but more on the transport sector and processes that require higher temperatures. van Wijk & Hellinga (2018) in their report, argue that it can also be an alternative for space heating in smaller villages, because various other sustainable options like DH or heat pumps are not feasible. Nevertheless they argue that hydrogen production is important process in the future for coping with seasonal differences in renewable energy production.

5.2.3 Excess heat

The report on the national route map for excess heat by the IPO is used to analyse the role for excess heat in the heat transition and to identify the barriers. One of the main barriers identified in the report is that Groningen has a high volume of excess heat available but the demand is low due to low density built environment around the heavy industry. In the report they mention a maximum potential of 46.000 houses that can be heated with the excess heat available. Therefore it can play a significant role in the heat transition. In figures 7 & 8 below, the availability of high volumes of excess heat is visually represented on the map of Groningen. Here we see the concentration of this volume mainly around the Eemshaven and Delfzijl. The smaller suppliers of excess heat are visually represented in Figure 7 & 8 below.



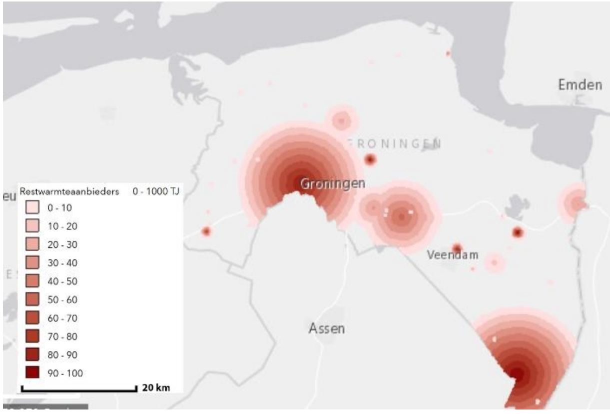


Figure 7: Potential excess heat high volume (Provincie Groningen, 2019) *Figure 8:* Potential excess heat smaller volumes (Provincie Groningen, 2019).

Another barrier is that there is no clear vision for the future role of excess heat in the heat transition. Because of this excess heat utilization is not stimulated, developing a vision and a policy on this could stimulate the utilization of excess heat. This is necessary because these projects need to be secured for longer periods of time in order to be feasible. The municipality left the utilization of excess heat mostly in the hands of the industry, Groningen Seaports is for example a big actor. In the report it is advised that Groningen could take on a more active role in this because Groningen is also shareholder in a network company, Enexis. The province could use this to support, organise and realise project that distribute the excess heat. Through the development of a vision and certain policies excess heat could be stimulated, for example by setting restrictions on the use of this heat to avoid this heat being dumped. Increasingly renewable gasses will be used in for processes that require higher temperatures instead of natural gas, as concluded from the reports of the municipality and the CE Delft. Therefore industries will switch to renewable gasses and this will result in more sustainable excess heat that can be distributed throughout DH networks.

5.2.4 Heat pumps

For this section the article is used by Mulder & Moraga (2018) about the electrification of heating and transport. A scenario is analysed for the Netherlands up until 2050. Based on this article and the structure of the province of Groningen with, relative low density areas, electric heating will, and already is, taking place on a large scale. One major barrier for this way of substituting gas boilers is that it results in an increase in electricity demand. In the article it is explained that in certain scenarios where heat pumps are utilized on a large scale, this requires a huge increase in electricity supply. Because of this it is argued that gas-fired power plants cannot be closed down as they will result in an electricity shortage. This increase in electricity demand needs to be captured by either central or decentral production. Central production could be done by using biogas to power gas fired power plants or through large scale solar and wind projects. A decentral production approach could be done via a neighbourhood approach with concepts like “Nul op de meter” housing. The problem with capturing this increase in electricity demand is that production via renewables is that there are seasonal differences in electricity production. Therefore it would require either the storage of large amounts of electricity for usage in periods where generation via renewables is low through for example hydrogen production or through the import of large amounts of decarbonised energy.

5.2.5 Biomass combustion

From the ‘Warmtekansenkaart’ it shows that there is a potential to use the woody biomass from municipal pruning rest streams. When looking at figure 9, the potential shows the highest value in the municipality of Groningen, with a value of at least 5 GJ/ha/year. For the municipality of Groningen this would mean a potential of around 42.000 GJ/year. This has a maximum potential to heat around 1000 homes. Near the sports centrum Kardinge already one biomass combustion operates with a large capacity. As explained in chapter 3, biomass combustion is a sustainable source as long as this biomass grows back with the same volume. Pruning waste streams are a stable source of woody biomass, therefore this rest stream could be explored as a source for residential heating in other municipalities in Groningen.

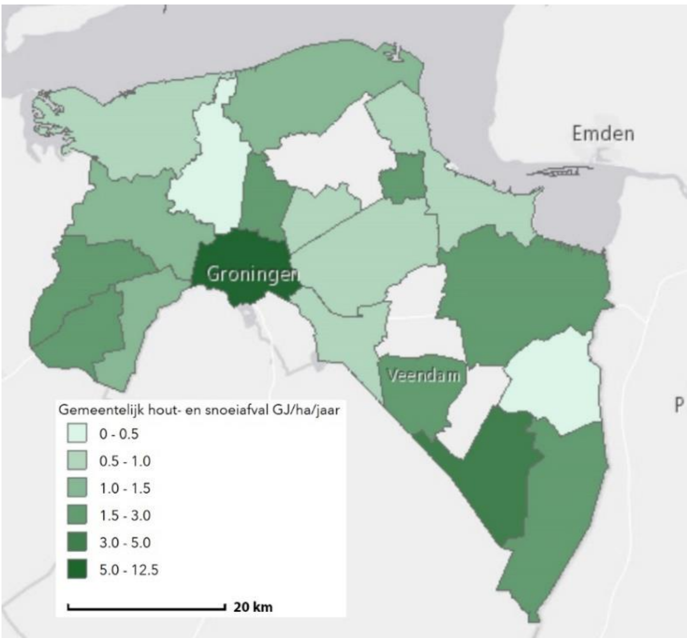


*Figure 9: W*oody biomass rest streams in Groningen (Provincie Groningen, 2019)

5.2.6 Home owners

Throughout this study the focus is mostly on collective solutions or approaches in which housing associations have the power to decide on alternative heating solutions for their housing stock. But also a large part of the housing stock is owned by private owners. As mentioned in the literature study a major barrier is to implement alternatives for natural gas use in the housing stock owned by private owners. This group is harder to motivate and often do not have the necessary resources to implement these alternatives. From the report of the RVO (2018) on natural gas independent housing stock, recommendations have been made on how to transition the existing housing stock. One conclusion is that beside the focus on heat plans on district and area levels, less attention is given to the residents themselves, and especially private home owners. The barriers for implementing alternatives for home owners that are mentioned in this report are: a lack of urgency, high investment costs, the trouble, lack of confidence in measures, lack of knowledge on their own house. Investment costs for an individual heat pump can range up to 10.000 euros and then renovation costs for isolating houses are not included. The payback period related to these investments are regarded as too slow by home owners. The trouble that they have to undergo to change their homes and the insecurities related to the measures are also a big barrier for implementation. In order to overcome these barriers for private home owners, energy booths, as mentioned before in this chapter are established. In the report from van Wijk & Hellinga (2018) it is mentioned that for private home owners a switch to renewable gasses is a lot cheaper. A switch to hydrogen would cost around 3.500 euros and has a minimal impact for the energy bill. Unfortunately these renewable gasses are not ready to be deployed on a large scale and are preferably used for processes that require higher temperature heat like industrial processes or electricity generation. The implementation would thus require on technological advancements.

6. Results

The previous section contained detailed results of the document analysis. In this section the results from the document analysis and the interviews will be combined in order to answer the subquestions. Each section will discuss a subquestion in which answers from the document analysis will be backed up by the results from the interviews in the form of quotes from the respondents.

6.1 The approach

- This section will discuss the results on the subquestions: *"What approach is suitable in the transition to sustainable heat for the built environment?" & "What steps have already been taken in Groningen to become independent of natural gas?"*

From the case study and the interviews it is shown that the approach that is taken on different scale levels is following the Trias Thermica approach, as described in the literature study. Experts from the interview also agree with this approach, especially the first step of the Trias Thermica seems a logical approach to start with, reducing the heat demand. The simple argument for this step is displayed by the statement from an interview respondent:

"*Then I will always start with saving energy, that is the most cost-efficient way. We can reduce our natural gas consumption by taking good energy saving measures*" ***(#R4)***

The next step of the Trias Thermica is that the existing heat supply has to be replaced with renewable heat. And if not possible, the third step, use the cleanest alternative available. When replacing this heat supply by renewable heat, different alternatives are discussed and the in table 2 below, the applicability of the different sources are evaluated for Groningen. In implementing these alternatives sources, local governments have a big role as became clear from the document analysis and interviews. From the interview with a local government two important roles became clear:

"Our role is pretty big. The municipality can assist in facilitating infrastructural adjustments that promote sustainability. The construction of a heat network is a good example of this. This is a collective service that without a doubt only comes when the municipality fulfils a leader role. […] Furthermore, the municipality finds it important to facilitate energy cooperation's and grass-roots initiatives…" ***(#R3)***

Since local governments are often shareholders of network companies, they have an important role in developing heat networks. Also a focus on the promotion of bottom-up initiatives seems very important since this is a way to increase the support for certain projects. These initiatives can be supported, promoted and connected by local governments. Successful initiatives can be scaled up, following an 'evidence based policy', an example of a reflexive activities from local governments Furthermore it is important to connect the heat transition to different other aspects, like a circular economy, solving problems of soil subsidence and upgrade the old building stock, in this way an integral approach can tackle multiple problems at the same time, therefore being the most cost-efficient.

The approach that local governments take can be summed up as an integral and area specific approach that is based on the Trias thermica and principles of transition management, like promoting grass-root initiatives. The local governments have several documents that can act as tools in the process of determining the plans for their region. Drs. Hillenius from the Rvo explains this process:

"Municipalities have to come up with RES (Regional energy strategies) based on the IBP agreement and also the climate agreement: space for renewable production, searching for renewable heat sources etc. Then they have to make a transition vision Heat, a document that determines the best possible option for sustainable heat at that time. After that they have to look at the best opportunities, for example:

geothermal heat, excess heat, or heat extraction from shallow water or all electric with a heat pump. This can differ for each neighbourhood." **(#R5)**

So the task of the central government remains mainly in assisting local governments. As explained by drs. Hillenius this is done through developing subsidy schemes, process guidance and by organising informative meetings. The different municipalities thus have to come up with their own regional energy strategy and establish this in the energy transition plans. Local governments also cooperate with local residents in determining these plans in order to create more support for the projects. How this process of cooperation with local residents take place is up to the local government to determine.

6.2 The potential of different alternatives for Groningen

- This section will discuss the results on the subquestions: "What are the barriers and opportunities for certain alternatives for natural gas in Groningen?" & "Which alternative heat sources are most applicable in Groningen?"

Based on the data gathered in the literature study and the document analysis, the different alternative heat sources and techniques are compared, see table 2. The comparison judges different aspects, like environmental impact, requirements, and applicability in Groningen. This table shows that the most applicable sources for Groningen are: Electrical heating, Renewable gasses, Excess heat and Solar thermal heat. A respondent in the interviews also agreed that in the Netherlands three of these sources are seen as most dominant modes, electrical heating, either full electric or combined with renewable gasses in a hybrid form, and excess heat:

"We are thinking that the hybrid solution has an important flight to make these coming years, and that this solution could also become an end-solution. […]The second route is that a lot of heat in the Netherlands is thrown away.[…] That heat we should use. […] The third alternative flavour that remains in heat is full-electric." ***(#R4)***

The consideration between these different sources will depend on the characteristics of an area. For example: Excess heat networks are costly to construct, therefore not profitable in areas with low densities and require a heat source nearby, also renewable gasses will be better applicable in low density areas with older houses because of the advantage that it does not require high energy efficient buildings per se.

For the heat sources, biomass combustion, waste incineration, and (deep) geothermal heat, the applicability in Groningen is low. Geothermal heat is not very applicable because of soil subsidence in Groningen. Increasing heat from biomass combustion would also be hard due to the low availability of woody biomass in the area. Waste incineration is also not very applicable due to high environmental impacts.

From the citation below and the document analysis it shows that thermal storage combined with another source of heat production is a very promising technique in which the municipality of Groningen has already made efforts. One of the respondents also mention this as a solution to decrease the cost price of heat networks, therefore making heat networks more profitable and possibly an outcome for less dense areas in Groningen.

"In smaller villages you are not going to reach such a size for a heat network with geothermal heat. But with a collective thermal storage, you could come really far. […] Still, neighbourhoods with hybrid solutions appear to be more opportune, but heat networks are definitely not excluded. Especially if you could reach a large decrease in the cost price." ***(#R4)***

Source/technique	Environmental impact	Opportunities	Barriers	Applicability
Electrical heating	Low *	High applicability, Also works in hybrid forms	Increases electricity demand, Upfront investment costs,	**High**
Biogas	Low **	Use existing gas grid, No extensive isolation requirements	Expensive production process, Requires stable input source, Upfront investment costs	**Very high**
Hydrogen	Low - Medium *	Use existing gas grid, No extensive isolation requirements	Expensive & inefficient process, Immature technique	**Very high**
Excess heat	Low - Medium ***	Use reststreams more efficiently	Requires stable excess heat source, High density buildings in proximity	**Medium**
Geo-thermal heat	Low	Low environmental impact, High temperature heat	Requires sufficient geological conditions	**Low**
Solar thermal heat	Low	Low environmental impact	Low yields especially in winter, Need to combine with heat pump	**Medium**
Biomass combustion	Medium	Use reststreams more efficiently	Requires stable input woody biomass, High environmental impact to area	**Low**
Waste incineration	Medium - High	Use reststreams more efficiently	High environmental impact	**Low**
	Conditions			
*	if source of electricity is not from fossil fuels			
**	if source of biomass is not too distant, otherwise transport increases CO2 emissions			
***	if source of heat is not from fossil fuels, environmental impact decreases			

Table 3: Comparison of alternative heat sources/techniques (2)

But also heat networks with an excess heat source can be an outcome for the areas less densely populated areas due to the large supply of excess heat available around the industry like the Eemshaven. Although costs for realizing the infrastructure is very high with heat networks, the potential for heat networks is not only limited to densely populated areas nor limited to excess heat as a heat source for heat networks.

"A heat network is seen as the most promising alternative. There is already a plan for Loppersum North, with which we start this year. By combining the heat network with seasonal storage and sustainable production of heat (on the long term), we create the most sustainable heat network imaginable." ***(#R3)***

One big challenge of the heat transition is that an increase in electricity demand resulting from an increase in electrical heating will occur. This creates a twofold problem: this increase in demand has to be fulfilled with sustainable energy, which is hard at certain peak demand moments. And second that this requires huge investments in the electricity grid in order to deal with certain peak demand moments. It is mentioned by one of the respondents that therefore a policy based renewable gas combined with electrical heating, a hybrid solution, is more cost efficient.

"If it is winter and it is cloudy and windless, then you actually have no output from renewable production. So then you have to think about storing energy at the moment it blows very hard and the sun shines. […] So then you would come faster to a conversion in which you convert solar electricity through an electrolyser, to make hydrogen. This would be way more cost-efficient then adjusting the whole grid infrastructure in order to deal with peak moments in the winter." ***(#R4)***

Renewable gas thus provide a solution to the problem of electrical heating. The province of Groningen also mention a focus on promoting biomass initiatives. From the document analysis it also became clear that biogas has a good potential in Groningen because of the large area of agricultural land. Although renewable gasses like biogas and hydrogen thus seem like a good outcome, from the interviews and the literature study it became clear that some barriers hinder production and implementation of renewable gasses. These are mainly related to the costs, the following statement from an owner of a biogas production company sums this up:

"*Biogas has a cost price of more than 30 cents per cubic meter, so without subsidies it is not possible to produce. […] We can produce biogas here for years in a profitable way, but that has to do with that it is a family business in which the extra hours are not that expensive as compared to hiring staff. […] So because rest streams are increasingly being utilized better, the cost price of the end product becomes higher. […] So I don't see biogas expand that much, that it would become an end-solution.*" ***(#R2)***

6.3 Other challenges in the heat transition

- This section will discuss what other challenges arise when transitioning from natural gas towards renewable heat in Groningen. Thereby answering the subquestion: "*What other challenges occur in the transition towards sustainable heat?"*

6.3.1 Costs

One of the biggest challenges the transition towards renewable heat is related to costs and the division of these costs. The three most promising sources all three have high costs which land on different shoulders. Firstly electrical heating has the problem of costs for private home owner. Isolation measures in older houses are very expensive, also there are costs for installing a heat pump. This seems to be a big barrier for private home owners to take these measures. One respondent sums up this problem:

"*They are researching if there are financial solutions. Like linking the costs to your mortgage.* […] *Of course it is nice if you get a subsidy of 2.000 euros, but if the costs are 17.000 it still is a big chunk. So possibly you need to do a lot with creating awareness and subsidies also.* " ***(#R1)***

With renewable gasses these costs mainly come down to the producers of these gasses. The production processes are very expensive. For biogas one of the main reasons for this is the increasing prices for rest streams. As mentioned before these producers often can't make a business without the provision of stable subsidy schemes over a longer period of time.

For heat networks these costs are related to expensive costs of facilitating the infrastructure. These costs come down to network companies, local governments, energy suppliers and investors. This shows that for each of these promising alternatives, costs are a big barrier. Between these heat sources the difference is that the costs are divided in different ways. This results in inequalities in costs that have to be paid for the heat transition between different areas and stakeholders. One of the respondents emphasizes this inequality as a big national challenge in which politics have no answer yet:

"So you are going to get differences in costs, depending on where you live. There is a big challenge in that, especially because there is no national plan for this. […] because for the one region they could find a cheap solution and we might have more sustainable electricity production, while in other regions there might be a shortage and there might be more expensive adjustments needed." ***(#R4)***

6.3.2 Motivating home owners and businesses

Another challenge is related to motivating businesses and private home owners to take energy saving measures and to install sustainable heat production systems in their homes and businesses. Central agreements are a solution for businesses to decrease gas consumption and install sustainable heat production systems. One example of such an agreement is settles in the law of Environmental conservation which obliges companies that consume large amount of energy or are in a lower class energy efficiency building to take energy saving measures. For businesses these agreements are easier to set in place then for private housing. As mentioned by the statement above from respondent number 1 and number 5 below, creating awareness and subsidies for private home owners are good examples on how to motivate home owners:

"Campaigns, but also subsidy schemes etc. to make it affordable. The government is still busy in determining and elaborating the policies, as a result of the Climate agreement." **(#R5)**

The barrier of high costs for isolation measures can for example be overcome by explaining that it is an investment which is returned after several years. With innovative financial constructions the barrier of high investment costs for private home owners could be overcome. Respondent number one and five both mention a financial construction that divides energy costs in a different way, this is explained by one of the respondents:

"With soft loans and loans that are bound to a building, this inequality can be solved for a big part. With a low energy bill you then might need an extra loan with interest to pay, this is almost equal to the costs before the renovation. In this way it can be done without extra expenses." **(#R5)**

Between housing corporations, landlords and home tenants an agreement can be made called the EPV (energy performance compensation). This is a written agreement that protects the home tenant against rising energy costs because of energy saving measures, and sustainable production measures. It also contains agreements on how the investment is paid back by the home tenant, therefore securing the payback of the investment. This agreement also divides energy costs different, by lowering energy usage costs and increasing rents.

6.3.3 Upscaling renewable gas

For a successful transition towards renewable heat, an increase in renewable gas production is necessary, this means a higher production of biogas and hydrogen. This is certainly necessary when considering that hybrid options are the most cost-efficient options in existing buildings and, that they can also be an end-solution. As became clear from the interview with a biogas producer, it is hard to increase production of biogas since rest streams are increasingly being utilized more. Small biogas companies have a hard time to make profit because of this. Increasing biogas production has to be left in the hands of the larger producers with the current subsidy systems, as explained by one of the respondents:

"You can see it by looking at the SDE's that are being requested, that are going to be installations that are at least as big as we have, and even bigger. But that are only a few. So I think that biogas is a possibility, one of the possibilities. But in my eyes it will never become the biggest, you can see it right now in the applications." ***(#R2)***

Because biogas cannot fulfil all the renewable gas for the future, hydrogen also has an important role to fulfil. Hydrogen production can help in balancing the electricity grid and function as an energy storage substance. Increased renewable electricity production is one of the requirements for an increased production of hydrogen. And since this is a rather new technique to use for heating purposes in houses, also initiatives with heating neighbourhoods on hydrogen help in successfully increasing hydrogen production. Principals of transition management like stimulating certain (bottom up) initiatives and a focus on reflexive activities like learning and developing the right policies will help in scaling up hydrogen to be used for heating purposes in the built environment.

6.3.4 Energy storage

Another challenge as already explained before is the balancing of the supply and demand for energy. Especially when considering the fact that finite resource like gas and coal used for energy production have to be phased out. With these resources heat supply can be provided in a short amount of time by for example gas or coal fired power plants. Because renewable energy production does not match seasonal differences in demand, with for example the high peak demand for heat in winter months, energy storage is required. As explained in the section above renewable gasses are ideal for fulfilling this demand in peak moments. Another option is thermal storage. Heat cold storage tanks have already been implemented in the city of Groningen and successfully reduced heat demand for buildings, but also in combination with heat networks this technique works well. Energy storage in the forms of heat cold installations, thus provide a good example on reducing heat demand for big buildings. This technique can also be promising to implement for housing when combined with heat networks as mentioned in the statement above from respondent number three. Therefore a continuation and expansion of the policy on heat cold storage would be a wise step.

7. Conclusion & reflection

In this thesis I have studied how Groningen can achieve a transition from a heat system in the built environment based on natural gas towards sustainable heat. Climate agreements and earthquakes resulting from gas extraction in the Groningen gas field have made it clear that the way we heat our houses and buildings is not sustainable. I have looked into the challenges and opportunities that different stakeholders have to face the coming years in this transition. Therefore this study can be best seen as explorative research in which the future challenges and opportunities are researched. In the chapter before I have answered the different subquestions. In this concluding chapter I will briefly discuss the answers to the subquestions, give recommendations and answer the main research question:

“How can Groningen achieve a transition from a heat supply based on natural gas towards a sustainable heat supply for space heating in the built environment”

7.1 Conclusion

The first subquestion relates to the theory: *“What are the important concepts and theories regarding an (energy) transition?”.* In the literature study the most important theory that came forward was the transition management theory. Using the different activity levels of transition management, a transition can be understood on different scale levels. These scale levels then interact with each other and create a transition towards a system with a different set of configurations. Also the frameworks of planning oriented action is a theory that helps in determining the right approach for the heat transition. This theory explains that the heat transition needs an area-specific and integral approach. What this means is that mainly decentralised governments like municipalities and provinces have to collaborate with multiple actors and look for each area what the most promising alternatives are. Also an integral approach should be taken, in which other relevant issues are being addresses as well. A good example of this is combining renovations of housing with making houses energy neutral and providing them with an alternative to heating on natural gas. Another important concept is the Trias thermica, and also relates to the second subquestion. Trias thermica is a rather simple concept but proves to be a logical and valuable concepts. Several experts have agreed to the steps of this concept: lowering heat demand, replacing existing heat supply with sustainable heat and if not possible, use the cleanest alternative available.

This brings us to the second subquestion: “*What approach is suitable in the transition to sustainable heat for the built environment?*”. As explained above, the Trias thermica, transition management and the framework of planning oriented action are important concepts that help us to understand how to approach this heat transition. An appropriate approach for addressing this heat transition should thus contain the following elements: A multi-level governance approach with on a local level an area specific focus, collaboration with multiple actors, following Trias thermica steps and general principles of transition management. These important principles are a focus on innovation and learning activities. These principles can be implemented by for example developing an evidence based policy, in which initiatives are supported and promoted and when proven to work, these initiatives can be scaled up.

The approach for decentralised governments is structured by different documents in which decentralised governments can establish their plans. A regional energy strategy is a document in which the province of Groningen have to determine the plan for the future energy configuration based on the agreements from the climate agreement. This document is established by cooperating with important actors like municipalities and water authorities. The central government can provide support in making these plans by sharing valuable information. For municipalities it is then the task to come up with plans for sustainable heat in their area, which is established in the document: "transitie visie warmte".

This brings us to the third subquestion: *"What sources and techniques can replace the demand for natural gas?".* From the literature study several alternatives to heating on natural gas came forward: Excess heat, heat pumps, geothermal heat, biogas, biomass combustion, waste incineration, hydrogen, solar thermal, and thermal storage. Each of these alternatives have different barriers and opportunities and where input for the analysis of the potential for these alternatives in Groningen. I will not address all of these in the conclusion since the following research question sheds light on which of these sources/techniques are most applicable in our case study of the province of Groningen.

The following subquestion: "*What alternative heat sources are most applicable in Groningen?*" will evaluate the potential for all of these different heat sources/techniques. In chapter five the comparison between the different sources and techniques is made. Basically it comes down to three techniques of heat production that are most promising to use in the province of Groningen: Electrical heating, renewable gasses, and excess heat. Of course every neighbourhood per municipality have different options, but these techniques have the highest cost-benefits for the province of Groningen.

Electrical heating fits best in houses that have a high energy-efficiency, therefore making it a good solution for new buildings. In older buildings, hybrid, is often the most cost efficient solution because this does not require houses to be perfectly isolated, thereby reducing costs for home owners. This hybrid solution can also become an end solution when replacing the natural gas by renewable gasses like hydrogen and biogas. Heat networks are also a good alternative when supplying excess heat. In Groningen the supply of excess heat is mostly concentrated in the north East around the heavy industry, therefore making it harder to use in densely populated areas of Groningen, where heat networks function most cost efficient. Nevertheless Groningen can try to exploit the supply of excess heat in neighbouring towns. When these heat networks are combined with heat storage, this makes heat networks more cost efficient. Another option to exploit the benefits of heat networks more is to try and adjust supply and demand so that excess heat sources become closer to densely populated areas by for example relocating businesses that produce large volumes of excess heat.

The next subquestions to be answered is: "*What steps have already been taken for Groningen to become independent of natural gas?*. The province of Groningen is still working on developing a regional energy strategy, but already efforts have been made. For example the province has set ambitious goals with regards to making their own buildings independent from natural gas. Also in the municipality of Groningen several heat storage tanks have been realised in big buildings, thereby decreasing their gas use. Between different municipalities the efforts differ, for example in the area in Groningen where buildings were damaged by earthquakes, several houses have already been made energy neutral and plans are developed more thoroughly in regards of switching neighbourhoods of natural gas. When time comes all municipalities will have to come up with plans due to the obligation from the central government.

Several other challenges will occur in the transition to sustainable heat, therefore the last subquestion is: "*What other challenges occur when transitioning towards sustainable heat?*". First I will address the issue of costs. For home owners this is a big barrier, especially considering older houses that are not very energy efficient. With loans with favourable conditions like soft loans or loans bound to the house or building provided by the government, this barrier can be overcome. This will divide energy costs, normally only paid to the energy supply company. Also the division of costs between areas is a national challenge with no answer yet. Not only between neighbourhoods, costs differ but also between stakeholders costs differ. Where one neighbourhood is creating a heat network, another neighbourhood will have to use heat pumps, which places the costs at home owners.

The second challenge is motivating home owners and businesses. Businesses can be motivated through certain agreements that can be obliged from the central government. Also national campaigns can motivate home owners and businesses. For home owners to overcome the barrier of costs, subsidy schemes and financial solutions like loans are most effective.

The third challenge lies in upscaling renewable gasses like biogas and hydrogen. This is necessary because a hybrid approach will be most cost-efficient in existing houses and buildings due to the avoidance of high network upgrading costs. Stimulating biogas and hydrogen production is therefore necessary in order to meet demands in the future.

Probably one of the most important challenges is the balancing of supply and demand for energy. This is necessary because of several reasons: Coal and gas-fired power plants will be phased out and these power plants can deliver electricity on demand. Renewable energy production show strong seasonal and daily differences. Along with an increase in electricity demand because of electrical heating, supply and demand for electricity does not match. This requires energy storage solution to match supply with demand. Heat cold storage can play a big role in reducing demand in the winter months, and renewable gasses can also play a big role in minimizing the high demand in the winter months. Energy storage and renewable gasses will therefore play a big role in the heat transition.

Now all of the subquestions have been answered, the main question will be discussed: *"How can the province of Groningen achieve a transition from a heat supply based on natural gas towards a sustainable heat supply in the built environment?"*.

A transition in general is carried out from different activity levels, as explained in the transition management theory. A transition requires interaction between these different activity levels. Following the multi-stage transition model, the heat transition can be placed somewhere in the take-off phase of the transition. This means that already efforts on the different activity levels have been made. On a strategic level goals have been set and visions are developed regarding sustainable heat, therefore a sense of urgency is created. On the tactical level, rules policies and regulations are changing. On the operational level the focus should remain on innovation. This focus can be implemented by promoting and supporting local initiatives, where successful initiatives can be scaled up. In all these different scale levels a reflexive focus should be built in so that policies and rules in the system are constantly monitored and evaluated, and improved where needed.

In practice these different scale levels mean a multi-level governance system in which different actors play different roles. The central government has the task to set the goals for local governments, which have an important task in the heat transition to determine plans for their areas and implement them, which is a process in which participation with multiple other actors like residents is important. They follow an area specific approach in which the Trias thermica is an important guideline for planning for sustainable heat. Following the steps of this concept, first the heat demand should be lowered. This shows most results in older buildings, in which the consideration should be made by replacing or renovating them. Renovating or replacing private owned buildings is harder since the costs are very high. A solution to this problem is a different division of energy costs, in which (soft) loans or loans bound to the house replace part of the energy costs, along with subsidies provided by the central government. With housing corporations and businesses agreements could be made or restrictions are set by the national government.

When local governments in the province of Groningen are establishing their transition plans for their heat supply, they should mainly focus on implementing the following heat sources since they are most applicable here: Electrical heating, renewable gasses, excess heat and solar thermal heat. The choice between these alternatives is determined by factors like: building density, proximity to excess heat source, ability to renovate the building. Where other options are lacking, electrical heating almost always seems to be an outcome. In most cases older buildings will require some isolation measures so that thermal efficiency is increased a little before installing a heat pump. Because these buildings still consume too much electricity when heated full-electric after some isolation measures, a hybrid route should be favoured. This hybrid route is also the most cost-efficient option when considering that the electricity grid needs a lot of adjustments in order to fulfil this increased electricity demand for heat pumps. One way to deal with this increased electricity demand is to focus on balancing the net by using energy storage options, like energy storage in the form of hydrogen. For the hybrid solution renewable gasses are also the best option to deploy in order to make this hybrid solution the most sustainable. Therefore increasing the share of biogas and hydrogen is very important to make this hybrid solution work. Next to these options a thermal storage has proven to work. Every heat network could use this technique in order to reduce the heat demand, as well for big buildings. A thermal storage tank is also an solution to make a heat network feasible in small villages. This could be an outcome for the smaller settlements in Groningen that are in proximity to the supply of excess heat mainly concentrated around the northeast of Groningen.

While the heat transition is already taking off, some general challenges still remain. While the central government can increase taxation on natural gas, it still remains hard to motivate home owners to take measures. There is also the challenge of uneven distribution of costs, not only between people but also between different areas. In the coming years the system's organisation, with regards to rules and policies will need to keep adjusting to the changing circumstances of a sustainable heat system for the built environment. Some challenges are yet to come and to be resolved, but a reflexive system will help a lot in being adaptive.

7.2 Reflection on theory and the process

The following sections are a reflection on the methods and theories used in this research. Also a recommendation for further research is given, based on the challenges that came to light.

7.2.1 Reflection on theory

The theories used in this research were helpful in gaining insights into different aspects of the heat transition. The transition management theory helped in understanding how to manage a transition on different scale levels and the different phases of a transition. The theory on planning oriented gave understanding into how to approach this transition from a governance perspective while the concept of the Trias thermica gave a simple but effective approach on the implementation side of the heat transition. This concept of the Trias thermica was first mentioned by advisory company Overmorgen, but was designed for a special case study. Therefore I have adjusted this concept in order to increase the applicability of the concept. The last step of the Trias thermica was a logical step but looking back, this step could also be adjusted to a step like heat storage for example. This would have increased the relevance of the concept even more. Although it was difficult to intertwine these three theories, it has proven to be a very useful to use them as a guideline on how to approach the heat transition.

7.2.2 Reflection on research process

The methods used in this thesis, literature study, document analysis and interviews were all proven to be relevant, nevertheless could be improved. The iterative research approach I have used, was also useful because in the process other insights would make certain sections not relevant anymore or required adjustments.

The first point of improvement for the method is that the data gathering methods used, all show a minor repetition of certain data or statements, which might make this thesis less readable. Following the iterative research approach I have adjusted certain subquestions for the document and literature study during the process. Determining a well thought structure upfront for the subquestions for the literature and document analysis might have prevented repetition of certain statements. The second point of improvement is in the interview part. The process of arranging professionals for the interviews was very time consuming and the requests showed low response rates. Starting earlier on in the process with making arrangements for interviews could have improved and added more interview data from professionals. Nevertheless, arrangements were made with a few of the most important stakeholders in order to capture different perspectives.

Furthermore in the beginning of this research the research area was demarcated. During this thesis it was sometimes hard to keep this demarcation because of the relationship between a wider playing field of the energy transition. Not only the boundary between heat and electricity was hard to keep but also the boundary of the case study and the scale level of the built environment. For instance when considering renewable electricity production for the increased demand of electricity by heat pumps, or the supply of excess heat by the industry.

In the early stage of the research process I made a time table for when to carry out the different steps in this research. Later on in the process this time table was not used anymore. Along with the low response to the interview requests this caused a delay in my time table which caused that the time table was not used anymore. Therefore I found out that setting own deadlines is crucial in finishing the research earlier.

7.2.3 Recommendations further research

This study about the heat transition has a very explorative character, identifying challenges and opportunities and exploring how to overcome them. Therefore my recommendation is to further study certain challenges of the heat transition more in depth. A few aspects are interesting to study more in depth, thereby following the challenges discovered in this thesis, for example studying on how to cope with the problem of balancing costs between different areas and social groups.

Another aspect interesting to study more in depth is the availability of different heat sources and techniques in Groningen. This might be interesting to study in the form of a case study in which different alternatives are compared more in depth. But also how to create more support and motivation between citizens, thereby researching different methods and evaluating what works best.

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Appendix 1: Interview CEER: L.A. Toolsema

I: Er is een enorme opgave om woningen duurzaam te laten verwarmen, ruwweg 200.000 bestaande woningen moeten worden aangepakt t/m 2050. Met welke opties ziet u dat die warmtevraag ingevuld gaat worden? / Hoe ziet u dat gebeuren?

R: Je hebt natuurlijk verschillende opties, ik ben er net toevallig mee bezig. De ene woning is al geisoleerd maar andere huizen hebben nog heel weinig maatregelen getroffen. Dus dat is een beetje de zoektocht waar je mee te maken hebt. Waar ik zelf net naar zat te kijken is de keuze tussen hybride warmtepomp of full-electric systeem. Dus bij de hybride heb je nog een cv ketel nodig. Die warmtepomp neemt het voor een groot deel over, op warmere dagen doet de warmtepomp het werk maar koudere dagen neemt de cv ketel het over. Maar dan kun je 90% van de warmtevraag met die warmtepomp doen.

I: Zie je hybride warmtepompen daarom ook vaker in bestaande woningen?

R: Precies dat is het punt inderdaad want als je een bestaande woning hebt die al een beetje is geisoleerd maar niet zoals het vandaag gebeurd. Dan is die full electric pas een optie als je het eerst verder isoleert, wat natuurlijk veel geld kost. En die full electric pomp is duurder, een hele investering die je moet doen. Dan is het veel meer haalbaar om zon hybride systeem aan te schaffen. Aan de andere kant als je een heel oud huis hebt. Dat zie je vaak bij woningbouwverenigingen gebeuren. Als er dan toch al isolatiemaatregelen nodig zijn dan kan je zeggen, dan doe je het in een keer goed.

I: Dus dat is dan vervangen van de huizen of helemaal aanpakken?

R: Ja dan zou je hem dus helemaal aan moeten pakken want dat huis heeft dan een zodanig slechte isolatie. Als je isolatie slecht is, kan je zon full electric warmtepomp niet doen. Want zon warmtepomp trekt het dan niet op de hele koude dagen. Dat werkt alleen als je huis heel goed geisoleerd is. Dus laten we zeggen bij nieuwe woningen, kan je dat doen. Maar bij huizen die ouder zijn en helemaal niet goed geisoleerd zijn kan je dat niet doen. In zon geval kan je ook voor hybride gaan. Maar dan kan je ook zeggen dan ga je alsnog isoleren. En als je dan toch bezig bent kan je ook zeggen we doen het in een keer goed en dan gaan we voor full electric, dat is wat je ook bij woningverenigingen ziet, bij van die rijtjeshuizen waar nodig iets moet gebeuren, dat ze dan soms gelijk naar 'nul op de meter gaan'. Dus echt zon schil om het huis heen. Dus dat huis wordt echt groter aan de buitenkant. Dus dan is dat huis zo goed geisoleerd dan kan je het ook met zon full electric systeem doen. Dan heb je voor de individuele woningen wat ook nog kan, is zon warmtenet.

I: Dat was ook mijn volgende punt, in wat voor situaties kan je dat goed inzetten?

R: Dat is vooral op plekken waar het al is, daar kun je het ook uitbreiden. Maar je legt zoiets niet zo gemakkelijk aan. Dat heeft met wet en regelgeving te maken, dat heeft ook te maken met de kosten voor het aanleggen. Maar ook naar consumenten toe, er is regelgeving over dat mensen niet meer kwijt mogen zijn als ze op een warmtenet zijn aangesloten als dat ze een cv zouden hebben. Maar dat is gewoon heel moeilijk te zien voor consumenten zelf. Want dan kan je wel zeggen dat ik meer betaal als dat ik op gas zou doen, dat kan je wel zeggen maar je hebt dan ook geen cv ketel meer.

I: Ja precies dus die kosten kan je wegstrepen.

R: Precies, maar dat geeft consumenten het gevoel dat ze heel duur uit zijn. Als het goed is, zijn ze niet duurder uit maar zo voelt het wel. In die zin is het dus, dat op plekken waar het al is je het kunt handhaven. Die snappen het ook niet helemaal maar daar is het al.

I: Is daar dan iets meer draagvlak?

R: Ja, dat denk ik. Maar op plekken waar je het in wilt voeren is dat heel moeilijk. Want je kan niet langs de deuren gaat om te vragen wil je het wel of niet. Op sommige plekken zou het dus kunnen, waar je restwarmte van industrie hebt of datacenters.

I: Ik hoorde dat ze ook datacenters wouden gebruiken ter vervangen van het warmtenet die eerst op geothermie zou draaien.

R: Dat weet ik zo niet, ik kwam gister wel een stukje tegen over een cathedraal in Haarlem. Daar hadden ze een verwarmingsprobleem en hadden ze een prijsvraag voor uitgeschreven over hoe dit groen verwarmt kan worden. En de winnaar van die prijsvraag was een architect die in de crypte van die kerk *om daar een datacenter neer te zetten. Het idee is er is verwarmingsvraag en op een andere plek heb je warmte over. Ik weet dat ze in amsterdam die warmte van die datacenters willen gebruiken in een warmtenet, en dat kun je natuurlijk overwegen op meer plaatsen. De week hiervoor was ik bij Groningen Seaport. En daar staat een enorm datacenter van Google. En daar zitten ze nu te overwegen of dit verplaatst kan worden naar de stad.*

I: Omdat het nu een probleem is dat er zon grote afstand tussen zit?

R: Precies dat is het dus. Als je vlakbij industrie of zon datacenter zit, dan zijn er zeker mogelijkheden. Op het moment dat die afstand groter is dan wordt het lastiger, maar het schijnt dat dit datacenter zo groot is en zoveel warmte produceerd dat het uit kan. Ik kom zelf ook uit de regio en dan denk ik, er zijn ook wat dorpjes misschien moet je die dan eerst pakken.

I: ja precies, maar dat is ook een dingetje. Want dorpjes hebben een kleine dichtheid, en is het dan wel mogelijk om zoiets daar te voorzien, gezien de investeringskosten ook?

R: Ja dat is inderdaad de grote vraag denk ik, en dat zie je ook in amsterdam bijvoorbeeld en ook in meer regios ook, in plaatsen waar het dicht op elkaar zit en waar je de combinatie hebt van waar je warmte over hebt, dus industrie zegmaar, en ergens waar je veel warmtevraag hebt, zoals kassen of woningen en dan inderdaad het liefst dat ze dicht op elkaar zitten. Aan de andere kant moet je het ook kunnen aanleggen. Zoals in de amsterdamse binnenstad is dat ook wat lastiger, waar monumentale panden zitten. Dus dat zijn allemaal afwegingen, waardoor je eigenlijk overal met maatwerk te maken hebt. Wat in amsterdam werkt, werkt in Groningen niet, het is allemaal maatwerk.

I: Ja dus er moet echt gewoon overal per wijk bezig gekeken worden.

R: Vaak met isolatie kan je al een heel eind komen. Maar het verschilt ook nog weer of het koopwoningen zijn of van een woningstichting. Die kunnen dat als groot project beschouwen en besluiten dat ze overgaan, en dan heb je daar als bewoner maar mee te doen. Dat schijnen ze ook steeds sneller te doen. Het kan zelfs in 1 dag, zon schil erom heen maken wat je bij rijtjeshuizen ook ziet.

I: In een dag? Dat is erg snel. Maar dat was inderdaad ook mijn volgende punt. Ongeveer 55 % van de woningen zijn koopwoningen. Op dit moment maakt die aanpak het meeste vaart via woningstichtingen en dergelijke met deals die er gemaakt worden, hun hebben natuurlijk ook veel meer vermogen als particulieren. Bij koopwoningen komen alle kosten terecht bij particulieren. Hoe denkt u daarover?

R: ja, daar zijn ze ook bezig met onderzoeken of fincanciele oplossingen zijn. Bijvoorbeeld of je de hypotheek kunt koppelen, als je zon systeem installeerd aan het huis in plaats van de bewoner. Dus als ik in mijn woningn zon full electric pomp zou installeren en ik sluit daar een hypotheek voor aan.

Dat die dan gekoppeld is aan het huis en als ik het huis verkoop dan gekoppeld is aan de bewoner. Zodat als ik verhuis niet nog jaren blijf betalen voor zon hypotheek. Dat degene die dan profiteerd van die maatregel, dat die dan daarvoor betaald. Linksom of rechtsom reflecteerd het natuurlijk wel in de woningprijs want iemand die mijn huis wil kopen en die krijgt er zon hypotheek bij dan is dat wel een ander bedrag dan wat hij ervoor wil geven als hij het niet krijgt. Maar aan de andere kant is die maatregel wel al genomen en deels al afgeschreven. En het is heel moeilijk om te overzien hoe dat financieel zit maar het is goed om over die maatregel na te denken. Je moet toch zien om die huiseigenaren te stimuleren om die maatregelen te treffen, en dat wordt natuurlijk ook al met subsidie gedaan, voor verschillende systemen.

I: Ja, dat is dus echt op het systeem zelf?

R: Ja dus als je een warmtepomp of een zonnepaneel of iets dergelijks, daar zijn allemaal subsidies waar je beroep op kan doen. Dus dat helpt wel een beetje, daar wordt het goedkoper van, maar het zijn nog wel grote stappen.

I: ik zat zelf gister ook te zoeken naar subsidies. Een SDE+ regeling bijvoorbeeld geeft korting op duurzame systemen. Maar voor het isoleren bijvoorbeeld daar vond ik niets voor, behalve leningen die gunstig geregeld zijn.

R: Ja precies ik weet niet of je ook al de kosten hebt gevonden, ik heb iets gevonden, een overzichtje van de kosten. Maar de kosten van verschillende maatregelen voor isoleren, je hebt vloer, spouwmuur, dak. Maar dus ook voor de pomp, maar ook voor zonnepanelen en zonneboiler, dus overal geven ze de kosten van aan met eventueel subsidie. Het is natuurlijk fijn als je 2.000 subsidie kan krijgen maar als het ding 17.000 euro kost is het nog steeds een grote hap. Dus dat moet je allemaal maar kunnen ophoesten en dat kan natuurlijk niet iedereen. Dus waarschijnlijk moet je toch heel veel doen met bewustwording, en subsidies ook. Dus ja dat kost veel tijd en niet iedereen is daar enthousiast mee bezig. Ik denk dat veel mensen in de provincie Groningen er wel de nut en noodzaak van inzien.

I: Ja vandaar dat dit onderwerp mijn interesse wekte omdat de noodzaak hier zo hoog is om iets te doen.

R: Ja klopt. Maar of dat nou echt, hoe moet je dat zeggen, in nieuwbouw gaat het iets makkelijker. Een nul op de meter woning is natuurlijk iets duurder dan een gewone woning maar op het moment dat je dat zoekt ben je daar natuurlijk al mee bezig. En als je het huis later gaat verkopen heeft dat ook een meerwaarde. Dus het verdient zich tot op een zekere hoogte ook nog weer terug. Dus dan maak je misschien een keuze wat makkelijker dan dat als je in een bestaande woning zit. Dan denk je na over iets te doen en dan vraag je je af hoeveel het dan opleverd. De kosten hebben ze ook wel een overzicht van wat je dan bespaart per jaar. Maarja dat is ten opzichte van een huis tov een huis die die maatregel helemaal niet heeft. Dusja als je bij zon huis een maatregel treft dan is het dat sws wel waard. Dat is dan de moeite wel waard, in een jaar of 7 verdien je dat wel terug. Dus als er dan wel iets op je bankrekening staat, dan kan je dat dus wel overwegen. Maar als je dus een huis hebt waar al wel iets aan gebeurt is maar het nog niet helemaal optimaal is, dan moet je een boel kosten maken om het iets te verbeteren. Dus dat is een beetje lastig. Het staat hier nog op het bord denk ik. Hier staan de kosten die je maakt voor isolatie, en op de andere as staat het verbruik. Wat je ziet is dat die lijn steeds vlakker gaat lopen dus op een gegeven moment moet je heel veel kosten maken wil je een beetje besparen. En dat is een moeilijke afweging. Dus op het moment dat ik niks uitgeef dan zit ik heel hoog, dan is het de moeite waard op te investeren. Dan is die terugverdientijd ook laag. Maar op het moment dat ik al wat gedaan heb of ik heb een nieuwere woning, en ik zit al op dit punt dan moet je heel veel investeren voor nog een kleine verbetering. Dus dat is weinig aantrekkelijk denk ik.

I: Dus daarom is het ook belangrijk dat er eerst wordt gefocused op de oudere huizen misschien?

R: Ja dat is ook wat je ziet bij woningcorporaties, dat ze daar gaan beginnen. Ook voor huiseigenaren is het zo dat als je een heel oud huis het die veel toch en koud is dan is het nog de moeite waar om er een keer 30.000 euro tegenaan te gooien, als je dat ergens vandaan kunt halen. Maar op het moment dat je zoals ik bijvoorbeeld in een huis woont uit 1980 waar al wel spouwmuur- en vloerisolatie zit, ja het kan wel beter maarja, hmmm. En dan krijg je weer dat punt van die verschillende pompen, misschien dat dan voor mij die hybride pomp interessant kan zijn omdat je dan met een kleine investering dan toch misschien 90% van mijn gasvraag kan vervangen door electra.

I: die zijn natuurlijk een stuk goedkoper dan full electric.

R: Ja precies, maar op het moment dat je in een heel oude woning woont waarbij je toch maatregelen moet treffen, en ook gewoon voor je eigen wooncomfort is dat, ja dan wil je het misschien meteen goed doen, maarja dat is wel een investering. En dan krijg je natuurlijk nog dat punt van dat rapport he, kunnen we allemaal doodleuk op elektriciteit overstappen. Als dit klopt. Als die scenarios met realistische cijfers zijn berekend dan heb je alsnog gas nodig.

I: Ja wat dat was inderdaad ook een puntje. Want met concepten als nul op de meter woningen, want daar wordt aan de ene kant hun jaarverbruik met zonnepanelen opgewekt, maar aan de andere kant wekken die dingen in de winter nauwelijks wat op, ja dan zit je inderdaad met een blijvende gasvraag. In het artikel werd gesteld dat dan de gascentrales moesten blijven draaien om die gasvraag te voorzien. Mijn vraag is dan, kan dat niet worden aangepakt met wind en zonneparken of is er dan nog steeds niet genoeg voor in de winter.

R: Ja dat kan, er zijn 2 dingen denk ik. In die scenarios hier is uitgegaan, van realistische cijfers. Tenminste we hebben verschillende scenarios. Je hebt eigenlijk twee extremen. Het fossil-fuel scenario is het sombere scenario, waarbij de elektrificatie eigenlijk niet doorkomt en full-electic is natuurlijk wel heel optimistisch. Die andere zit er tussenin. Maargoed je kunt die twee zien als extremen, waarschijnlijk zullen we ergens daartussen uitkomen, het vervelende is dat je in beide gevallen nog gas nodig bent. Dus het moet wel heel optimistisch gaan wil je dat niet nodig hebben. Dus we gaan ook uit hoeveel zon en wind je nodig zou hebben. Nou dat is gebaseerd op waar de politiek op inzet. Dat kan natuurlijk veranderen als de politiek zegt we gaan 3x zoveel doen. Het doel van het rapport is eigenlijk te laten zien dat op de lijn waar we nu op zitten, dan komen we niet uit op dat we in 2050 geen gas meer nodig hebben. En als we dus veel meer wind en zon gaan doen dan zijn we minder gas nodig maar dan moet er dus nog wel een stap genomen worden met betrekking tot de politieke keuzes. Je blijft wel een beetje dat probleem houden van die pieken. Want inderdaad op een dag met weinig zon en wind dan wek je gewoon weinig op. Dus hoe ga je dat dan opvangen. En dat is in nederland de moeilijkheid. Als we toevallig nog ergens bergen en snelle rivieren hadden is dat ook nog een optie, dat gaat wel door. Maar dat probleem hebben we hier een beetje. Dat als die zon en wind er niet is, wat ga je dan doen.

I: Ik heb vorig jaar een keer een lecture gehad waarin ook gezegd werd dat dat heel moeilijk gaat worden om allemaal met zon en wind in te vullen omdat het gewoon heel veel ruimte kost. Ook hoorde ik iets van dat ze in de Eemshaven vanuit Nuon ook een van de gascentrales, die willen ze laten gaan draaien op waterstof.

R: Maar waar komt die elektriciteit dan vandaan? Het lastige is dat, kijk deze studie is ook een onderdeel van een grotere studie die is uitgevoerd in meer landen, zoals Duitsland en Frankrijk, en ook daar kan je niet zomaar van het gas af. Dus vanuit daar kan je het ook niet importeren zegmaar. En ja misschien vanuit Scandinavie, durf ik zo niet te zeggen hoe je dan uitkomt qua hoeveelheden. Maar het wordt vaak genoemd als oplossing, ook voor woningen om het gas te vervangen voor waterstof.

I: Ja inderdaad of met biogas bijvoorbeeld.

R: Ja maar dat is dus een probleem want dat waterstof moet gemaakt worden met elektriciteit. Maar het hele idee van die studie is eigenlijk dat we meer elektriciteit nodig hebben en daar kunnen we eigenlijk niet aan werken. Dus dan moet je weer gas inzetten om die elektriciteit te maken. En je gaat dan natuurlijk niet gas inzetten om elektriciteit te maken en dan met die elektriciteit waterstof te maken en dat in het net te spuiten.

I: Dat zou dan inderdaad heel onefficient zijn.

R: Ja dat klopt, dan ben je al de helft kwijt geloof ik tegen de tijd dat je het bij de huizen hebt. Dus het is heel leuk om te zeggen dat het technisch mogelijk is maar het moet dus wel ergens vandaan komen. En hier geven we al aan dat die elektriciteitsvraag zo omhoog gaat dat het nodig is om elektriciteit te produceren dat die gascentrales in werking blijven. Dus ik denk dan, dat is mijn persoonlijke interpretatie, dat je inderdaad moet zien of je nog meer zonne- en windenergie kunt doen op een of andere manier en dan inderdaad biogas nog meer, maar dat schijnt ook beperkt te zijn. Maar waar je wel misschien naar toe kunt gaan is dat je in wat woningen betreft om zoveel mogelijk probeer om op elektriciteit over te gaan, met name bijvoorbeeld in de dichtbevolkte gebieden kan je misschien zo'n warmtenet gaan gebruiken. En dan in de dorpen zegmaar, en op het platteland dan zon hybride systeem waar je dus nog wel gas bij nodig hebt, maar wel veel minder en dat zou dan misschien biogas kunnen zijn.

I: Oke, en dat is ook bijvoorbeeld iets voor binnensteden in Groningen, waar heel veel monumentale panden zijn.

R: Ja precies, dat is ook wat ik over Amsterdam zei, zoveel mogelijk elektrisch doen waar dat kan. En waar het dan niet kan, in ieder geval hybride doet zodat je toch die gasvraag behoorlijk terugdringt. Als je 90% minder hebt dat scheelt nogal, en dan kun je misschien ook genoeg biogas produceren om die restvraag daaraan te voldoen. Dus dat zou misschien een werkbare oplossing zijn.

I: In hoeverre is het dan mogelijk om volledig onafhankelijk van aardgas te worden?

R: Ja dat is dus wat ik net zei, op sommige plekken wordt dat heel moeilijk. En het kan allemaal wel maar het kost zoveel, technisch kan het wel. De moeilijkheid zit hem dus in dat als mensen dat zelf moeten gaan betalen, maar heel veel mensen hebben daar het geld gewoon niet voor.

I: het is dus een probleem met die piekvraag, maar andere opties daarvoor zijn misschien opslag, warmte-koude opslag zien we nu veel in de stad. En misschien opslag van elektrisch.

R: In dat rapport zit ook iets van opslag en je ziet dat dat gewoon heel moeilijk is

I: Ja, en misschien heel duur ook?

R: Ja maar heel weinig ook. Want in deze scenarios zie je ook dat je bijna geen overschot hebt, alleen op hele goeie dagen met veel wind en zon, dus dat kan je opslaan. Maar dat is maar heel beperkt. Volgens deze scenarios lost dat het dus niet op. Maar als je het kan uitbreiden op een een of andere manier. En misschien als er in de toekomst meer zon en windenergie komt dat je daar iets mee komt maar het is nu gewoon heel weinig. Dus dat maakt niet zon heel grote vaart volgens onze berekeningen.

R: En waar ik net nog even aan moest denken is dat ze ook energie opwekken met golven. En kijk dat is natuurlijk wel iets wat de hele tijd doorgaat. Ik kan me voorstellen dat dat iets vrij stabiel iets. Maar het voordeel van een gascentrale is dat je die kan aanzetten wanneer er een piekvraag is.

I: Wat er ook gebeurd is dat de gasprijs voor consumenten duurder wordt. Want dat is ook een middeltje hoe we consumenten maar ook bedrijven kunnen stimuleren om van gas af te stappen.

R: het zijn allemaal financiele prikkels in feite. De dingen die je niet wilt maak je duurder en wat je wel wilt maak je goedkoper met subsidies. Als je wilt dat huiseigenaren iets gaan doen, dan is dat waarschijnlijk wel de manier. Er zijn 2 dingen denk ik, financiele prikkels en bewustwording wat je kunt aanvliegen. Ik was laatst op een beurs voor duurzame energie en energie besparen en dan kreeg je een gratis advies hoe je energie kan besparen voor jou huis. Ja dus dat soort dingen aanbieden kan ook helpen. Dat mensen die wel willen maar niet zo goed weten hoe het moet aangemoedigd worden. Kijk want je kan wel zeggen, je gaat morgen van het gas af maar dat is toch vrij moeilijk denk ik.

I: In die zin speelt de overheid dus wel een grote rol dat ze dus in die zin de grootste winst kunnen boeken.

R: Ja dat denk ik ook inderdaad, met die financiele prikkels.

I: je ziet ook dat in warmtenetwerken als bron, grootschalig warmtepompen worden ingezet, ik had daarover gelezen dat Groningen die wou kijken of het mogelijk was in buurten buurtcentrales neer te zetten, dat er per wijk gekeken worden wat de beste optie is. Dat je dan een centralen in de wijk hebt waar energie wordt opgewekt, verdeeld en opgeslagen. Is dat een optie ook voor de kleinere dorpen.

R: Dat klinkt bijna als een soort mini warmtenet. Daar kan ik me wel wat bij voorstellen want ten eerste klinkt het efficient omdat je ipv 100 warmtepompen gewoon 1 grote er neerzet. Ik kan me ook voorstellen dat dingen wat bij woningen niet altijd mogelijk is zoals iets met bodemwarmte is waarbij de bodem opgegooid moet worden maar daarnaast ligt een parkje waar wel mogelijkheden zijn, ja daar kan ik me wel wat bij voorstellen. En dan moeten er duidelijke afspraken over kosten komen. Maar ik kan me goed voorstellen dat dat in dorpen kan gaan werken. In steden kan je misschien beter, zeker als er zon datacenter in de buurt zit, met warmtenetwerken gaan. In dorpen is dat misschien wat lastiger maar aan de andere kant is daar wel de ruimte om die leidingen neer te leggen.

I: Is dat dan lastiger met het oog op investeringskosten of omdat het niet praktisch is.

R: Ik zou zeggen dat de coordinatie lastig is omdat op het moment dat iemand in die wijk al iets geinstalleerd heeft dan kan hij zeggen van ik doe niet mee hoor, ik heb al een. En dan moet je kijken nemen, we die straat dan wel mee of niet, want daar staan huizen verder uit elkaar, dus dan moeten die wat meer meebetalen. Maar ik kan me wel voorstellen dat dat haalbaarder is en dat je zo meer mensen mee kan krijgen. En ik stel me voor dat het in verhouding goedkoper kan zijn. En op het moment dat zoiets wordt ingezet vanuit de gemeente dan wordt je echt voor die keuze gesteld of je mee wil doen of niet, dan hoef je er zelf niets aan te doen. Dan wordt het voor je geregeld. Ik denk dat dat ook iets is waardoor mensen over de streep getrokken kunnen worden omdat je ze dan bij de hand neemt, en ook de financiele voordelen. Maar aan de andere kant hou je ook het probleem dat mensen in zon straat zeggen dat ze het niet kunnen betalen. Dus ik denk niet dat er een kant en klare oplossing is. Het is overal maatwerk.

I: Hartelijk dank voor het interview, wou u nog wat toevoegen, denkt u dat ik iets nog niet gevraagd heb?

R: Ik denk dat waar we het nog niet over hebben gehad is dat het ook belangrijk is om in te zetten op omscholing. Bijvoorbeeld bij installatiebedrijven om zo duurzame maatregelen te stimuleren en ook mensen hiervoor te blijven opleiden.

Appendix 2: Interview Kloosterman biogas: Johan Kloosterman

I: Biogas kan grote rol spelen in de overgang naar duurzaam verwarmen bij gebouwen en huizen. Maar het is niet eenvoudig om zoiets op te starten. De grootste barrieres zijn de kosten. Vooral voor kleinere en minder efficiente biogas producenten is het lastig om subsidie te krijgen. Daarnaast heb ik gelezen dat er in de loop van de jaren niet echt een stabiel support schema is vanuit de overheid.

I: Kunt u mij vertellen wat er nodig is om een biogas installatie rendabel te laten werken? Op hoeveel ha land produceren jullie ongeveer, waarvan restromen naar de installatie gaan?

R: Biogas heeft een kostprijs die meer dan 30 cent boven aardgas ligt dus zonder subsidie is het sowieso niet haalbaar om te maken. Zonnepanelen zijn tegenwoordig al bijna te bekostigen zonder subsidie maar biogas zeker niet, tenzij de prijs van een kuub gas zo hoog, ergens boven een euro. Er zijn ook heel veel biovergisters in Nederland die het niet gehaald hebben. Ik denk dat het rendement hoofdzakelijk komt door de bedrijven die zo'n installatie hebben. Het moet een continu iets zijn en niet een bijzaak voor een veeboer die het al druk heeft met zijn varkens en koeien. Het moet een core-business zijn.

I: Dus het is niet mogelijk voor kleinere bedrijven om biogas rendabel te produceren?

R: Nee, dan in combinatie dat ze hun mest gezamenlijk door een vergister laten lopen en dan daar iemand op zetten. Maar het moet een core-business zijn. Het is een 24-uurs bedrijf en dan kan je savonds niet om 5 uur weggaan en de deur dicht doen. Wij kunnen hier al jaren rendabel draaien, maar dat heeft te maken met dat je een familiebedrijf hebt waarbij de extra uren niet zo duur zijn dat als je mensen in moet huren. Maar anders is het een vrij grote opgave.

I: En het lijkt me dan om in aanmerking te komen voor alle vergunningen en subsidies dat dat ook niet makkelijk is. Hoeveel jaren heeft het bijvoorbeeld geduurd om dit op te starten?

R: Bij ons niet zoveel. Het was voor de gemeente een uitdaging en de wet en regelgeving was er niet. Dus wij hebben hun uitgenodigd om mee te gaan over de grens naar Duitsland om hun te laten zien wat het inhoud om een biovergister te bedrijven. En dan hebben wij nog een specifieke vergister waar wij geen mest in doen. Een gelijkwaardige vergister staat ook bij de Suikerunie. Het ministerie van Landbouw heeft ons 4 jaar lang onder een gedoogvergunning geacteerd. Puur voor het gene dat wij wouden nog geen wet en regelgeving was. Maar dat ligt nu allemaal vast. Maar 99% van de vergisters in Nederland zijn mestvergisters en daar moet minimaal 50% mest in zitten. Als er dan bijvoorbeeld mond en klauwziekte heerst dan heb je een probleem met je invoer voor je vergister en dan ligt je productie stil. Het zijn dus vrij riskante dingen. Maar wij hadden in die tijd heel veel grond dat braaklag en toen besloten wij daar mais op te gaan telen dus vandaar dat wij een plantaardige vergister kozen. Wij moesten 10% van de grond braak laten liggen, dan kreeg je een vergoeding, maar daar mochten wij wel energiemais op telen. Vandaar dat het zo ontstaan is.

I: Ik las dat jullie voor ca 3.000 huishoudens aan groen gas produceren.

R: Ja dat doen we nu, vroeger produceerden we elektriciteit toen je nog een MEP regeling had, dat is nu SDE. Met die MEP regeling hebben wij binnen 10 jaar onze installatie kunnen aflossen. En die was toen niet op, dus toen hebben we verlengingssubsidie aangevraagd. Maar niet weer voor elektriciteit maar voor groen gas. Dat komt omdat Attero bij ons kwam die wouden graag dat we groen gas gingen leveren. Dus toen is er een biogas verzamelleiding aangelegd, die is gefinancierd door Brussel. Toen was er een leverancier dus nodig. Die MEP regeling was afgelopen dus toen dachten we dan kunnen we het gas van die motoren ook naar die leidingen doen. Dus wij vervoeren nu al het biogas naar Wijster waar het wordt opgewekt tot aardgaskwaliteit. Dus wij hebben nu een pelletkachel die de silo verwarmt. Want we hebben geen warmte meer van de motoren die elektriciteit op wekten.

I: Hoeveel ruimtebeslag is er ongeveer nodig om zoveel biogas te produceren als jullie doen?

R: Wij kopen de biomassa grotendeels in. Je moet ongeveer rekenen dat wij zo'n 30-35% van de biomassa kunnen voorzien en de rest komt van buitenaf. Maar dat kan ook de buurman zijn. Maar in een cirkel van rond de 50 kilometer ongeveer.

I: Er zijn meerdere manier om biogas in te zetten. Door het te injecteren in het aardgasnet of bijvoorbeeld om het te gebruiken voor WKK's die elektriciteit en warmte produceren, zoals bij elektriciteitscentrales en industriele processen. Wat ziet u als beste manier om de biogas in te zetten?

R: Ik denk wel dat het omzetten in aardgas efficienter is dan inzetten dan elektriciteit maken. Omdat met een WKK die elektriciteit maakt, omdat 40% van de kracht die eruit komt elektriciteit is. Dus als je de warmte ook efficient kan benutten door verwarmen van bijvoorbeeld stadsverwarming. Maar zomers draaien die machines ook en dan heb je warmte waar je niks mee kunt. Dus in de winter heb je dan een hoog rendement als je die warmte kunt benutten. Maar in de meeste gevallen is die warmte niet altijd te benutten. En dan zeg ik maak er dan aardgas van. Maar dan denk ik dat je van biogas een netto rendement overhoud van maximaal 80% en als je elektriciteit opwekt is dat maximaal 40%, zonder de warmte te benutten. Maar als je de warmte kunt benutten zal het niet zoveel uitmaken, maar in de zomer zit je dus met het probleem dat je de warmte niet goed kwijt kunt. Laatst was ik in Noord-Duitsland waar ze ook biogas produceren. Daar schakelen ze van het net af, de elektriciteit en warmte wordt bij een overschot dan gevoed naar een warmtenetwerk, met overschot elektriciteit worden warmtepompen aangezet. Maar als het dorp dan ook geen warmte afneemt dan hebben ze nog een alternatief, dat ze warmte leiden naar een grote droger die hout droogt. Dus als je dat nou allemaal kunt combineren… Het ligt er dus aan hoe je vooral aan hoe je de restwarmte en overschotten gaat benutten.

I: Denkt u dat het mogelijk is om voor Groningen de aardgasvraag voor woningen en gebouwen te vervangen door biogas?

R: Dat weet ik niet. Maar als je de industrie en dergelijke erbij rekent, ja… Nee dat is niet te vervangen door biogas. Industrien moeten een alternatief hebben voor aardgas, maar in mijn ogen zal het jaren en jaren duren voordat we van aardgas af zijn als het niet meer van Slochteren komt. Dan komt het nog wel ergens uit Rusland, het systeem ligt er. Waterstof is naar mijn mening ook een energiedrager voor de toekomst.

I: Hoe ziet u de rol van biogas in de toekomst. Denkt u dat het nog een hele grote rol gaat krijgen in de toekomst bij het verwarmen van huizen? Dat er meer geproduceerd gaat worden en meer ingezet gaat worden.

R: Ik denk in het kleine landje dat wij hebben., kijk als je in een land als Australië met heel veel grond en weinig mensen, dan kun je daar natuurlijk makkelijker een paar hectare land afhalen om je biomassa te telen. Dan heb je afvalproducten voldoende. Je kan ook niet van alles gas maken, dat geeft dan weer zoveel onderhoud aan je installaties dat het per saldo niks levert. Maar om terug te komen op je vraag. Je ziet het zelf aan de SDE's die aangevraagd worden, dat worden minimaal zulke installaties als wij hebben, en groter. Maar dat zijn er maar een klein aantal. Dus ik denk groen gas is een mogelijkheid, een van de mogelijkheden. Het zal in mijn ogen nooit de grootste worden, dat zie je nu ook wel in de aanvragen. Iedereen wil panelen, wij installeren nu ook al 15mw in zijn totaliteit. Dat is eenvoudig neer te zetten met weinig onderhoud. Dus daar zie ik meer in. Alleen dat kost ook grond. Dus omdat wij biogas leveren en niet meer via die weg elektriciteit opwekken leggen wij nu panelen om ons in de energiebehoefte te voorzien. Maar biogas, we hebben nu zon 100 bedrijven in Nederland, daar zullen nog zon 50 bijkomen, 50 groten. Maar dan stelt het eigenlijk nog niet zoveel voor. Als het dan onze grote zijn, dan komt daar nog 50 x 8 miljoen kuub groen gas erbij. Nou dan praat je alsnog over een druppel op een gloeiende plaat.

I: Hoe kan de biogasproductie in Nederland gestimuleerd worden?

R: Ik denk dat biogas is nu denk ik zon jaar of 12 gaande in Nederland. Misschien wel langer, de meeste waterschappen maakten al langer zonder subsidie biogas wat ze zelf verwerkten. Maar biogas, ik zie niet zo verschrikkelijk veel mogelijkheden want ja, iedereen zit aan die reststoffen te trekken. En het heeft een hoge kostprijs. Dus je kan er allemaal wel dure producten instoppen maar als het aan het eind van het ritje er niets meer aan verdiend wordt dan is er ook geen onderneming meer die daarin investeert. Dus ik denk zelf dat we die grens wel zon beetje bereikt hebben.

I: Dus om het te stimuleren, zou het met subsidies kunnen om nog verder die kostprijs te drukken?

R: Ik ben een beetje bang dat we een punt bereiken dat de gemeenschap niet zon prijs wil betalen. En dat heeft volgens mij alleen maar te maken dat mensen te snel willen. Ze hebben nu een x gezegd slochteren gaat dicht op korte termijn. Dat is een gigantische ingreep voor Nederland en de staatskas. En dat moet allemaal wel weer doorgegaan, en stimulerende subsidie, zonder subsidie had ik dit niet gehad. Dus ja je moet ze ook blijvend helpen, met biogas vooral, wind en zon zitten op het punt dat het bijna zonder subsidie kan. Alleen die infrastructuur moet er wel aangelegd worden. Alleen daarbij zit je al vrij gauw bij een dekkende kostprijs, bij biogas niet. Ik zie alleen maar biogas prijzen oplopen, doordat er al heel veel aan die markt zitten te trekken. Vroeger kreeg je misschien geld toe om een ander bedrijf van dat afval af te helpen, en tegenwoordig worden voor de slechtste producten geld betaald. Dus doordat reststromen steeds beter benut worden wordt de kostprijs van het eindproduct steeds hoger. Dus dat zie je ook bij de biovergisting die prijzen zie je niet naar beneden gaan, omdat de kostprijs oploopt. Dus ik zie biogas niet dermate uitbreiden dat het echt een oplossing is. Je ziet gewoon in de praktijk dat het zo is. Er komt heel weinig uitbreiding in de biogas. Ook worden de gronden steeds duurder, en ook de gewassen. Dus ik denk niet dat Nederland daar een geschikt land voor is.

Appendix 3: Interview municipality Loppersum

1: Wat is de rol/aanpak van de gemeente in het verduurzamen van woningen en gebouwen?

Die rol is best wel groot. De gemeente kan bijdragen in de totstandkoming van infrastructurele aanpassingen die verduurzaming faciliteren. De aanleg van een warmtenet is daar een goed voorbeeld van. Dit is een collectieve voorziening die er zonder twijfel alleen maar komt als de gemeente een trekkersrol vervult.

Verder vindt de gemeente het belangrijk om energiecoöperaties en andere inwonersinitiatieven zoals Buurkracht te faciliteren. Deze organisaties spelen een belangrijke rol als het gaat om voorlichting, bewustwording en draagvlak.

2: Hoe kan de gemeente er voor zorgen huiseigenaren te motiveren om te verduurzamen?

Door bovengenoemde burgerinitiatieven te faciliteren. Energietransitie is moeilijk top-down te realiseren. Tegelijkertijd kan de gemeente er voor zorgen dat haar inwoners interessante mogelijkheden krijgen om hun woning te verduurzamen. Mogelijkheden die zó aantrekkelijk zijn dan inwoners worden verleid om er gebruik van te maken. Te denken valt aan duurzaamheidsleningen, subsidies of andere stimuleringsmaatregelen.

3: Welke alternatieven voor aardgas hebben de meeste potentie in de gemeente Loppersum? Is het bijvoorbeeld haalbaar om een warmtenet aan te leggen?

Een warmtenet wordt als een kansrijkste alternatieven gezien. Er ligt al een plan voor Loppersum Noord waar dit jaar mee gestart gaat worden. Door het warmtenet te combineren met warmte (seizoens)opslag en duurzame opwekking van warmte (langere termijn visie) ontstaat het duurzaamst denkbare warmtenet.

4: Zijn deze alternatieven ook betaalbaar voor mensen die niet veel te besteden hebben?

Ja, een warmtenet oplossing is veelal goedkoper dan alternatieven zoals een warmtepomp. Het vergt geen dure installaties in of om het huis.

5. Hoe wordt de renovatieopgave als gevolg van aardbevingsschade gekoppeld aan de verduurzamingsopgave?

Het voordeel van een warmtenet is dat huizen die nog niet zijn versterkt en/of verduurzaamd toch aardgasvrij gemaakt kunnen worden. Het aardgas vrij maken wordt dus juist losgekoppeld van versterking en verduurzaming. Activiteiten kunnen zodoende parallel worden uitgevoerd, hoeven dus niet op elkaar te wachten.

6: De gemeente Loppersum lijkt redelijk voorop te lopen met het maken van plannen over aardgasvrije wijken. Hoe kan de gemeente Loppersum als voorbeeld dienen voor andere gemeenten in Groningen voor het ontwikkelen van aardgasvrije wijken? Zijn er bijvoorbeeld al concepten of plannen die gebruikt kunnen worden in andere gemeenten?

Onze plannen zijn van concreet (korte termijn) tot volop in ontwikkeling (langere termijn). Naarmate de tijd verstrijkt wordt het realiteitsgehalte groter en worden we als voorbeeld voor andere gemeenten interessanter. We zijn altijd bereid om onze plannen te delen met andere gemeenten.

Appendix 4: Interview Enexis: Kees van Dalen

I: Wat is uw functie bij Enexis?

R: Ik ben strategisch adviseur bij Enexis group. Ik ben gestationeerd bij het onderdeel Enpuls. Wij hebben een gereguleerd netwerkbedrijf en hebben de wettelijke taak voor gas en elektriciteit. Verdura en Enpuls zijn onderdeel van Enexis Group, Verdura is een beetje de commerciele verhuur om allerlei energiegerelateerde zaken, transformatiehuisjes en dat soort dingen. En Enpuls is bij ons een bedrijfsonderdeel gericht op versnellen van de energietransitie. En binnen die club hebben wij ook een groepje wat zich bezig houd met warmtenetten, daar ben ik dus onderdeel van.

I: Wat is de rol van Enexis in de verduurzaming van warmtelevering aan de gebouwde omgeving?

We hebben denk ik best een hele belangrijke taak, we hebben voor miljarden infrastructuur in de grond liggen, die we in de transitie gewoon nog steeds kunnen blijven gebruiken, electriciteits en gasnetten. We zijn al tientallen jaren gewend om dat uit te breiden waar nodig, we zullen natuurlijk een aantal nieuwe duurzame energieproductie locaties gaan aansluiten de komende jaren, zon en wind. Dus dat is een belangrijke rol, het faciliteren van nieuwe opwek, anderzijds ook een belangrijke speler als het gaat om nadenken over die veranderingen. Daar ligt in de gebouwde omgeving een belangrijke regierol voor gemeentes en wij zijn feitelijk partners van die gemeentes, om mee te denken om wat nu goeie manieren zijn om die verduurzaming verder vorm te geven. Dat doen we eigenlijk door een stukje data beschikbaar te stellen, overhuidige energieverbruiken en anderzijds de impact door te rekenen en te laten zien wat bepaalde keuzes zoals het bijplaatsen van windturbines tot en met de impact van electrisch vervoer op ons netwerk.

I: Dus als ik het goed begrijp spelen jullie dan ook als een soort van consult voor beslissingen die gemeentes gaan maken?

R: Ja, consult is een beetje een betaald advieswerk, dat is het zeker niet. We krijgen niet betaald maar we willen wel graag aan de voorkant betrokken zijn bij initiatieven en plannen die er spelen om hier zo snel mogelijk op te anticiperen. De doorlooptijden voor het aanpassen van een stuk infrastructuur die zijn best wel fors. Dus wij positioneren ons vaak een beetje als een partnerschap, schouder aan schouder met de gemeente. Uiteindelijk zijn deze gemeentes ook onze aandeelhouder. Wij zijn ook een publieke partij met een maatschappelijke taak en die willen we zo goed mogelijk uitvoeren, om zo de kosten voor heel nederland zo laag mogelijk te houden. We zijn een heel simpel bedrijf, alle kosten die we maken voor de aanleg en het onderhoud, die delen we door het aantal mensen die zijn aangesloten op het net en daarmee hebben we een gesocialiseerde situatie waarin iedereen evenveel betaalt, ongeacht of die in Drenthe, in het buitengebied of in de binnenstad woont van Eindhoven. Als wij teveel winst zouden maken, dan gaan de vastrecht tarieven omlaag. En al we verlies maken, zouden we genoodzaakt zijn om de tarieven op te hogen om dit weer uit te middelen. Hierbij worden we continu vergeleken met andere netbeheerders om kostenefficient de operatie in te richten.

I: Is het dan ook zo dat doordat er veel aanpassingen nodig zijn op het net als gevolg van de energietransitie, deze kosten worden doorberekend aan de consument?

R: Jazeker, we betalen dat linksom of rechtsom allemaal zelf. Voor een deel zit dit in de toename van de energiebelasting op je gas en electra. Anderzijds zit dit ook in meer kosten voor aangesloten zijn op de infrastructuur. Je kunt je wel voorstellen dat de kosten die ook nodig zijn om wind op zee te connecten aan het net, daar zijn geweldige investeringen voor nodig, die hoeven gelukkig niet in 1 jaar betaald te worden maar die worden natuurlijk wel over een periode van 40 of 50 jaar door alle Nederlanders betaald. De verwachting is dat de kosten voor de infrastructuur van onze energievoorziening gaan toenemen, maar de energiekosten, het zuivere leveringsdeel zou goedkoper moeten worden. En dat heeft te maken met dat windmolens heel veel geld kosten om neer te zetten, maar als hij eenmaal staat dan hoef je er geen benzine of olie in te gooien, dan blijft die stroom er gewoon uit komen.

Welke alternatieve verwarmingsopties hebben volgens u de grootste potentie om aardgas in de gebouwde omgeving te vervangen?

R: Dan begin ik altijd wel met energiebesparing, dat is de meest kosten effectieve manier. Wij kunnen natuurlijk door goeie energiebesparende maatregelen minder aardgas verbruiken. Er zijn ook hybride warmtepompen denkbaar waarbij een belangrijk deel van het jaar, je elektriciteit gebruikt voor je verwarming en koeling. En die hybride oplossing denken we daarvan dat dat zeker de komende jaren een belangrijke vlucht moet maken, en ook een eindoplossing kan zijn waarbij dan de opgave ligt om dat aardgas op termijn dan te vergroenen, of met waterstof of synthetisch gas. Maar in ieder geval een type gas waar geen CO2 uitstoot bij plaats vindt. Dus dat is een belangrijke route.

De tweede route is dat we heel veel warmte in Nederland hebben die we weggooien, of niet inzetten. Dat kan warmte zijn uit de bodem, in de vorm van warmte of koude opslag of geothermie als je dieper boort. Die zouden we effectief kunnen aanwenden. Ik praat dan ook over bedrijfsprocessen of industrien die heel veel warmte produceren. En dan heb ik het ook over zonthermie, de zon kan zijn steentje bijdragen, ook aquathermie & riothermie. De inschattingen daar zijn dat dat misschien wel een kwart tot de helft van de woningen zou kunnen zijn in Nederland. Dus dat zou betekenen dat er best een aantal nieuwe warmtenetten ontwikkelt moeten worden, vooral in stedelijk gebied lijkt dat een goeie oplossing. Maar dat is natuurlijk een commerciele uitdaging, het is een hele kostbare infrastructuur een warmtenet. Die ook veel plek vraagt in de straat. Daar liggen wel gewoon hele grote uitdaging. Zoals we daar nu naar kijken moet ook gewoon die kostprijs 20-40% omlaag om dat echt op grotere schaal uit te kunnen rollen.

En dan de derde alternatieve smaak die je dan overhoud in die warmte is full-electic, dat betekend dat je geen CV ketel hebt maar een warmtepomp op elektriciteit krijgt. Dat is opzich geen rocket science, bestaat al jaren. Maar we weten allemaal dat je daarvoor een goed geisoleerde woning met lage temperatuurverwarming nodig hebt, anders ga je wel heel veel elektriciteit gebruiken om je woning te verwarmen. Het belangrijke is bij all electric is dus goed geisoleerd zodat het electriciteitsverbruik binnen de perken blijft.

I: U had het net over warmtenetten, dat een noodzaak daarbij is om de kostprijs 20-40% te drukken, is het dan ook zo dat als die kostprijs lager is dat warmtenetten dan haalbaarder worden in minder stedelijke gebieden? Zodat het bijvoorbeeld een uitkomst kan zijn in dorpen of iets dergelijks?

R: Ja ik denk, we hebben nu in Brabant ook een dorp waar een warmtenet gaat worden aangelegd. Daar staan geen flats ofzo maar daar staan veel grondgebonden woningen. En dat zou zeker op termijn uit kunnen als men ook toegang heeft tot bronnen. Kijk als je natuurlijk in het buitengebied bent en er is geen bron aanwezig, geothermie zou bijvoorbeeld geen optie zijn, bij geothermie moet je ook gauw denken aan 4,5-6 duizend woningen die je minimaal daarop moet aansluiten omdat het anders niet uit kan. In kleinere dorpen ga je denk ik die omvang niet bereiken, dus daarmee valt geothermie daarmee wel af. Maar dat zou je wel met een collectieve WKO, wat ondiepere bodemwarmte een eind kunnen komen. Alsnog wijken met meer een hybride oplossing in die dorpen schijnt opportuun te zijn, maar warmtenetten zijn zeker niet uitgesloten. Zeker als je daar een forse kostprijsdaling in ziet te krijgen.

I: Electrificatie van verwarming zal in de toekomst een grote rol gaan spelen, welke aanpassingen aan het net zijn hiervoor benodigd?

R: Nog niet eens zo zeer ligt de uitdaging in het net. Die ligt daar zeker he want als het koud is gaat iedereen elektriciteit gebruiken en dan krijg je een geweldige piek. Maar het belangrijke is ook wel, kun je in die koude piek al uberhaupt wel hernieuwbare elektriciteit krijgen. Kijk als het swinters bewolkt is en koud is en windstil, dan heb je feitelijk geen opbrengsten uit duurzame opwek. En dan zul je dus nu moeten nadenken over opslag van energie op het moment dat het wel heel hard waait en de zon schijnt. En dan zou je die stroom, en dan is de vraag op je die kilowattuurtje aan stroom moet transporteren of dat je de conversie naar gas moet maken, of dat nou waterstof is of iets anders, daar moet je goed over na denken want we kunnen die netten wel gaan verzwaren voor die koude winterpieken, die 5 of 10 dagen per jaar dat iedereen electrisch aan het verwarmen is, maar dat is natuurlijk buitengewoon zinloos dat als je weet dat als je een gasaansluiting hebt, een veel groter vermogen kunt leveren aan een woning. Dan kan je beter 10 dagen per jaar met moleculen in plaats van electroden een woning van warmte gaan voorzien. Dat is veel kostenefficienter.

I: Bij electrificatie van de verwarming neemt de stroomvraag enorm toe en is de stroomvraag en het aanbod van duurzame energie niet goed met elkaar gematcht waardoor we dan op sommige momenten afhankelijk zijn van fossiele energiebronnen, zoals gasgestookte energiecentrales. Is energieopslag in de vorm van batterijen of waterstof dan bijvoorbeeld de uitkomst om dit aanbod en vraag meer te laten matchen?

R: Ja, waarbij de batterijen bij mij als snel afvallen omdat je enorme batterijen nodig bent en je gaat niet een batterij gebruiken die je zomers oplaat en swinters leegtrekt, een batterij is bedoelt op meerdere keren op te laden en leeg te trekken gedurende een jaar. Dus dan kom je al veel eerder in een conversie waarin je vanuit zonnestroom middels een electrolyser, waterstof ofzo gaat maken. Dat zou veel efficienter zijn, dan dat je die hele netinfrastructuur gaat aanpassen op de piekuren gedurende de winter.

I: Zijn deze benodigde aanpassingen op het net niet zo kostbaar dat andere alternatieven zoals de inzet van duurzame gassen of warmtenetten goedkoper zijn?

R: Dat is nu wel de aannaame ja, dat het goedkoper is om met gassen te doen of met een warmtenet. Want die warmte kan er swinters wel beschikbaar zijn. Dat is dus makkelijker naar woningen te transporteren dan alles met stroom.

I: Full-electric oplossingen zijn tevens kostbaar voor burgers omdat deze huizen moeten isoleren zodat de warmtepomp goed werkt. Is daarom een hybride oplossing een goede tussenstap?

R: Ja, je hebt die drie dominante smaken die ik in het begin ook zei. Bij alle drie zit er een verschil in de investering die gepleegd moet worden. Bijvoorbeeld aan de zeide van de woning, of aan de infrastructuur dan wel aan de opwek kant. Dus in de huidige situatie waarin we ongeveer 95% van de woningen op gas en elektriciteit hebben, is voor iedereen het zelfde, gaan we straks naar een situatie waar een derde misschien op warmte zit, misschien een kwart op volledig electrische oplossingen zitten, vooral de nieuwbouw. En dat er nog een substantieel deel van de mensen op een warmtenet zit en die mensen krijgen een hele dure infrastructuur waar ze aan bij moeten dragen, zowel mensen met een hybride oplossing hebben die hoeven eigenlijk helemaal niet zoveel bij te betalen aan de infrastructuur omdat die al voor een belangrijk deel al gerealiseerd is. Dus je gaat verschillen krijgen afhankelijk van waar je woont. Daar zit nu nog de grote uitdaging in, gezien er nog geen nationaal aanvalsplan is voor elke buurt en wijk in Nederland. Daar zijn eerst regionale energiestrategien voor nodig. Dat is een heel programma waarin voor 30 regio's in Nederland inzichtelijk wordt gemaakt hoeveel potentie is er om elektriciteit op te wekken, waar is warmte beschikbaar en wat zijn de kosten voor de infrastructuur die er nodig is om de aanbod en de vraag met elkaar te verbinden. Op basis daarvan kunnen gemeentes voor hun eigen stad of dorp een afweging maken in welke buurt of wijk een bepaalde oplossing de voorkeur zou hebben. Ze zullen daar ook het draagvlak voor gaan toetsen. En langzamerhand moet er dan zicht komen welke buurt of wijk ga ik beginnen. En tel dat dan vervolgens op naar de nationale doelstelling die we nastreven. En in dat hele proces zullen we ook moeten nadenken hoe we om kunnen gaan met de verschillen, want voor de ene regio kunnen we het misschien wel heel goedkoop oplossen en hebben we misschien veel meer duurzame stroom over hebben terwijl andere regios te kort hebben en misschien een veel duurdere aanpassing nodig hebben. En we komen uit de geschiedenis van socialiseren, dus hoe kunnen we nu even zorgen dat het voor iedereen gemiddeld in Nederland bereikbaar is om mee te gaan aan die verduurzaming en niet dat het in bepaalde regios onbetaalbaar is of in bepaalde woningtype onbetaalbaar is terwijl daar net allemaal mensen wonen met een smalle beurs. Dat is een nationale opgaven en daar heeft onze politiek en ons kabinet nog geen oplossing op. Dus daar zit wel een belangrijke uitdaging in de komende 2-3 jaar om daar een soort nationale visie op te ontwikkelen zodat we handelingsperspectief krijgen voor alle gemeentes in Nederland. Want nu zie je dat gemeentes erg aan het pionieren zijn.

I: Ja dat is inderdaad wat je nu veel ziet, dat gemeentes voorop willen lopen. Ook in Groningen is dat te zien met bijvoorbeeld gemeente Loppersum die erg voorop loopt, ook in het opstellen van energietransitieplannen. Het lijkt nu inderdaad of gemeentes onderling geen brede consensus hebben maar een beetje onafhankelijk te werk gaan. Is dat wat u bedoelt?

R: Ja dat is precies wat ik bedoel. Dan krijg je op een gegeven moment ook weerstand in de wijk, waar een gemeente bijvoorbeeld zegt we gaan hier een warmtenet aanleggen dat is de beste oplossing. Maar dat mensen dan zeggen: Ik lees in de krant dat we allemaal een warmtepomp moeten hebben, of waterstof, moeten we die CV ketel wel verwijderen of alleen de brander kunnen aanpassen. Dat soort vragen leven gewoon in de samenleving. Het is heel lastig als gemeente dat aan je burgers uit te leggen als er geen nationaal kader is. Daar zit wat mij betreft de grootste pijn.

I: Maar denkt u wel dat het mogelijk is om zo’n nationaal kader te maken, omdat het natuurlijk heel erg locatie afhankelijk is, wat waar beschikbaar is.

R: Ja maar tegelijkertijd denk ik dat generiek best het een en ander te zeggen is over hoe je met de kosten om moet gaan. Dat kan middels garantiefondsen of kennis vanuit het rijk voor gemeentes om dit soort plannen daadwerkelijk vorm te geven. Ook in de volgorde van wijken. Als je als wethouder een pilot wil in je wijk, bijvoorbeeld in Loppersum, om te zeggen we gaan hier beginnen met een warmtenet, dan zal de buurt een uitleg willen, zo van: waarom niet de volgende wijk en ben ik dan niet een early-adapter en zit ik de kosten vooral te betalen, en profiteerd de volgende wijk hiervan zodat het voor hun goedkoper wordt? En daar moet je een perspectief van bieden om mensen mee te krijgen.

I: Is dat al niet geregeld in wetten, zoals de warmtewet waarin staat dat consumenten niet meer mogen betalen dan de kosten in vergelijking met verwarming op een cv ketel met aardgas.

R: Ja dat is er in feite nu al met de warmtewet, dat die kleinverbruikers eigenlijk beschermd dat ze niet teveel betalen. Maar wat die warmtewet niet regelt is dat er in feite een aansluitplicht is voor degene die daar een warmtenet gaat aanleggen. Wat je nu ziet is dat als er een warmtenet wordt aangelegd dat er op basis van vrijwilligheid moet gebeuren, terwijl het eigenlijk een collectieve voorziening is. Je kunt idealiter als je een wijk van het gas af wil krijgen en je gaat er een warmtenet voor terugleggen, dan wil je dat iedereen erop aansluit zodat de kosten ook over zoveel mogelijk mensen worden verdeeld. Dus wat er in die warmtewet nog niet geregeld is, is dat er een doorzetmacht is, een soort verplichting dat als je eenmaal in een democratisch proces een warmtenet een goeie oplossing is, er zijn ook warmtebronnen in de buurt en er kan veel CO2 mee bespaart worden. Dan moet je dat ook als een collectief iets zien waar iedereen aan moet mee betalen. Zodat er maar een beperkte keuzevrijheid is. En dat betekent dus ook dat er partijen moeten zijn die zeggen ik sta daarvoor aan de lat, en ik ga niet alleen een warmtenet aanleggen met een paar flats en klanten die ik interessant vindt, maar dat ze een propositie gaan voorleggen zodat alle burgers in dat gebied ook een aansluiting op dat warmtenet kunnen krijgen. Want op het moment dat de gaskraan dicht zou gaan, dan moeten die mensen als ze geen gebruik maken van dat net, overgaan naar een all-electric oplossing wat nog veel duurder is. Dus je wil voorkomen dat er straks een warmtenet in de wijk ligt waarin niet iedereen kan op aansluiten, omdat ze vanuit kosten oogpunt geoptimaliseerd hebben. Dus als je dan de paralel met elektriciteit en gas pakt, we hebben als netbeheerder een aansluitplicht dat iedereen die om een gas of electriciteits aansluiting vraagt, voor een gesocialiseerd bedrag dit moet aanbiedien. Bij warmte is dat nog niet geregeld. Ik denk dat dat een belangrijk element is dat bij de nieuwe warmtewet moet worden ingebracht. Hoe borgen we nu dat we echt voor het hele gebied met een oplossing gaan komen. En niet oneerbiedig gezegd dat iedereen aan selective picking kan doen, en alleen de lucratieve dingen aansluit waardoor het voor de rest moeilijker of kostbaarder wordt om aan te sluiten.

I: Is het dan ook niet een soort van belemmering dat mensen uit zichzelf warmtepompen in hun huis gaan aansluiten? Omdat als er dan een transitieplan komt in zo'n gemeente dat een warmtenet in de weg kan staan, als mensen zelf oplossingen gaan aanschaffen.

R: Ja ik denk zelf dat particuliere woningeigenaren die willen maar een ding weten, komt er een warmtenet of niet? En als er geen warmtenet komt dan is de warmtepomp een logisch alternatief, en dan weten ze ook dat ze moeten gaan isoleren. Ongeacht of er een warmtenet komt of niet, is isoleren altijd goed. Maar die duidelijkheid moeten we aan de burgers wel gaan bieden. Maar all-electric zoals ik zeg heb je vele tienduizenden euros nodig om je woning daarvoor geschikt te maken. Bij een warmtenet zullen de kosten vooral voor een groot deel in de infrastructuur belanden. En kun je misschien nog uit de voeten met de binneninstallatie van de woning die nu nog op gas zit. Dat betekent dus dat die infrastructuur dus wel over voldoende schouders moeten worden uitgesmeerd om dat te kunnen realiseren.

I: Heeft u nog belangrijke dingen toe te voegen, zijn er dingen die ik misschien niet genoeg belicht heb in dit interview?

R: Ik denk dat het meeste wel gezegd is, het kosten verdeling vraagstuk is heel belangrijk, het nationaal plan wat er moet komen. En toch ook het feit dat er op enig moment een democratisch proces moet worden doorlopen waarbij je een keus voor een buurt of wijk maakt, waarbij je dan toch ook van iedereen in zo'n gebied een bijdrage vraagt. En dat hele proces moet wel eerst staan voordat je die 200.000 woningen per jaar kunt gaan halen waarover het kabinet zijn zinnen op heeft gezegd om per 2020, 2050 zijn doelstellingen te halen.

Appendix 5: Interview RvO: drs. M.L. Hillenius

1: Wat is de rol en de aanpak van het RvO in het verduurzamen van de warmtevoorraad?
De Rijksdienst voor Ondernemend Nederland (RVO) is de uitvoeringsorganisatie van het ministerie van EZK, maar we voeren ook opdrachten uit voor andere ministeries. We staan iets op afstand van het kernministerie, spelen een rol in de uitvoering van beleid. Er werken nu meer dan 4000 mensen bij RVO en er worden heel diverse opdrachten uitgevoerd, die ik ook niet allemaal weet. Van exportsubsidies, tot octrooien verstrekken, landbouwsubsidies verstrekken en zo nog veel meer. Ik werk voor de duurzame poot van de organisatie en die is een stuk kleiner. RVO heeft daarin allerlei rollen:

- Advies en beleidsondersteuning: de RVO-deskundigen staan de beleidsambtenaren van de ministeries bij bij het opstellen van nieuw beleid. Bijv. de nieuwe warmtewet. Of aardgasvrije nieuwbouw, nieuwe bouwregelgeving of bevorderen van geothermie. Advisering over de duurzaamheidscriteria rond biomassa etc. Vaak heeft RVO ook een schakelrol naar de markt. We krijgen signalen uit de markt en bespreken dat met EZK, dat dan kan bekijken of beleid wellicht moet worden bijgesteld.

-We voeren ook heel veel subsidieregelingen uit, zoals SDE++ (duurzame energie, ook duurzame warmte)

-Soms krijgen we ook opdrachten van andere overheden. Zelf werk ik bijv. voor een opdracht van de provincie Zuid-Holland aan RVO, waarbij we als procesbegeleider gemeenten bijstaan bij het opstellen van de warmtevisies die ze moeten maken op grond van het KlimaatAkkoord en de Regionale Energiestrategieën.

2: Op welke manieren kunnen jullie decentrale overheden steunen?

We zijn wel een opdrachtgestuurde organisatie, dus als een vraag o.i.d. van een gemeente of provincie binnen een opdracht van het Rijk te passen is, kunnen we de mede-overheden steunen.

- Bijv. subsidieregelingen
- Procesbegeleiding als hierboven
- We organiseren soms kennisbijeenkomsten, bijv. over aardgasvrij.

3: Wat voor aanpak volgen gemeentes in het verduurzamen van de warmtevoorraad?

Gemeenten moeten ogv het bestuursakkoord IBP (googlen) en ook het KlimaatAkkoord een regionale energiestrategie opstellen (RES): ruimte voor duurzame opwekking, zoeken naar duurzame warmtebronnen etc. Vervolgens moeten ze een TransitievisieWarmte maken: een stuk dat voor iedere wijk in kaart brengt wat de beste opties zijn voor een duurzame warmtevoorziening t.z.t.. Daarbij wordt gekeken naar wat zijn de grootste kansen: bijv. geothermie, of restwarmte, of warmtewinning uit oppervlakte water, of toch all electric met een warmtepomp. Dat kan per wijk en regio verschillen.

4: Hoe worden de plannen vastgelegd?

RES en TVW worden door de gemeenteraad vastgesteld.

5: Is het altijd zo dat buurtbewoners inspraak krijgen in het proces van de planvorming?

Ja, hoe en wanneer precies kan per gemeente verschillen. Op dit moment is het ook een zoekproces voor iedereen, want het is nieuw voor iedereen. Maar inspraak, participatie etc. wordt heel belangrijk gevonden. Ook alleen al omdat draagvlak heel belangrijk is. De gemeente heeft op dit moment nog geen doorzettingsmacht om een wijk van het gas af te halen.

6: Hoe kunnen huiseigenaren gemotiveerd worden om te verduurzamen?

Campagnes, maar ook subsidieregelingen etc. om het betaalbaar te maken. Het Rijk is nog druk bezig met het opstellen en uitwerken van zijn beleid wat dat betreft, als uitvloeisel van het Klimaat Akkoord. In de komende maanden horen we meer.

7: Voor sommige gemeentes is de verduurzaming van de warmtevoorraad misschien makkelijker te bereiken dan voor andere gemeentes. Er kunnen bijvoorbeeld warmtebronnen voor de hand liggen en bij sommige gemeentes is dit minder het geval. Ook komen kosten in sommige gevallen bij huiseigenaren terecht en in sommige gevallen bij andere partijen. Dit resulteerd in een ongelijke kostenverdeling, zowel onderling tussen gemeentes als tussen huiseigenaren. zo krijgt de ene huiseigenaar een warmtenet in de wijk waardoor hij niet veel hoeft te investeren en moeten sommige huiseigenaren over op een warmtepomp.

- Hoe denkt u over deze ongelijke kostenverdeling in de warmtetransitie?

Klopt in grote lijnen wat je hierboven zegt. Hoofdlijn zal moeten zijn dat er middelen beschikbaar komen om het voor iedereen betaalbaar te laten zijn. Prijssturing bijv.: gasprijs zal omhoog moeten in de eerste plaats. Nu is het nog heel lastig om met gas te concurreren. Verder is het natuurlijk zo dat mensen in een goed geisoleerd huis met een warmtepomp nog maar heel erg weinig energielasten hebben. Mensen op een warmtenet in een matig geisoleerd huis houden een behoorlijke energierekening. Dus met zachte leningen en gebouwgebonden leningen moet deze ongelijkheid een heel eind op te lossen zijn. Bij een lage energierekening heb je dan nog wel misschien een extra lening en rente te betalen, die ongeveer gelijk is aan de energielasten van voor de verbouwing. Zo kan het woonlasten neutraal. Voor corporaties is er al wel instrumentarium ontwikkeld. Bijv. de EPV, energieprestatievergoeding. Google maar even.

- Wordt er daarom aan sommige gemeentes meer ondersteuning geboden dan aan andere gemeentes, bijvoorbeeld in de vorm van meer financiële ondersteuning?

Nee, niet vanuit het Rijk. Algemene regelingen gelden voor iedereen in Nederland. Soms doet wel een provincie iets extra’s.