Towards a more sustainable heat system in South-Holland

- Saving energy by making heat supply more sustainable -

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Picture: realisation of thermal grid geothermal energy source Green Well Westland, source: VB projects, n.d.

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Executive summary

In this report the possibilities of sustainable heat supply in South-Holland are reviewed. The province of South-Holland has set ambitious targets to reach 20 PJ sustainable heat in 2020, which is defined by the province as renewable heat plus waste heat. On the longer term a sustainable heat and cold share of 50% in 2050 is aimed for. This is based on opportunities such as a large demand for heat, a large availability of waste heat and the specific opportunities in the horticultural sector in the region. However the low existing sustainable heat consumption in South-Holland as well as the existence of numerous barriers to the implementation of sustainable heat means there is a long way to go.
After analysing the existing and planned sustainable heat and cold projects and taking into account the business as usual growth of different sustainable heat technologies, it is clear that reaching the 2020 targets will indeed be extremely difficult. By continuing on the current track just over half of the targeted amount will be reached, if all planned projects follow through. In order to increase the chance of meeting the targets, focus must lie with those areas in which large potentials can be reached, such as geothermal energy in the horticultural sector. However, the rest of the technologies and sectors must not be forgotten. In the end the targets can only be reached if all different technologies fulfil their share and if all sectors become significantly more sustainable. This being said, large shares of the total heat demand are unfitted for sustainable heat supply because of practical barriers, for instance retrofitting existing buildings with sustainable heat technologies is impractical and expensive. This must be taken into account and policy should initially be targeted at those shares of the build environment that are more suitable, such as large office buildings and apartment complexes to be build.

Considering the long term sustainable heat targets merely stimulating the separate sustainable heat technologies is not sufficient, instead a transition to a sustainable heat regime must be aimed for. In order to keep on the right track towards this transition, but also to increase the effectiveness of policies on the short term, an analysis of the barriers in place should be the starting point to base policy upon. By basing this barriers analysis on transition and innovation theories the focus will lie with transformative change, this reduces the risk of policies that provide short term gains without constructively adding to a long term solution for the problems resulting from fossil fuel use.
This barriers analysis takes into account the limits of the role of the province by acknowledging the existence of barriers that cannot be influenced, such as the low price of fossil fuels as a result of the externalization of negative costs. The most important barriers are found to be the complexity of the heat network, the lack of coordination between policies and activities on different governmental and sectoral levels and the lack of focus on the demand side of the heat system. There are of course more barriers that play a role and most barriers are to some extent interconnected. For instance the lack of sustainable heat infrastructure can partly be overcome by targeting this problem in association with other parties, reverting back to the complex network barrier.

In order to reduce these barriers, measures and policies need to be implemented. The program office that is set up in South-Holland must be used to unite the complex network, by recognizing shared goals and profitable projects, the network can be better used to realise and promote sustainable heat. By aligning provincial policies with the national government and municipalities in the province the aim to

stimulate transformative change will be shared between parties and embedded in policies. This should reduce opposing policies and aid the development of long term stable policies towards a sustainable heat regime. Furthermore, by carrying out research into the demand side needs and perceptions, by increasing the promotion of sustainable heat and cold and by making sustainable heat better suited to the needs of users, the extent of sustainable heat in the built environment can be increased. Lastly practical barriers such as the lack of infrastructure should be overcome as much as possible, for instance by setting up a provincial guarantee scheme for geothermal energy and by supporting the development of local thermal grids.

If the province would succeed in largely overcoming the barriers in place, a sustainable heat potential of over 18 PJ in 2020 and 48 PJ in 2050 can be reached. This is clearly in reach of reaching the provincial sustainable heat targets, reaching this potential would form a good starting point towards significantly more sustainable heat in South-Holland in a way that is supportive of a system transition. However, for the province of South-Holland it is considered foremost important not to focus too much on the actual number of PJs but to focus more on the process of sustainable heat supply and the desired transition. The output of sustainable heat depends to a large extent on external factors and barriers out of scope. By focusing not on the target but on the process, the province can clear the way for a transition towards a sustainable heat regime that can be reached over time by coupling efforts with other parties and by moving in the right direction together.

Table of contents

1 Introduction

1.1 Background

1.1.1 *Introduction*

Against the background of external pressure to increase the share of sustainable energy in the Netherlands, and after recognition of unique heat supply possibilities in South-Holland, the province formulated its goal to replace 14% of its heating and cooling demand with sustainable heat, defined as renewable heat plus waste heat, this amounts to 20 PJ. The focus on sustainable heat and cold arises from the ideal situation in South-Holland. A large demand for heat, in urban areas as well as the horticultural sector, as well as large possible supply of heat in the form of industrial waste heat, and good possibilities for geothermal heat make an excellent case for energy reduction (CE Delft, 2011; Provincie Zuid-Holland [PZH], 2011). As means to reach this target, the province mainly focusses on heat and cold storage, thermal grids and geothermal energy (Green Deal, 2011). These provincial ambitions are recorded in a Green Deal between the national government and the province. This Green Deal plan counts on cooperation with large municipalities, the large horticulture sector in the region, energy companies and other stakeholders.
The sustainable heat ambition does not end with the 2020 targets, on the longer term a supply of 50% sustainable heat in 2050 is strived after, this cannot be translated in a specific amount of sustainable heat considering the uncertainties of future heat demand. This target shows a serious aim to make a transition to a system no longer dominated by fossil fuels.

In this report it is analysed in what way the province can more effectively work on reaching these targets. First the potential of different sustainable heat technologies in different sectors, based on heat demand characteristics, is analysed to shed light on the possibilities and opportunities with respect to sustainable heat supply. Next the current effort are reviewed and the share of sustainable heat that can be expected under existing policies is examined in order to determine what part of the potential is actually realised and whether the province is on track. This is coupled with an analysis of the barriers in place that reduce the potential and create incentive to implement policies. This barrier analysis not only involves the short term barriers but more notably those that hinder the long term transition to a sustainable heat supply system. This is used as input to come to an advice on how the province can overcome these barriers by a different focus and specific policy measures, thereby increasing the potential for sustainable heat, and increasing the chance to reach the targets.

1.1.2 *Background*

Over the last decades the ever increasing consumption of fossil fuels resulted in increasingly more environmental and economic problems. Modern society's addiction to fossil fuels has already led to climate changes as a result of the increase of greenhouse gas concentrations. The fact that fossil fuels

are limited and geographically unevenly distributed furthermore leads to problems with the availability and affordability of these energy carriers on which our energy system is heavily dependent.
In reaction to these issues international and national policy programs have been initiated, although with a somewhat unclear focus, changed over time from a focus on safeguarding affordable, reliable and secure energy to a focus on climate change and greenhouse gas reduction and finally a focus on reducing climate impacts and reducing the dependence on foreign fossil fuels (Negro, Alkemade, Hekkert, 2012). Presently the European Commission focusses on preventing dangerous climate change and developing adaptation strategies (European Commission, 2013). Targets of 20% reduction of greenhouse gasses in 2020 and 80-95% reduction in 2050, compared to 1990, show a high level of ambition. Initiatives to meet these targets consist of adopting legislation to increase the share of renewable energy to 20% by 2020 and to increase the energy efficiency with 20% by 2020 (ibid.).

In 2008 the European heads of government reached consensus about national 2020 renewable energy targets. As part of the Renewable Energy Directive (2009/28/EC), member states were given legally binding targets based on the reference situation, opportunities and barriers in each country. The Netherlands was given a relatively low target, compared to other countries, of 14%.
However, even though the target of the Netherlands is relatively low, it does seem out of reach. Between 2011 and 2012 the share of renewable energy increased from 4.33% to only 4.37%, the Netherlands is currently ranked 24th out of the 27 EU countries, only keeping the United Kingdom, Luxembourg and Malta behind (Eurostat, 2013). Countries with much larger targets, of which Sweden has the largest (49%) are on track to reach these and will probably even exceed the targets.
Even though the current sustainable energy efforts make it seem highly unlikely that the 14% targets will be reached in 2020, on November 5th, 2012 the Dutch cabinet increased the sustainable energy target to 16% in 2020, only to lower it again in the newest Energy agreement (Ecofys, 2013; SER, n.d.). This highlights a typical problem of Dutch energy policy, although there is plenty attention for sustainable energy politics, there is less attention for the practical implementation of politics and the focus lies mainly with short term gains instead of assuring long term stable measures (TU Delft, 2010).

The sustainable energy focus of the Dutch government has lied with renewable electricity and transport fuels in the last few years, whereas the consumption of heat has been somewhat neglected. However, heat production is the largest part of final energy use in the Netherlands with a share of about 40%, considering the large sustainable energy challenge making the consumption of heat and cold more sustainable should become more of a priority. In the words of the International Energy Agency ([IEA], 2012): *"Heating and cooling remain neglected areas of energy policy and technology, but their decarbonisation is a fundamental element of a low-carbon economy"*
Within the Netherlands the share of greenhouse gas emissions is by far the largest in the province of South-Holland (Emissieregistratie, n.d.), due to it being the most populated province and because of the extensive industry and energy sector, mainly in the Rotterdam region (PZH, 2011). In order to realise the remaining needed national renewable energy, it is therefore crucial to aim for a considerable contribution in South-Holland. An ambitious sustainable heat target in South-Holland and effective plans to reach this target are an important step towards reaching the sustainable energy requirements of the Netherlands and thereby contributing to a transition to a system independent of fossil fuels. On the

other hand, the impact of climate change but also renewable energy policy is potentially large in South-Holland, being a coastal province with an extensive industrial sector, therefore reducing the fossil fuel dependence on own terms is also in the interest of the Province itself.

1.2 Goal of research

1.2.1 *Problem definition*

In order to make a transition from the current fossil fuel based heat system to a new sustainable system, efforts on all fronts need to increase. This means recognising where the opportunities lie and seizing these opportunities through identifying what aspects hinder the realisation of sustainable energy and overcoming these barriers with effective policies. Although the province clearly sees the opportunities of sustainable heat and cold in the region, and set a target of 14% sustainable heat and cold in 2020, clear plans on how to reach this target this still need to be formed.

Although there are plenty of opportunities in the province, there are also clear limitations when it comes to provincial policy instruments. This creates the necessity to work together with the entire heat supply and demand network in order to collectively work towards reaching the targets. The importance of the network also implies the relative unimportance of the province, the influence of the province on existing barriers is limited and the attractiveness of sustainable heat in comparison to fossil heat is predominantly determined by external factors and EU and national policies.
So the province has set very ambitious targets whereas the influence of the province is limited, as well as the available resources. To make matters even more interesting, the external factors are not entirely favouring sustainable heat. The national government focusses solely on renewable heat thereby not supporting waste heat for instance. And although the government increased its renewable heat targets, there are little additional measures proposed to promote renewable energy or demote fossil fuels. The external landscape factors in the form of the financial crisis, cheap electricity and the interest in new fossil fuels such as shale gas are also not benefitting sustainable energy. The question arises what the role of the province in stimulating sustainable heat can be and in what way the province can maximise its chances of reaching the target, taking into account these outside

Now that the province is in the middle of creating sustainable heat policies and developing specific plans, more knowledge about the opportunities in South-Holland, the potential of heat technologies and the impact of policies is needed. This can be used to evaluate whether the current efforts will result in reaching the desired outcome or whether additional policies are needed. If this latter is the case, the policy approach needs to be specifically linked to the barriers not addressed by current policies, in order to maximise the potential that can be reached.

1.2.2 *Aim*

The aim of this project is to analyse in what way the provincial sustainable heat targets for 2020 and 2050 can best be reached. This will be done by analysing the technical and economic potential of different sustainable heat supply measures and by analysing the barriers associated with the supply and demand of sustainable heat that limit the potential to implement these measures. These two parts are then integrated to form an analysis of the measures to reduce barriers, the achievable potential and the role of the province in overcoming barriers.

The first part of this analysis, chapter 4, will consist of an exploration of the reference situation of heat supply in South-Holland in order to identify the geographical distribution of heat supply and demand and the spread over the residential, services and horticultural sector. In the next part the technical and economic potential of sustainable heat measures, based on the demand for heat, the applicability of sustainable technologies, scenarios of future development of heat use indicators and the payback times of technologies. The existing and business as usual sustainable heat consumption in South-Holland is then analysed and compared with the technical and economic potential in order to analyse the share that is inhibited by barriers. In the second part, chapter 5, the barriers that reduce the potential are analysed. This will be done with the desired transformation in mind and with a focus on the specific types of sustainable heat technologies and the characteristics of heat use in the different sectors. The role of different stakeholders in the heat supply and demand system will also be considered. These two parts will be integrated to form an analysis of the best way in which the province can ensure the transition to a sustainable heat regime, by reducing those barriers that lie within the influence of the province.

1.3 What is this research about

1.3.3 *Research question*

The abovementioned aspects result in the following research question:

Research question

What is the best way to increase the consumption of sustainable heat in South-Holland in order to meet the provincial 2020 and 2050 targets?

Sub-questions

What is the current situation of heat supply in the province?
What is the current situation of heat demand in the province?
What is the current situation of existing and planned sustainable heat projects in South-Holland up to 2020?
What is the potential of different sustainable heat measures in 2020 and 2050?
What are the barriers to a transition towards a sustainable heat regime?

What policies and measures should be implemented by the province of South-Holland?
What will the effect of these policies be on reaching the 2020 and 2050 sustainable heat targets in the province of South-Holland?
What are the limits of provincial policies when it comes to reducing and overcoming barriers?

Answering these questions will result in an understanding of how to best use the waste heat potential and the renewable heat potential in the area, now and in the coming decades in a way that is contributing to a transition to a heat supply regime independent of fossil fuels.

1.3.4 Relevance of research

This project is all about sustainable development, which is about using less, using renewable sources and using energy more efficient. The program Sustainable Development aims at: “analysing the changes needed to achieve an environmentally and socially accountable society” (University of Utrecht [UU], n.d.-a). This project is a good example of how knowledge gained in the program can be of use in analysing societal problems and contributing to a reduction in energy use in the Netherlands. The practical transition of a fossil fuel based energy system to a sustainable energy system based on renewable energy will be analysed, thereby using academic knowledge to seek answers to practical and regional objectives. This analysis will benefit the province of South-Holland, and can be used as a starting point for a broader analysis.
The challenge of delivering services using less energy is particularly addressed in the track Energy & Resources. This track focusses, among other things, on future energy demand and energy efficiency improvement and renewable energy. This project analyses the possibility of supplying part of the heat demand with renewable energy sources such as geothermal heat, thereby lowering the fossil intensity of heat supply.
The aim of considering the transition of the heat system as a whole, consisting of the technics of heat supply but also perceptions and values associated with heat supply and the existing infrastructure based on gas and electricity is in close analogy with the aim of the Copernicus Institute to address interconnected issues such as environmental sustainability, social acceptance of energy systems and pressure on resources in an integral manner. This research project is a good example of how science and technology can be of use to make society more sustainable. This project specifically links to the ´Energy and Resources´ research themes by considering the energy efficiency of heat supply in the South-Holland region (UU, n.d.-b)

1.3.5 Brief summary of current energy context

The primary energy use in the Netherlands has gradually increased, since the 1980´s, from about 2500 PJ in 1982 to 3300 PJ in 2004, as can be seen in figure 1. In recent years, the energy use somewhat stabilized, which can for a large part be explained by the economic crisis and reduced economic activities. (Statistics Netherlands [CBS], 2011).

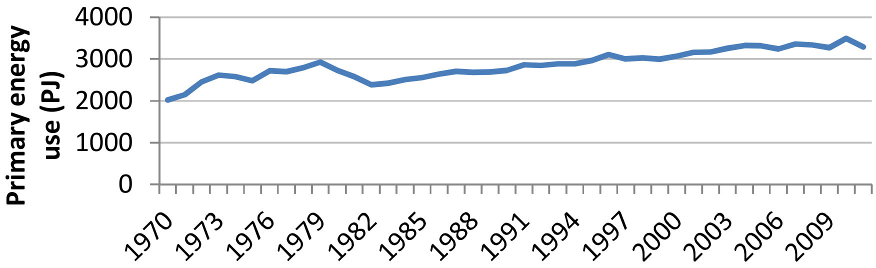


Figure 1. Primary energy use in the Netherlands, 1970-2012 (CBS, 2013a)

Energy carriers

When looking at the share of different energy carriers, especially the large share of gas stands out, as can be seen in figure 2. The Netherlands has a strong history with gas use, following the discovery of the first gas in the Slochteren gas field in Groningen, in 1959. During the 1960´s decade the use of gas almost completely repressed the use of coal and coal gas for heating purposes (Gas in beeld, n.d.). In the years since, the national gas grid developed to the most extensive gas grid in Europe (Energie-Nederland, 2011).

The Slochteren gas field is one of the largest 10 gas fields in the world and counts for 25% of the European gas production. This advantageous situation led to the fact that the share of gas in the total energy use is higher in the Netherlands than any other European country (Energie-Nederland, 2011).The Dutch government expects to remain a net gas exporter until 2025, after this period, when the gas production from the Slochteren field will have reduced, the government focusses on remaining an important gas hub for the transportation of gas through Europe. (Rijksoverheid, n.d.).

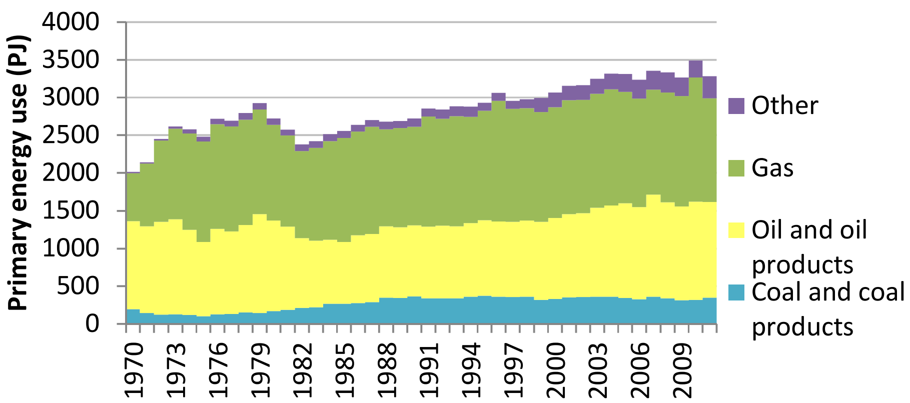


Figure 2. Primary energy use per energy carriers in the Netherlands, 1970-2012 (CBS, 2013a)

Heat use in the Netherlands

The share of heat makes up a relative constant 36-39% of the total primary energy use in the Netherlands, this makes it by far the largest energy carriers, as can be seen in figure 3 (CBS, 2010). In recent years, the use of gas for heat production has reduced slightly due to better insulation of houses and the introduction of high efficiency condensing boilers (Energie-Nederland, 2011).

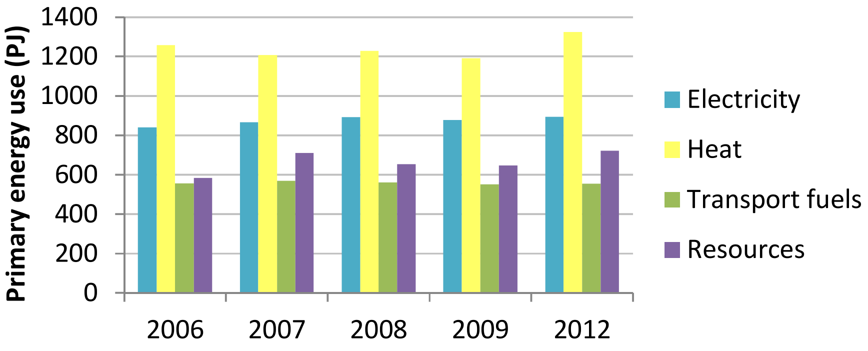


Figure 3. Primary energy use in the Netherlands divided over different uses (CBS, 2013a)

More information about the heat demand and supply in South-Holland and the extent of sustainable heat can be found in Chapter 4.

1.4 Reading guide

Chapter 3 of this research present the theoretical framework of this report, consisting of the theoretical background on which this report is based. Chapter 3, the methodology, presents through which methods the data used in this report is gathered. In chapter 4 the technical, economic and business as usual potential of sustainable heat in South-Holland is analysed. Chapter 5 follows with an analysis of the barriers to sustainable heat in the region and an identification of the stakeholders involved. Chapter 6 will combine these chapters in order to answer how the barriers can best be overcome and what the effect of proposed policy measures will be.

2 Theoretical framework

2.1 Scope

This research project is limited to a scope of the province of South-Holland and the period 2013-2050. Because of the extensiveness of the needed data it is not feasible to carry out an analysis for the whole of the Netherlands. Furthermore because of the unique sustainable heat opportunities in South-Holland this province is considered the most interesting to explore.
Only the low temperature (<120 °C) heat use is considered in this analysis. The situation of supplying sustainable high temperature heat is entirely different and is limited to use in industrial areas and therefore highly specific. It is not considered useful for the province of South-Holland to analyse this at this stage.
This report is furthermore limited to an analysis and calculation of the potential of sustainable heat supply; energy saving measures other than heat supply are excluded. Depending on the available data and expectations about the potentials also minor contributors to sustainable heat supply will be excluded from the potential calculation.
Measures that improve the efficiency of heat supply, or eliminate some negative aspects of fossil fuel use, such as Carbon Capture and Storage, will not be taken into account. Furthermore building side measures that lower the demand for heat, such as insolation of houses, will not be considered. The changes in the demand for heat in the future are considered, but are only used as an input in the analysis of the future potential of sustainable energy supply in certain sectors and the total future heat demand.
When considering the future developments, existing scenarios will be used to provide indicators of future heat demand and sustainable energy, these scenarios will be coupled with some assumptions based on existing trends. The used scenarios are explicitly not updated to incorporate the effect of the current economic crisis; scenarios are in itself representations of a possible future, not an analysis of the most likely future. By combining four scenarios with a full range of different effects and indicators, it is assumed that these scenarios together present a broad range of future possible developments.

2.1.1 *EU climate and energy package*

Aside from the underlying reasons why it would be beneficial to invest in sustainable energy, the EU climate and energy policy package provides the justification for increased policies. The national 14% target is after all determined by the European Union and based on the “20-20-20” targets. These targets consist of a 20% reduction of greenhouse gasses, 20% energy efficiency improvement and a renewable energy share of 20% in 2020, compared to 1990. A set of binding legislations should ensure that the EU will meet these targets. This climate and energy package consists of four measures:

A reform of the EU Emissions Trading System
The European Trading System (ETS) is the tool designed to lower the greenhouse gas emissions of large emitters, such as industrial companies, in the EU. By giving out tradable emission permits and thus putting a price on emitting carbon dioxide, market forces were expected to regulate emissions. However,

an overabundance of permits, largely created by the governments which give away free rights to companies, is standing in the way of effective market regulation. Whereas experts consider a price level of >€50 per ton of emitted CO_2 equivalents necessary to ensure a sufficient stimulus of renewable energy and energy efficiency measures, in reality the price dropped to <€3 the beginning of 2013 (VNCI, 2010; Brookings, 2013). From 2013 a revision and strengthening of the system will be applied which should make it more effective. These revisions include the replacement of national caps for a single European cap but most importantly this cap will be cut each year, in 2020 the emissions included in the ETS will lie 21 per cent below the 2005 level.

National targets for non-EU ETS emissions

Only about 40% of the total EU emissions are included in the ETS, 60% of the emissions stem from sectors that are not included, such as the residential and agricultural sectors. EU member states have agreed on binding national targets for the reduction of these emissions, these span the 2013-2020 period and range from a 20% reduction compared to 2005 by the richest countries and a maximum allowed increase of 20% by the least wealthy.

National renewable energy targets

As explained earlier, under the Renewable Energy Directive (2009/28/EC) member states agreed on binding national targets about the share of renewable energy in their energy mix. One of the problems with the RED is the lack of clear consequences of failing to meet the targets, according to the Directive a Member State only has to submit an updated action plan if the share of renewable energy falls under the indicative trajectory (article 4(4)) and inform the Commission if they think they will be unable to meet the target (article 5(2)).

Carbon capture and storage

As a temporary measure to avoid the emission of CO_2 into the atmosphere, CO_2 can be stored in geological formations, such as empty gas or oil fields. In order to make the storage of CO_2 possible, the climate and energy package includes the creation of a legal framework for the environmentally safe use of carbon capture and storage

Although the idea behind the climate and energy package is to achieve a considerable reduction of greenhouse gasses, the means to reach this objective fall short, caused by the failed ETS scheme and the shifting focus between CO_2 and renewable energy. For instance, national policies are heavily steering in the direction of biomass use for renewable energy production although these measures often result in more greenhouse gas emissions.

2.1.2 *Definition sustainable heat*

When talking about renewable energy and sustainable energy it is important to define these terms since these can mean different things for different parties. Whereas the Dutch government defines sustainable heat as heat supplied by renewable heat sources, the province of South-Holland also includes waste heat as an energy saving option in sustainable heat targets (Ecofys, 2008). In this research the explicit difference is made between *renewable* heat supply, and *sustainable* heat which also includes the recovery of low caloric heat. Sustainable heat supply thus includes measures that lower the fossil fuel intensity of heat supply and is made up of renewable and recoverable heat. This is done in analogy with the generally accepted definition of sustainable energy, which includes, although in different wordings depending on the source, the twin pillars renewable energy and energy efficiency.

2.1.3 *Trias Energetica*

When talking about making heat use or energy use more sustainable it is important to determine what the best approach would be. In this light the different shades of saving energy must be identified. The province of South-Holland has adopted the Trias Energetica concept. This concept was developed in 1979 and internationally introduced in 1996 and can be applied to sustainable designs in general and provides a useful tool to determine a preferred sequence of energy saving measures. The strategy consists of three steps: First limit the demand for energy, second make optimal use of energy from sustainable sources and third use fossil fuels as efficient as possible to supply the remaining energy demand (TriasEnergetica, 2013).

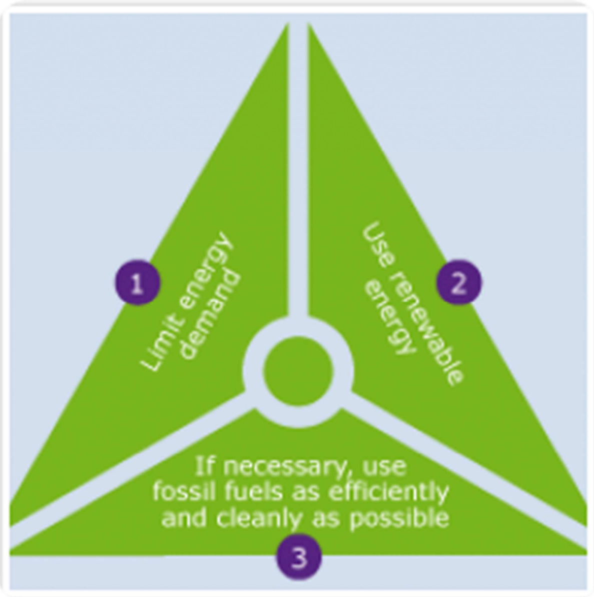


Figure 4. Trias Energetica

The concept of Trias Energetica is considered a useful approach to give direction to the objective of lowering greenhouse gas emissions in the region and making the transition to a sustainable heat system.
The focus of this research will lie with the second and third step of the Trias Energetica. In South-Holland the potential to supply renewable heat but also industrial waste heat is very large. Furthermore these are the areas on which the province can exert the most influence. Limiting the demand for energy is almost entirely determined by EU and national policy and is even then difficult to influence.
It must be said that skipping the first step can cause friction. For instance when analysing the business case of waste heat delivery through thermal grids it is advantageous not to limit the demand for heat. Limiting this demand could make it more difficult to form a business case since this limits the profits for thermal grid heat providers. This aspect is the source of debates about whether thermal grids should be promoted as sustainable solution.

2.1.4 *Transition and innovation management*

The energy supply system in general is changing. Concerns about the availability and affordability of fossil fuels and about the negative environmental effect of burning these fuels have led to a shift towards more decentralised and sustainable energy generation. This change also affects the sustainable heat system in South-Holland and has an impact on all the stakeholders in the heat system. Parties are reacting to this change by trying to safeguard or better their own position, for instance energy companies recognise this transition and are investing in sustainable energy in order to safeguard a role in the future system (F. Goudswaard, personal communication, 7 March 2013), horticultural companies on the other hand are interested in sustainable energy because they want to reduce greenhouse gas emissions but also in order to have more security of long term stable energy prices (T. Zwinkels, personal communication, 12 March 2013).

It seems as though the heat system is in transition. A transition is a change from a stable equilibrium, through different phases of radical changes and insecure events, to a new and different system. Figure 5 shows the identified typical phases of a transition. When considering the heat system, although it is in its entirety in transition, the phase of specific technologies varies from a pre-development or take off phase to technologies well in the acceleration phase.
In recognition of this transition, and by acknowledging that the province has a desired end goal, the focus of sustainable heat policy should be aimed at steering the transition to a future system of sustainable heat. A transition is inherently uncertain and the outcome of a transition cannot be determined, however the direction of a transition can be influenced in order to push the transition towards the desired end system. This is crucial since with any transition the risk arises of a lock-in of technologies and practices that eventually may lead to a system less optimal than the desired end goal or even compared to the initial starting point. By recognising and aiming for a transition, policies can be adjusted to the phase of the transition, and the process can be smoothed in order to reduce the impact on stakeholders.

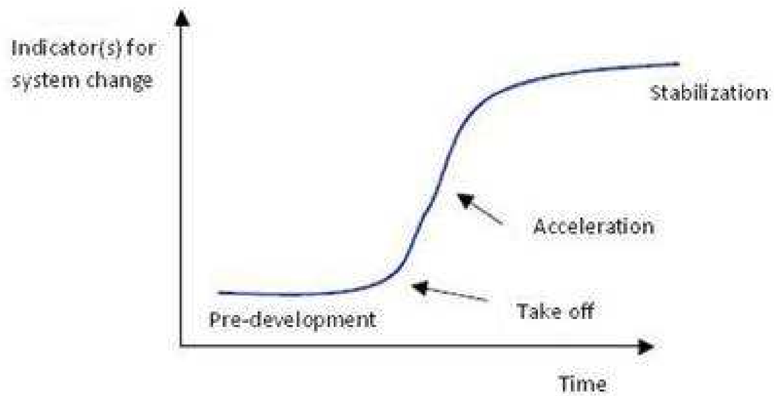


Figure 5. The transition curve

The aim to focus on a transition needs to be translated into a policy program based on transition management, as is envisioned by the Dutch Knowledge Network on System Innovations and Transitions (Fisher-Kowalski & Rotmans, 2009). In this approach two theories are combined, transition theory or management and complex systems theory. Transition theory explains how transitions from one regime to a different regime come about. Complex system theory on the other hand studies the dynamics of complex societal systems (Rotmans & Loorbach, 2009). Better insight in the functioning of complex systems and the different pathways of transitions provides understanding about the possibilities of steering transition in the aimed direction.

Although transition policy is very useful in guiding and stimulating transformative change, it is sparsely used by policy makers. It was applied at one point by the Dutch government but after the 2011 elections the use of it became unclear (Negro, Alkemade, Hekkert, 2012). Innovation policy on the other hand has a strong policy base and is widely used to stimulate R&D investments and innovative capacities. However, although the path to a new regime is paved with product and process innovations, innovation policy is often badly aligned with transition policy since by increasing the level of innovations in general foremost the economic position of incumbents is strengthened. On the other hand, transition policy stimulates disruptive innovations by new sustainable entrants in order to change the system.

By combining innovation policy and the transformative features of transition policy, the benefits of both policies can be combined (Weber, Rohracher, 2012). By doing so, the systemic problems that block the development of innovation systems, in the context of transformative change, can be identified (ibid.) Transition theory and innovation theory are applied in this report to provide policy suggestions fitted to stimulate a societal system transition. These theories will be used to analyse the barriers to a transformation to a sustainable heat supply system and to provide policies to reduce these barriers.

2.2 Potentials

2.2.1 *Potentials*

To analyse the possibilities of reaching the set targets and thereby moving in the right direction towards a sustainable heat regime the potentials of the different sustainable technologies need to be analysed in order to assess whether additional policy measures are needed.

The ***physical potential,*** as defined by the IPCC (2007b), is the theoretical, thermodynamic potential of the implementation of technologies, taking into account, and relying upon, the future development of these technologies as well as new technologies that may be developed. Taking only thermodynamic limitation into account this potential provides an upper limit.

The ***technical potential*** is the potential based on the implementation of technologies that are proven and used or expected to be proved in a certain timeframe. The potential is scaled down based on practical constrains, such as the lifetime of buildings, the availability of resources and the rate of production and installation of new technologies. Also the demand for heat is included as limitation. Although financial barriers are not taken into account, the replacement rate of capital assets does form an important and leading barrier (IPCC, 2007b)

The ***socio economic potential*** is defined as the amount of commercially available, cost-effective options based on social cost pricing and discount rates, for a given carbon price. As carbon prices both the current carbon price and a theoretical future carbon prices can be used. Cost-effective is in this sense defined as those technologies for which the net present value of benefits exceeds the incremental costs to society. This potential still takes into account technical limitations of the adoption of new technologies (IPCC, 2007b)

The ***economic potential*** is defined as the amount of commercially available, cost-effective options based on private costs and benefits. The approach is the same as for the socio economic potential only using private investment criteria instead of social costs and benefits criteria. The adoption of sustainable energy measures will, according to this potential, be motived by cost-effectiveness criteria based on market conditions (IPCC; 2007b).

The ***market potential*** is the potential that might be expected under forecast market conditions. These conditions include barriers and policies in place but exclude possible future policies. The market potential is based on private unit costs and discount rate as they are in the reference year and as they are forecasted to change in the future based on current policies (IPCC, 2007b).

In this analysis the technical and the economic potential will be analysed. Reaching these potentials is hindered by sets of barriers, as can be seen in below figure 6. (IPCC, 2001). Barriers impeding the growth of sustainable heat must therefore be removed to increase the output. The next section will explain into more detail the barriers framework that is used.

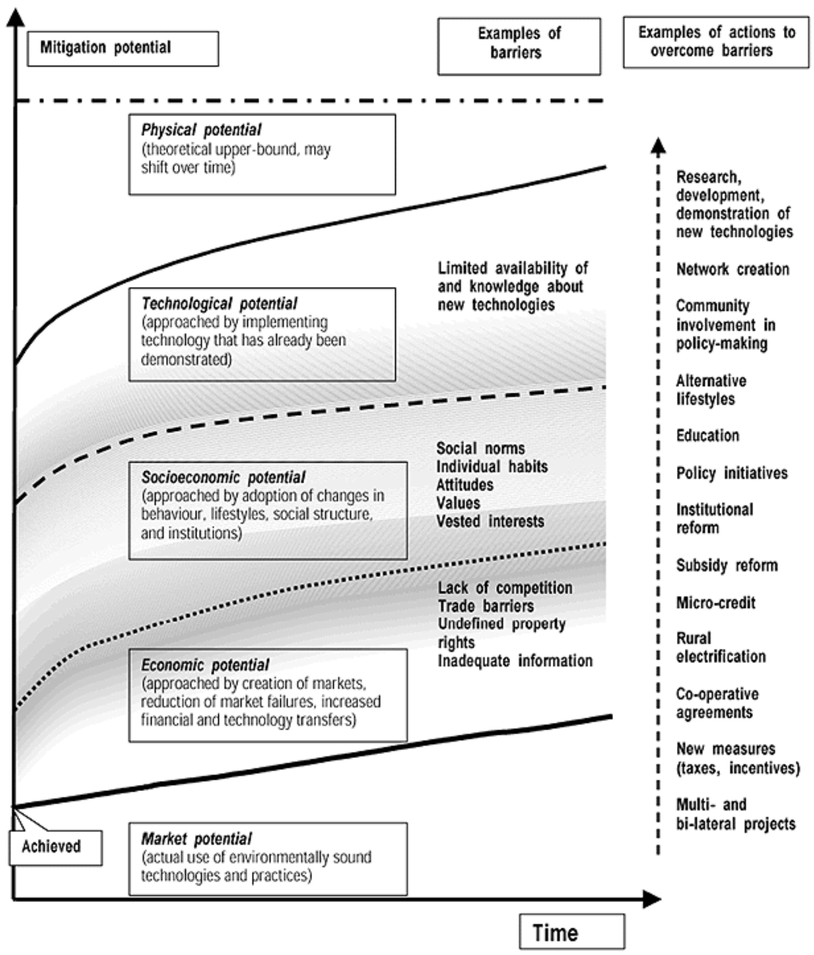


Figure 6. The link between potentials and barriers

2.2.2 *Barriers*

In literature the temp 'efficiency gap' is often used to indicate a lowered potential as a result of barriers in place, this gap is the difference between the level of investments in energy efficiency and the higher level that would be expected from cost benefit analyses (Hirst & Brown, 1990). Applying the broad definition used by the IPCC: "A barrier… is any obstacle to reaching a potential that can be overcome by policies and measures" (IPCC, 2007b). By studying the barriers in place the efficiency gap can be identified. Reducing this efficiency gap, through overcoming barriers, is the key to increasing the sustainable heat potential. In a later stage specific policies will be proposed to overcome these barriers. To identify barriers and form strategies to overcome these it is important to analyse (Sorrel et al., 2000):

1. What is the barrier?
2. Who or what is it an obstacle to
3. What does it prevent?

In this report the focus will lie with those barriers that prevent the transition to a sustainable heat supply system. A comprehensive framework, developed using insights from innovation theory and transition theory, will be used to identify failures that can cause delay in the diffusion of sustainable heat and the transformation to a new system. This framework consists of classical market failures, the standard base for policy intervention in innovation activities, structural system failures, concerning the sub-optimal mechanisms that contribute to weak system performance, and transformative system failures, accounting for the goal of transformative change (Weber, Rohracher, 2012). The below table sums up the barriers that will be used.

Table 1. Failures framework

Market failures	Information asymmetries
	Knowledge spill-over
	Externalization of costs
	Over-exploitation of commons
Structural system failures	Infrastructural failure
	Institutional failure
	Interaction or network failure
	Capabilities failure
Transformational system failures	Directionality failure
	Demand articulation failure
	Policy coordination failure
	Reflexivity failure

The barriers will be shortly described in this section, in chapter 5 the case specific influence of these barriers on sustainable heat in South-Holland will be analysed.

Information asymmetries	Uncertainty about the real and long term value of technologies leads to sub-optimal relocation of resources and thus an undersupply of funding and R&D.
Knowledge spill-over	The difficulty of protecting information as private asset reduces the returns of innovations for individual companies and therefore leads to sub-optimal investment in basic R&D.
Externalization of costs	Some activities have a negative effect on external parties or the entire environment. Companies can often externalise these costs, instead of being forced to internalise these costs, thereby reflecting the social costs and benefits in product prices. This leads to an innovation climate which does not take external costs into account and therefore also supports innovations with a negative social cost benefit balance.
Over-exploitation of commons	The fact that benefits of exploiting commons are obtained individually whereas costs are shared by the entire group of users leads to over-exploitation.

Infrastructural failure	A lack of physical, financial and knowledge infrastructure, compared to the reference system, makes it difficult for sustainable heat to compete.
Institutional failure	Formal institutions such as regulations or standards may hinder sustainable heat technologies, informal institutions such as values, culture, and norms etc. form unfavourable circumstances for system transition.
Interaction or network failure	Too strong interaction may lead to a lock-in of established practices and blindness for new trajectories of change. Too weak interaction on the other hand prevents the sharing of complementary resources and processes and prevents the possibility of learning from network partners.
Capabilities failures	A lack of capabilities, such as skilled technical personnel, prevents the successful adaption to new circumstances. This can lead to the wrong technology choices, risking over-dimensioned systems.
Directionality failure	Shared future visions and collective coordination by key policy makers as a basis for implementing policies serves to define the direction of change. The definition of acceptable development paths helps to steer innovation and transition in the right direction.
Demand articulation failure	Innovations are often not taken up by users and consumers. This can be overcome by integrating users and consumers in innovation processes, promoting the use of new technologies and by innovation-oriented procurement mechanisms by governmental bodies.
Policy coordination failure	The lack of interaction of different policy areas limits transformative changes. Coherence is needed between the activities and timing of interventions of national, regional, sectoral and technological institutions.
Reflexivity failure	Monitoring and self-governance is needed to keep on the right trajectory towards a system transformation. Policies must be adapted if they turn out to be less effective than expected, a policy package should be able to cope with general uncertainty.

The focus of the barriers analysis will lie with the most important and relevant barriers in South-Holland. As stated above, the goal of this research is to analyse the potential of sustainable heat and to propose ways to overcome the barriers in place to increase this potential. Therefore, after identifying all barriers that play a role on different sustainable heat technologies, the focus will be brought on those where the Province can play a role.

2.3 Policy suggestions

The identification of the barriers and potentials forms the basis of the suggested changes to reach a higher potential. The end goal is ultimately to provide a way for the province to reach targets and thus to make clear policy suggestions. In principle the needed changes to the heat system will be proposed without taking into account the possibilities and limitations at the province, such as the available resources. The purpose of these suggestions is not to determine exactly the sustainable heat policy at the province in the coming years but is to show optimal policies when just looking at the stimulation of sustainable heat. The role of the province will however be taken into account and additional measures that lie outside the scope of the province will also be analysed to show the potential that can be reached when policies of other stakeholders, mainly the national government, are aligned with those of the province.

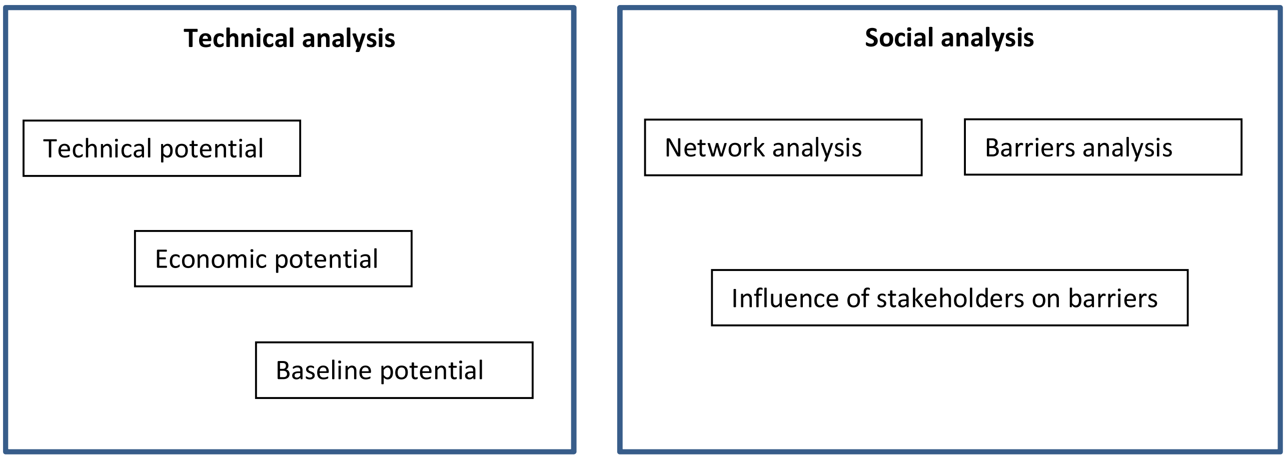
3 Methodology

3.1 Introduction

This chapter will explain the methodology used to answer the research questions. First, by analysing the specifications of sustainable heat technologies and the characteristics of heat use in the different sectors, the preferred use and possible application of sustainable heat technologies can be determined. This will broadly be based on literature review and statistical research into the extent of sustainable heat technologies in different sectors and the historical growth rates. This will be used to calculate the technical, economic and business as usual potentials for sustainable heat.
In the next part this is coupled to an analysis of the barriers in place. The selected barriers will be based on transition and innovation theories, the identification of barriers in place will be based on specific literature research into the heat system in South-Holland, interviews with stakeholders and the results from the first part of the analysis.

3.2 Research framework

This research consists of two parts, a technical analysis and a social analysis. In each part the heat system is analysed through a different view. These views are then combined in order to look through the system in a way which will provide answers to the research question. The technical analysis consists of an analysis of the technical, economic and baseline, or business-as-usual, potential. The social analysis on the other hand analyses the sustainable heat network in South-Holland, the barriers to sustainable heat and the influence of stakeholders on barriers. Combined these parts will provide proposed measures to overcome barriers and to increase the sustainable heat potential.



3.3 Literature review

A literature review has been conducted in order to analyse the characteristics of heat delivery in the Netherlands in general and in South-Holland in particular, as well as the existing sustainable heat supply in the region. Within this review, the focus lies with the role of sustainable heat and the compatibility of sustainable heat technologies with the existing organisation of heat supply. The potential of different technologies to reduce the fossil fuel use for heat supply is analysed, making use of literature reviews about the applicability of technologies in certain sectors and information about the costs and benefits of technologies.

Desk research about the opportunities and barriers associated with the different sustainable heat options is used as a base for the barriers analysis. These opportunities and barriers are specifically analysed for their role in South-Holland, the regional characteristics of heat demand and supply are used to place the barriers and opportunities into a provincial setting.

3.4 Heat atlas

Based on the data made available by AgentschapNL in the WarmteAtlas a sketch of the heat demand and supply characteristics in South-Holland is made, this broad analysis is made in order to highlight the possibilities of sustainable heat use.

The retrieved data from the online source provides information about the heat use in all different districts in South-Holland, of which only the low temperature heat use is taken into account (<120 °C). This is used both to calculate the heat use in South-Holland specified per sector as well as to provide information about the geographical distribution of heat use and waste heat availability which can be used to determine the potential of sustainable heat in certain areas.

It must be mentioned that it proved not feasible to construct a detailed map of the (industrial) waste heat supply because of the unwillingness of companies to provide data about their heat use and discharge. Instead both literature sources on the largest point sources of waste heat, as well as information on all industrial waste heat suppliers, as shown in bandwidths in the WarmteAtlas, will be used.

3.5 Existing sustainable heat consumption

The existing contribution of sustainable heat technologies is for the most part reviewed by making use of the Statistics Netherlands database. The Statistics Netherlands data for sustainable energy is in general not split over the different provinces; therefore indicators were used to estimate the provincial share:

Table 2. Indicators of South-Holland share of sustainable heat technologies

Sustainable heat option	Source	Year	indicator
Heat and cold storage	CBS	2011	2008 ratio of subsidy request provinces
Biomass woodstoves	CBS	2011	Map of large biomass projects in the Netherlands and ratio of applicable houses for residential woodstoves.
Solar thermal energy	CBS	2011	2008 ratio of subsidy requests provinces
Heat from milked milk	CBS	2011	Number of milk cows

There are two exceptions to this approach, waste heat and geothermal energy. Waste heat is not considered sustainable by Statistics Netherlands and is therefore not shown in sustainable energy reports or databases. Since there are no significant existing waste heat projects, the current contribution of waste heat is neglected.

The geothermal energy consumption is calculated using key figures of the existing projects in South-Holland. Most of the Statistics Netherlands data stems from 2011 and is therefore slightly outdated. For most sustainable heat options this is considered an acceptable approximation considering the modest absolute growth rates. However the first geothermal energy source has only been operational since the end of 2007 and the field is rapidly changing. This problem is overcome by calculating the gross final heat consumption of the existing geothermal sources, using the key figures of hot water production from these wells. The generated energy is calculated using the following formula:

$E = Q * C_p * \Delta T * \rho * t$

E= energy [J]
Q = flow [m^3/s]
C_p = specific heat capacity [J/kgK] = 3541 J/kgK
ΔT = temperature different [K]
ρ = density [kg/m^3] = 1071 kg/m^3
t = elapsed time [s]

For the elapsed time a load factor of 5000h is used, based on the monitoring protocol renewable energy 2010 update (AgentschapNL, 2010). The constants are based on research into an existing geothermal well in South-Holland (Gonzalez, 2012).

3.6 Business as usual sustainable heat potential

The Business as Usual (BAU) potential of sustainable heat in South-Holland in 2020 is calculated, this is the potential based on the development of sustainable heat under existing conditions. This will serve as baseline in order to analyse the needed additional efforts in order to meet the sustainable heat target. For this analysis, two different approaches were used. The sustainable heat technologies can roughly be divided into two categories, waste heat and geothermal energy projects are characterised by large (and few) systems, whereas the other technologies are smaller in size but greater in number.

For the latter group trend lines are used based on Statistics Netherlands data, this data shows a similar growth trend for most technologies, exponential growth at first, followed by a somewhat linear growth path, consistent with the S-curve life cycle generally associated with innovations. It is assumed that these growth rates will remain linear until 2020.

When it comes to waste heat projects and geothermal projects there is no real business as usual scenario since activities in this field only started a few years ago and it is not yet clear in what way the market will develop. For these two cases the status of existing plans is critically reviewed and the projects that are likely to be developed will be taken into account to be used as business as usual in the coming few years. Since the realisation of these projects spans at most a couple of years, a trend line for geothermal energy based on the Statistics Netherlands data is constructed anyway and used as a default BAU trend for the last years of this decade.

3.7 Future economic and technical potential

3.7.1 *Technical potential*

The technical potential is analysed in a top down manner, using the demand for heat as starting point, based on the heat atlas data. The heat demand specified over the different sectors in South-Holland will form the bases for this analysis since the applicability of certain technologies in certain sectors forms the foremost limitation. By scaling the demand for heat down based on certain limitations, for instance the replacement rate of existing heat supply system, the technical potential can be analysed. This is first done for the separate technologies, after which this is synthesised into a province wide technical potential based on the preferred use of certain technologies over others. This potential is calculated up to 2020, after 2020 the development of technologies and the introduction of new innovations is expected to significantly change the potential, this lies outside the scope of this report and is not taken into consideration.

3.7.2 *Economic potential*

The economic potential on the other hand will be calculated in a bottom-up fashion, looking at the possible installation rates of specific technologies in specific sectors. This is based on the payback times of measures under the business as usual market conditions. It is assumed that different sectors will handle payback times differently and that within sectors there are risk takers that are prone to invest in new technologies and others that perceive new systems are uncertain or even threatening. It is therefore assumed that in each sector a certain percentage will invest in the technology based on the pay back times. In this a difference is made between existing, new and renovated properties.

3.8 Social analysis

3.8.1 *Stakeholder interviews*

The literature review about the barriers and opportunities of sustainable heat is complemented by a stakeholder analysis. These semi-structured interviews provided information about the heat system in South-Holland, about specific technologies and sustainable heat projects in the region and were used to confirm, complement or weaken those barriers and opportunities already identified. Within these interviews specific attention was given to the role of these stakeholders as perceived by themselves as well as their perception of other parties in the heat supply system, in particular the Province of South-Holland. Also the perception of the opportunities of sustainable heat in South-Holland as well as the barriers that hinder the implementation of technologies and the possibilities of overcoming these was accentuated. These stakeholders were furthermore asked to explain in what way the province could play a role in overcoming these barriers, in what way the province could make implementing sustainable heat more attractive, and which barriers can probably not be solved by the province. Lastly these stakeholders also provided insight in the complex sustainable heat field and could give specific information about current and planned sustainable heat projects. A list of conducted interviews can be found at the end of the Bibliography.

3.8.2 *Selection of barriers*

The barrier analysis will be based on a transition management perspective. By focussing on those barriers that inhibit the transition to a sustainable heat supply system, this transition can be stimulated through overcoming the barriers. By considering the importance and role of barriers, specific policies can be proposed, again motivated by transition theories.
Furthermore the focus of this report lies with the barriers that are most important and most applicable to the case of sustainable heat in South-Holland as reviewed from a province perspective. After identifying the stakeholders involved in the heat supply system as well as the relation between these stakeholders and the influence of these actors on the existing barriers and solutions, the attention will be brought back to the Province of South-Holland.

4 Technical Analysis

As can be seen in chapter 4.1 the low temperature heat use in South-Holland, in the horticultural services and residential sectors together, is about 150 PJ. In theory this can all be supplied by waste heat since the excess heat availability to heat use ratio is between 2 and 5 in South-Holland. However, this is largely made up off dispersed low concentrated sources. When considering the discharge of warm water in the port of Rotterdam area, still over 35 PJ is available as can be seen in 4.2, combined with the large potential of geothermal energy, especially in the Westland area, the availability of sustainable heat is therefore considered no limitation.

In chapter 4.3 the future demand for low temperature heat and the cost benefit balance of sustainable heat technologies is analysed. This by analysing the changing indicators of heat use and sustainable heat extent, based on four scenarios. In chapter 4.4 these indicators are used to calculate the economic potential for sustainable heat in 2020 and 2050. This is based on the payback time characteristics of technologies and assumptions about the implementation of technologies. This analysis shows the limited contribution that can be expected from measures in the residential and services sector. The economic potential for geothermal heat in the horticultural sector is however large, making the total economic potential, excluding waste heat, about 27 PJ in 2020. In theory reaching the 2020 targets is therefore considered possible from an economic point of view. The four 2050 scenarios on the other hand show the need to include all forms of sustainable heat in all sectors in order to reach long term targets.

Chapter 4.5 shows the technical potential for sustainable heat use in South-Holland in 2020, ignoring economic constraints, but taking into account barriers with respect to the suitability of certain technologies in certain sectors and the replacement rate of existing heat supply system. This potential amounts to over 50 PJ in 2020. By influencing the payback time of sustainable heat technologies a significant larger potential can thus be reached.

However, at the end of the chapter the economic and technical potential are left aside. In the end, the potential that can be achieved based on the existing sustainable heat, the business as usual growth rates of technologies and the planned geothermal and waste heat projects is reviewed. This shows a potential of only 11.2 PJ heat consumption, this makes clear that extra efforts are needed and the barriers that hinder the implementation of sustainable heat need to be reviewed.

4.1 Reference situation of heat use in South-Holland

In this analysis only the low temperature (<120 ^{0}C) heat will be taken into account. This low temperature heat can relatively easy be supplied by sustainable heat and is characterised in South-Holland by both a large demand as well as a large supply. This low temperature heat analysis takes into account residential heat use, horticultural heat use, and the low temperature heat used in services sector buildings.

The Heat Atlas is used to provide information about the heat use in the different sectors, figure 7 shows screenshots of this online database. Upon clicking on the various districts the heat atlas shows the heat consumption in these districts in 2011, this is calculated into a list of the heat use in all municipalities of South-Holland. The total residential heat use amounts to 65.1 PJ and the horticulture heat use to 41.9 PJ. The heat use in the services sector is not yet shown in this atlas and is estimated based on the national heat use and the number of buildings, as well as the value of building permits in the different provinces. The share of South-Holland in the number of buildings is 19.9% and the share in the building permits is 20.4% (CBS, 2012a; CBS, 2013b). The total primary heat use in the service sector in South-Holland is estimated as 20.15% of the national services sector heat use. Using this fraction, the services sector heat use is estimated to be 46.7 PJ in South-Holland (SenterNovem, 2009).

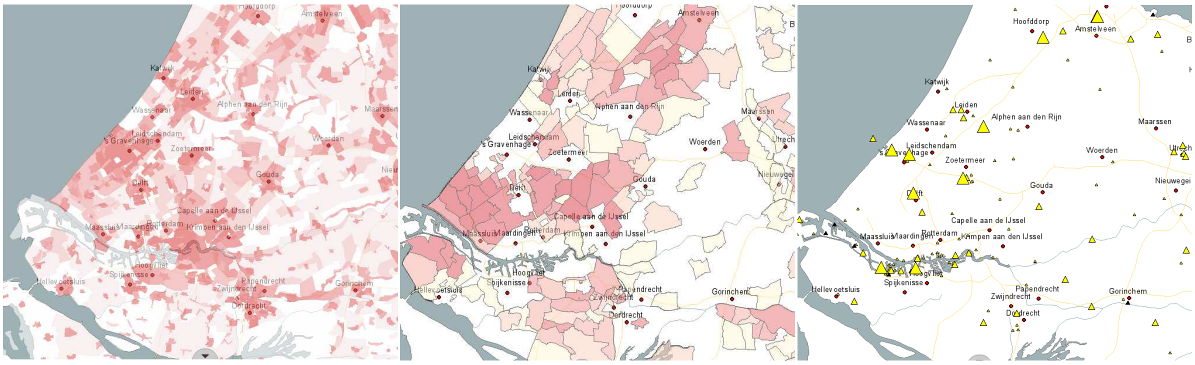
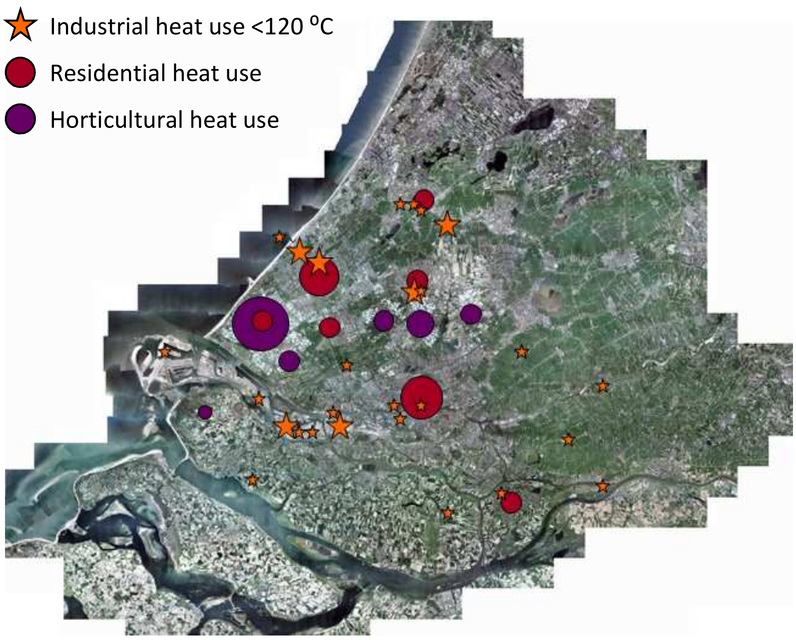


Figure 7. Heat maps of residential heat use (a), horticultural heat use (b), industrial low temperature heat use (c) (AgentschapNL, n.d.-a).



This total of 153.7 PJ heat use is unevenly distributed. The residential heat use is, as can be expected, closely related to population densities. The horticultural heat use is mainly centred around the Westland municipalities, accounting for 47% of the total. Figure 8 shows a geographical indication of the largest users of industrial, residential and horticultural heat use.

Figure 8. Rough geographical indication of large sources of industrial, residential and horticultural heat use calculated using data from the heat atlas (AgentschapNL, n.d.-a)

4.2 Heat availability in South-Holland

4.2.1 *Waste heat*

Creating complete insight in the availability of waste heat in South-Holland is extremely difficult since industrial companies are hesitant or refusing to give information about their heat use and discharge. To a certain extent these companies are obliged to report their discharge of heat, however this only holds for ETS companies and MJA-3 companies (companies that participate in a voluntary long-term agreements) (CE Delft, 2011). This discharge information is however classified as confidential and is therefore not publicly available.
To overcome this confidentiality problem, AgentschapNL shows the available data, as reported by ETS and MJA-3 companies, as bandwidths. This way the information provision is maximized without compromising the confidentiality of information (CE Delft, 2010). These bandwidths are shown in the national Heat Atlas and can be seen in the below figure 9 (AgentschapNL, n.d.-a).

The data in this atlas is based on the amount and temperature of heat as it is discharged to the environment, through air or water. However, when looking at possible use of industrial waste heat, particularly the amount of heat available before it is cooled to meet discharge standards is of interest. This information is however not available and reduces the usefulness of the heat atlas in this respect.

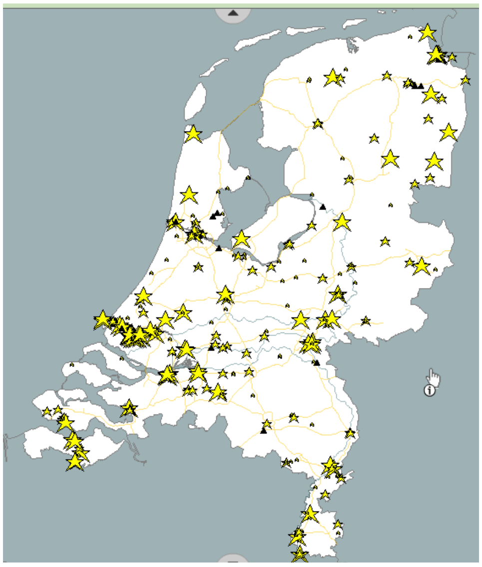


Figure 9. Waste heat <120°C, AgentschapNL, n.d.-a

Analysing the data from the heat atlas shows that low temperature waste heat is abundantly available in the province. By far the largest part is available in the Rotterdam municipality, in the Maasvlakte, Europoort en Botlek districts. Looking at the heat map it is tempting to conclude that the largest availability of low temperature heat is in the Botlek area. However, calculations of CE Delft (2002) estimate an energy availability, in the form of hot water, of 17.5 PJ in the Maasvlakte, 8.3 PJ in the Botlek, 5.6 PJ in Pernis, and 5.2 PJ in the Europoort. This waste heat can be used sustainably by transporting this to the Westland horticultural area and the The Hague municipality; this is a distance similar to a waste heat pipeline being under construction in the Rotterdam area (De Nieuwe Warmteweg, 2013).

In figure 10 both the heat use in South-Holland and the availability of low temperature industrial waste heat is shown. In the Netherlands there is more excess heat available than the demand for heat in the residential and services sector (ratio of 1.15; Euroheat & Power, 2013) Zooming in to South-Holland, for large parts of the province this ratio is between 2 and 5 (ibid.).

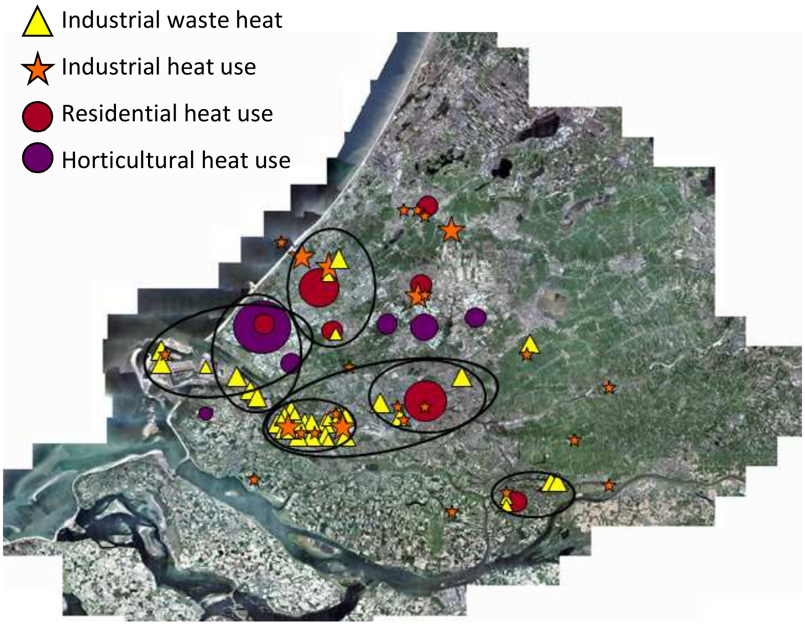


Figure 10. Heat use and consumption < 120 °C in South-Holland, calculated using data from the heat atlas (AgentschapNL, n.d.-a)

Geothermal potential

Next to the large potential of waste heat, the potential for geothermal heat is also considerable. Below South-Holland there are two promising aquifers. Additionally, the locations of the geothermal potential of these two aquifers shows a near perfect match with the areas of large horticulture heat use, as is shown in figure 11.

The Cretaceous aquifer lies roughly around a depth of 2000 m, in this aquifer a handful of geothermal wells are operational. The Triassic aquifer lies roughly at a depth of 4000 m, this aquifer could house projects with larger energetic outputs however the expected outcome is also far less certain. Although the temperature of the aquifer can be estimated with great accuracy, the permeability of the aquifer is less certain. This permeability, and the possible need to increase the permeability with hydraulic fracturing techniques, is the key to the potential of Triassic geothermal projects.

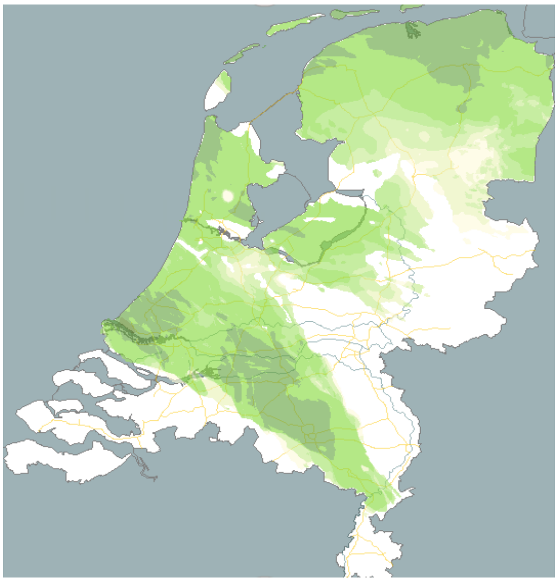


Figure 11. Geothermal potential from aquifers 1500-4000 m depth (AgentchapNL, n.d.-a)

4.3 Available sustainable heat technologies

4.3.1 *District heating*

District heating is the technique of supplying heat in the form of warm water through central pipelines, so called thermal grids. The heat source for district heating can either be waste heat or heat generated specifically for this purpose. According to some analyses, the delivery of heat through CHP district heating has one of the lowest carbon footprints of fossil fuel generated heat supply to buildings (Claverton Energy, 2009). Replacing the fossil fuel by a renewable heat source would further improve the sustainability of the system. District heating consists of three different subsystems, the supply of heat to the central grid, the transportation of heat and the distribution of heat to individual houses.

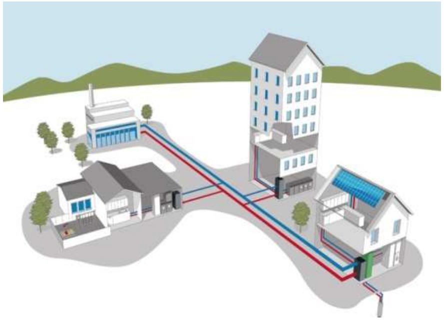


Figure 12. District heating system

4.3.2 *Geothermal energy*

When harnessing heat from the earth, the distinction is made between deep geothermal energy (>500 m) and shallow geothermal energy (<500 m). From now on the distinction will be made between deep geothermal energy, which will be called geothermal energy and shallow geothermal energy for which the term Heat and Cold Storage is used. Technically HCS systems do not produce sustainable heat but merely store generated heat, however the origin of the stored heat is often sustainable and these techniques form an excellent addition to sustainable heat systems and are therefore included in this analysis.

The Netherlands is reasonably suitable for deep geothermal energy. Although temperatures are moderate, ranging from <70°C to >90°C at 2000 m depth, the presence of sufficient thick and permeable aquifers are favourable circumstances that make hydrothermal circulation possible. These aquifers can mainly be found in the Northern and Eastern part of the country and in parts of North-Holland, North-Brabant and South-Holland (Lokhorst & Wong, 2007). The first geothermal heat system in the Netherlands has been operational since 2006, in South-Holland, and a total of six wells have been drilled in the province in total.

Heat and Cold Storage (HCS)

The seasonal storage of heat in shallow aquifers below 10 meters where ground temperatures are largely constant year round. Through pumping up water and extracting the heat stored heat in summer can be used in winter. Systems vary in size of single houses (closed system, storing water in pipes underground) to large commercial and office buildings (open system, storing heat directly in aquifers).

(Deep) geothermal energy

The production of sustainable heat from permeable aquifers >500m depth through pumping up hot water or steam, extracting the heat and pumping back cold water through a different well.

Because the underground of the Netherlands is characterised by an abundance of suitable shallow aquifers, HCS is widely applied with a focus on large open systems. These systems are especially applied on large scale in South-Holland with a focus on horticultural areas, as can be seen from the permits granted in the province in figure 13.

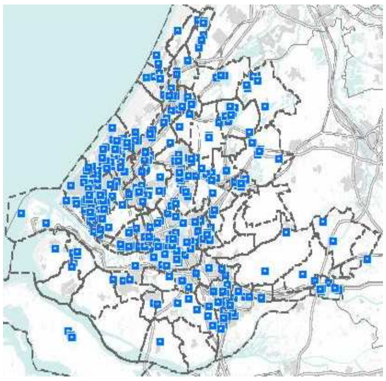


Figure 13. HCS permits South-Holland

HCS is often combined with heat pumps, these use electricity to produce either heating or cooling, depending on the thermal direction of the pump. A ground source heat pump, coupled to underground water circulation, offers a 45% reduction of fossil energy compared to a high efficient condensing gas boiler, air source heat pumps on the other hand offer a 25% reduction (Fraunhofer ISI, 2011; International Energy Association, 2008).

High Temperature Heat Storage is also considered in this report, this is the storage of heat of a higher temperature, for instance generated through a geothermal well. Excess heat is stored in the winter, at greater depths than normal HCS, and used in the summer, when it will have retained some of its heat. His application is solely meant for heat storage, no cold water is stored during the winter and the system will therefore add heat to the underground. This application is still being researched, in the form of pilot projects (If Technology, n.d.).

4.3.3 *Solar thermal energy*

Solar thermal energy is the use of sunlight to produce heat. By circulating water through flat plate collectors, the water is heated and can be used as tap water base load heating or in low temperature heat supply systems in modern houses. Solar thermal energy can be applied to individual houses, in combination with a gas boiler, or on the scale of building blocks, with combined storage tanks and boilers or heat pumps to provide back-up heating.

4.3.4 *Biomass*

Energy generation from biomass can be divided in the burning of woody biomass and the anaerobic digestion of wet biomass to biogas. When analysing the role of biomass for sustainable heat supply, the biomass availability is taken as a limiting factor. The incineration of imported biomass is considered to be not sustainable, also agreed by the province, and is therefore undesirable. Furthermore it is important not to double count the contribution of biomass to sustainable heat targets. Heat generated by the incineration or co-firing of biomass could already be included in the analysis as waste heat used in thermal grids.

4.4 Technical potential sustainable heat and cold in South-Holland

The available sustainable heat technologies mentioned above can in theory be used in all different heat use sectors, however not every technology is suitable for every type of heat use. Furthermore there are limitations that reduce the possible implementation of sustainable heat. This next part will analyse the technical potential of the different sustainable heat technologies and the total potential of sustainable heat in South-Holland in 2020.

4.4.1 *Changing heat demand 2013-2020*

The energy use in the horticulture sector is expected to decrease with 1.3% per year until 2020 (ECN, 2007). Since the energy use in this sector is largely in the form of heat, it is assumed that the demand for heat will also decrease with 1.3% per year (ibid.). The total amount of horticultural area is assumed to remain unchanged, this would result in a heat demand in 2020 of 38.3 PJ. The heat use in the residential sector is assumed to remain unchanged. The gas use in households, which is a good indicator for heat use, has been gradually decreasing over the past decades, however, in the past years the gas use has been more or less stable, ignoring climate effects (CBS, 2008). Assuming that in the coming years energy saving measures will be offset by an increase in housing size and the number of houses, the heat use is predicted to remain roughly constant until 2020. In the services sector the effect of rising energy prices is expected to lead to a decrease of the heat use of 0.5% per year in this sector, this based on the argumentation that the average size and number of buildings in this sector will not increase as much as in the residential sector considering the trend towards more efficient use of building space in this sector (TNO, 2011)

4.4.2 *Technical potential sustainable heat technologies*

Heat and Cold Storage

Small closed HCS systems are suitable to be applied in the residential sector. However the use of heat and cold in this sector is characterised by a large imbalance between heat and cold demand, this is considered such a practical barrier that the use of HCS in the residential sector is not taken into account. Larger open systems can be used in the horticultural and services sector. In the first, the cold use is highly inferior to the use of heat, only in so called 'closed greenhouses' and in a few specific subsector the need for cold can be high enough to justify a HCS system. Therefore the application of normal HCS systems is also limited in the horticulture sector. High temperature heat storage could however be combined with geothermal heat to increase the output of the geothermal system. Albeit a low load factor these installations can be valuable because they offer this larger output against little costs. Because the use of high temperature HS is considered to be possible in the coming years, the horticultural heat demand is taken into account.

Next to the limitation of HCS in the residential sector, also the negative aspects of interference between heat and cold sources plays a role and limits the number of HCS systems per area in the other sectors. In

this analysis a lower limit of one open HCS system per hectare is used. However, considering the large possible output of systems, up to 20 MW, the possible output of HCS per hectare forms no limitation (Lokhorst & Wong, 2007).
The next limitation to HCS systems is the existing heat supply systems, it is assumed that these systems will not be replaced before the end of the depreciation period. For the horticultural sector a CHP unit is used as reference, with a depreciation period of 10 years. The technical lifetime of a CHP unit is 10-15 years (Energiek2020, 2010), the economic lifetime of most CHP installations however is 10 years (European Commission, 2006). In this report a period of ten years is used as the minimum period after which companies might replace the CHP for a sustainable alternative.

Ten years ago in 2003, the installed CHP capacity was only 27% of the 2011 production (CBS, 2012b; CBS, 2013c). It is assumed that no new capacity has been installed since 2011. Since 2011 both the production and the installed capacity of CHPs decreased, furthermore in the last two years the circumstances for CHPs were less than favourable, with the gas prices being high and the electricity prices relatively low. The 2013 CHP heat production is therefore assumed equal to the 2011 production, at 64% of the total horticultural heat production (ibid.). It is therefore assumed that in 2003 27% of the 2013 production was already installed, therefore 73% of the current CHP heat production has been installed in the last ten years.
Understanding that 73% of the current CHP heat production has been installed within the last ten years, and that the total CHP heat production makes up 64% of the total heat production, the potential of geothermal energy based on the replacement rate of CHPs in 2013 should be scaled down with 47%. Towards 2020 this limitation disappears, the increase of the potential between 2013 and 2020 is considered equal to the increase in installed capacity between 2003 and 2010.

In the services sector a high efficiency boiler is used as reference, the service life of this is estimated to be 15 years. Assuming that the instalment of high efficiency boilers has been gradually over the years, the potential for replacement will be 7% of the heat demand per year, minus the reached energy efficiency improvements (Consumentenbond, n.d.). Finally, taking into account the efficiency of heat and cold storage, the technical potential of HCS is calculated to be 23.6 PJ in 2020.

Geothermal energy

The potential for deep geothermal energy systems in the horticulture sector is limited by the geographical distribution of heat supply, the geographical distribution and the concentration of heat demand, the dominant electricity demand in some companies and the replacement rate of existing CHP installations.
The supply of heat forms no limitation, in the Cretaceous aquifer in the Netherlands, of which about a third is located in South-Holland, below the Westland municipality, there is about 3000 PJ heat in place, in the Triassic aquifer, largely located under South-Holland this is even 30 000 PJ (Lokhorst & Wong, 2007). Considering the concentration of heat demand in the Heat Atlas only municipalities with a horticultural heat consumption over 500 TJ are assumed to be potential areas for geothermal energy, this based on the average size of existing geothermal installations and the assumption that geothermal

projects will not be designed to meet all of the horticultural demand in the entire municipality. Using this threshold, 6.6% of the total demand for heat is excluded, bringing the potential down to 35.8 PJ
Electricity use is dominant, compared to the demand for heat, for some illuminated cultivation sectors, this is mainly the case for the production of cut flowers (ECN, 2007). In 2012 the share of horticultural area used for this type of production was 26.6%, decreasing from 37% in 2000 (CBS, 2013d). In this analysis 25% of the horticultural heat use is excluded based on electricity demand, bringing the potential to 26.8 PJ.
Taking the depreciation period of CHPs into account, and assuming that the share of CHPs is equally distributed over the different type of horticulture companies, the potential needs to be scaled down with the share of CHPs not yet depreciated, as explained above in the HCS analysis.
It is assumed that drilling capacity is no limiting factor for the installation of geothermal wells. Drilling for geothermal energy is comparable to drilling for oil and gas. The future demand for geothermal drilling will still be small compared to the current demand for oil and gas drilling. With a focus shift from oil and gas production towards geothermal heat production it is considered likely that the increase in drilling demand will result in more companies specialising in geothermal energy drilling. All of the above amounts to a potential of 26.8 PJ in 2020.

Biomass

In this analysis the local availability of biomass will be used as limitation for the application of biomass stoves in companies or households. Considering the fact that the amount of biomass is limited throughout the whole of the Netherlands and that other provinces will have a use of their own for locally produced biomass, only the South-Holland based biomass is included in this analysis.
The biogas opportunities map of the province of South-Holland is used to calculate the availability of biomass in the region (PZH, 2013). This map shows the different types of biomass available in all municipalities in South-Holland, from sewage sludge to biodegradable municipal waste and agricultural waste, as well as the potential production of biogas from this. This is estimated using three conversion techniques based on the type of biomass: co-digestion with manure, digestion with composting and digestion with thermal after-treatment. The total potential for the production of biogas is 146 million m^3 per year. Using an energy content of 22 MJ/m^3 and a (very high) thermal conversion efficiency of 65% the total technical potential based on all available biomass comes down to only 2.1 PJ (Alterra, 2006; Ecofys, 2010)

Solar thermal

Solar collectors are mainly used for the heating of tap water, making them not suitable for use in the horticultural sector and the services sector since the use of hot water in these buildings is very limited. This excludes the space heating share of the heat demand, about 75% of the total heat demand (Energie-Nederland, 2011). The requirement to have roof space available to place a solar collector excludes apartments, also rental houses are less suitable because this raises split-incentive issues. Cooperative owned flats are suitable to place a larger scale combined solar collector system. She hare of owner-occupied houses is 50% in South-Holland (CBS, 2013i) and the share of apartments is about 45% of this owner-occupied total (CBS, 2013f). This lowers the potential with 22.5%.

4.4.3 Technical potential of individual measures

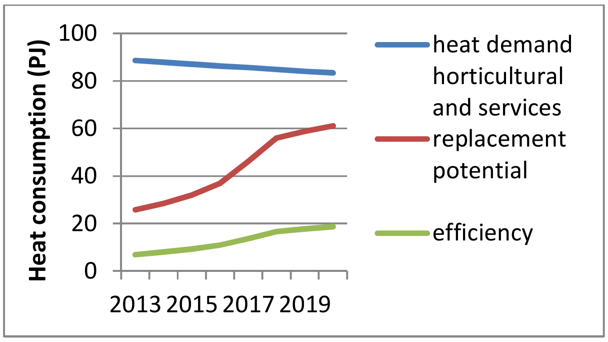


Figure 14. Technical potential HCS

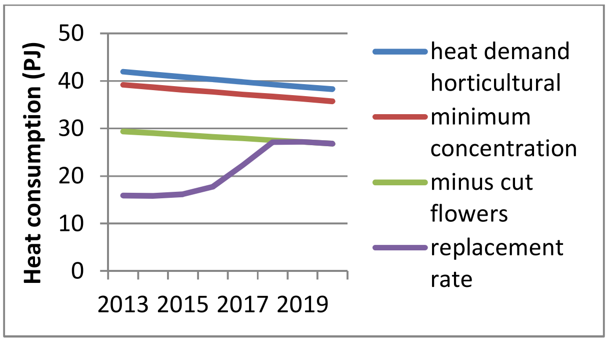


Figure 15. Technical potential geothermal energy

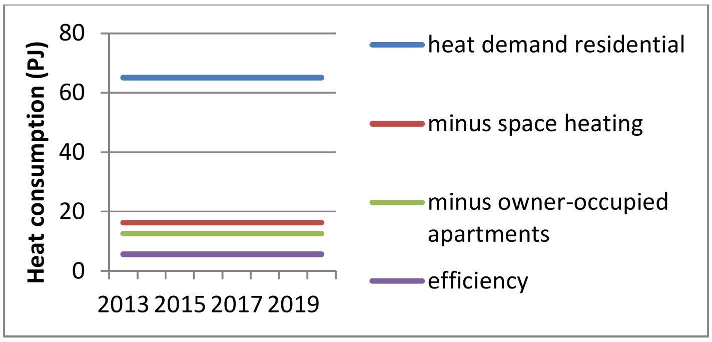


Figure 16. Technical potential solar thermal energy

Table 2. Technical potential sustainable heat technologies in South-Holland

Technology	Potential (PJ)
Heat and cold storage	18.7
Geothermal	26.8
Biomass	2.1
Solar thermal	5.7

4.4.4 Total technical potential

Considering the fact that some of the potentials overlap, the total potential is slightly smaller. For the horticultural sector it is assumed that geothermal energy is preferred over heat and cold storage. Combining the two would not increase the total potential since this is limited by the heat demand. The remaining potential for heat and cold storage in the horticultural sector is made up of the shares of the sector not serviced by geothermal energy, namely the heat demand at cut flower companies and the heat demand in low concentration areas. Considering the flexible application of biomass stoves it considered technically possible to consume the entire 2.1 PJ over all different sectors.

Table 3. Total technical potential sustainable heat in South-Holland

Sector	Technology	Technical potential (PJ)
	Biomass	2.1
horticultural	Geothermal	26.8
	HCS	2.9
services	HCS	9.1
residential	Solar thermal	5.7
Total		**46.6**

These potentials exclude thermal district heating grids. In principal district heating can best be applied in new build projects or large scale building renovation. In theory all heat demand can be supplied with waste heat, including heat demand in all sectors and of all quantities. The technical potential for waste heat is therefore mainly limited by the possible supply of this heat to the grids. As mentioned earlier the ratio of excess heat available to heat demand is greater than 1 in South-Holland making it in theory possible to supply all heat demand with district heating fuelled by waste heat.

4.5 Economic potential sustainable heat and cold in South-Holland in 2020

The balance between costs and benefits, and therefore the payback time of sustainable heat measures plays a critical role in the market uptake. In the calculation of the economic potential solely these economic considerations are taking into account, ignoring other barriers. It is taken into account that different actors value investment opportunities in a different way. Furthermore some parties have greater access to capital and thus more investment possibilities than others. This analysis is done from a bottom-up perspective, assuming that users of heat have to invest in heat systems in order for these to be taken up by the market.

Looking at the economic potential it is assumed that the payback time of measures determines the implementation rate of these technologies. This payback time is taken from literature, the simple payback time is used which takes into account the investment sum, costs and benefits of technologies and does not account for the time value of money.

The costs and benefits of technologies are highly dependent on different factors that are difficult to control and to predict, such as the use of systems and the evolution of energy prices. The use of systems is per definition not optimal, and often far from it, this must be taken into account when looking at theoretical payback time figures.

Table 4. Payback times sustainable heat and cold technologies

Technology	Payback time (years)	Uncertainty
Aquifer Thermal Energy Storage (open HCS)[1]	5-8	Conditions often far from optimal
Geothermal systems[2]	5-10	Geological risk
Borehole Thermal Energy Storage (closed HCS)[1]	10-15	Conditions often far from optimal, in that case there are no benefits
Bio-CHP [3]	>10	Against current biomass and electricity prices never
Solar boilers[4]	15-25	Including subsidy and rising energy prices of 3%, could be longer

[1] BodemenergieNL (n.d.); Provincie Drenthe (2011) [2] Platform Geothermie (n.d.) [3] AgentschapNL, n.d.-b [4] Energiezuinig.nl, n.d.; AgentschapNL, n.d.-c

In this chapter the potential of sustainable district heating is not taken into account, for users of heat connecting to a heat grid offers no benefits, and will therefore not be undertaken from an economic perspective. This because the NMDA-law applies, which indicates that district heating cannot cost more than the reference price for heating based on gas. The top down payback time of district heating grids, for the parties investing in the placement of new grids, is in the order of 10-15 years. The International Energy Agency (2008) assumes that all areas with a heat demand over 360 GJ/ha-year can economically be served by district heating, however in this bottom-up analysis this is excluded.

4.5.1 *Residential sector*

When considering the economic implementation in the residential sector, a distinction is made between new buildings/renovated buildings and existing buildings. This because sustainable technologies will be easier and cheaper to implement in combination with new heat systems, furthermore heat users will be more inclined to spend money on sustainable heat when part of a larger renovation project or part of a new house (AgentschapNL, 2009).

Looking at the payback times, 10 years is considered a critical tipping point in the residential sector. For instance the interest of the public in solar panels sharply increased once the payback time of these systems dropped below 10 years (Duurzaam bedrijfsleven, 2013). In 2012 the private use of solar panels increased with 45.000 systems, 1.2% of the home owners (Energie plus, 2013; CBS, 2013g). Using this yearly implementation rate it is assumed that in 7 year time about 8% of the home owners would adopt this technology. Rounding this to 10% it is assumed that taking nothing else into account the implementation of systems with a payback time less than 10 years is 10% in 2020.

Having said this, not the payback time of technologies but the size of the total investment is considered limiting in the residential sector since home owners usually have limited financial possibilities. This limitation excludes the larger systems, geothermal energy and open HCS. Although when considering the shorter payback time, close HCS would be preferred over solar energy from an economic point of view,

HCS and solar thermal energy are considered well compatible and can economically be used next to each other, it is assumed that 5% of the heat users would invest in solar energy in 2020.
The percentage of new houses is assumed to remain equal to that of the past years, leading to an assumed 1% growth for the residential sector, large renovations of houses is assumed to take place in 0.5% of the housing stock every year (CBS, 2012c; CBS, 2013g; Bouwend Nederland, 2013).

4.5.2 *Services sector*

The services sector must be divided into commercial and non-commercial buildings, the share of non-commercial services sector buildings is 20.3% in South-Holland (CBS, 2013h). Commercial buildings usually handle a maximum acceptable payback time of about 3-5 years whereas non-commercial buildings can accept payback times up to 10 years (NVRD, 2009), it is assumed that this translates in to an implementation rate of 0% in commercial buildings and 100% in non-commercial buildings for open HCS, with a payback time of 5 years. Since presumably 100% of the non-commercial companies invest in open HCS systems, there is no investment potential left for geothermal energy.

4.5.3 *Horticultural sector*

In the horticultural sector economic arguments to invest in sustainable heat are not just based on the payback time of technologies but more importantly on security of energy costs (T. Zwinkels, personal communication, 12 March 2013). Considering the large interest in geothermal heat it is assumed that horticulturists are to a large extent interested in technologies with a similar payback time, below 10 years. However the access to financing can play a limiting role in horticultural companies. In order to make an assumption about the number of companies that can invest in geothermal energy, the following data is used:

Payback time geothermal energy	10 years
Investment in a geothermal energy system	€8.000.000
Maximum size of cluster investing in a small geothermal energy system	10 companies (equally sized)
Profitability in the horticultural sector	100%*
Share of energy costs in the total production costs	27%**

* LEI WageningenUR, n.d.
** Energiek2020, 2010b

A geothermal energy payback time of 10 years results in benefits of €800.000 per year, or a minimum of €80.000 per company. Representing 27% of the cost, this translates to a company with yearly production costs, thus income, of €296.000 per year.
Considering the available data about the number of companies, and the categories of standard income used, it is assumed in this analysis that only companies with a standard income > €250.000 will invest in geothermal energy, assuming that the acreage of companies is closely related to the heat demand, this results in 55% of the horticultural heat demand being excluded.

Considering the fact that expenditures on HCS systems are smaller, it is assumed that also the companies in the €100.000-€250.000 category have the possibility to invest in HCS, this leaves 79% of the total heat demand. However, it is assumed that those companies that have invested in geothermal energy will not be implementing HCS because all their heat demand is already covered, this leaves a potential of 57%.

All of the above combined leads to the table x of adoption rates of technologies in the different sectors.

Table 5. Economic adoption percentages sustainable heat and cold technologies

Payback time (years)	Residential	Services	Horticultural
	New/renovated	Non/commercial	
Closed HCS	10%	0%	0%
Open HCS	0%	100%	34%
Geothermal	0%	0%	45%
Bio-CHP	0%	0%	0%
Solar boilers	5%	0%	0%

The efficiency of the sustainable heat supply technologies is taken into account in order to calculate the contribution of the different measures to the new system independent of fossil fuels. With HCS a limited reduction in gas use can be achieved since these systems can only supply low temperature base load heating and depend on secondary systems to raise the temperature of the water, rates of 40% in the services sector and 25% in the other sectors are used (ING, 2011). A Solar boiler can in principal only be used to provide sustainable tap water, which accounts on average for 25% of the heat use in houses (Netherlands Environmental Assessment Agency [PBL], 2012; Energie-Nederland, 2011). Thermal grid heating systems and geothermal energy systems can in principal be used to supply 100% of the heat demand, however in practice back-up infrastructure will be used to supply peak load heat demand, it is therefore assumed that these technologies supply 90% of the demand for heat with sustainable heat.

Table 6. Sustainable heat supply as share of heat demand.

Technology	Sustainable heat supply
Closed HCS	25%
Open HCS (residential; services, geothermal)	25%; 40%; 25%
Geothermal	90%
Thermal grid heating	90%
Solar boiler (PBL, 2012)	25%

Using the above data and the data about heat consumption in the different sectors, the economic potential in 2020 can be calculated. It is assumed that the entire economic potential for geothermal heat is reached through a linear increase in 2020.

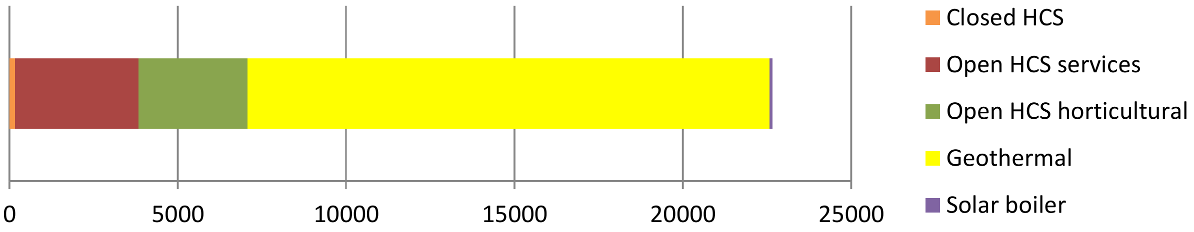


Figure 17. Economic potential sustainable heat in South-Holland in 2020

The total economic potential of sustainable heat amounts to 22.7 PJ. This graph shows the importance of the sustainable heat developments in the horticultural sector. Without taking the horticultural sector into account the remaining potential is reduced to just 3.9 PJ. This also implies a large needed role for sustainable thermal grid heating.

4.6 Existing and business as usual sustainable heat and cold in South-Holland 2013-2020

4.6.1 Existing sustainable heat and cold

Although the economic and technical potentials show plenty possibilities for the realisation of waste heat in South-Holland, in the end it comes down to the actual sustainable heat consumption. In this part the existing sustainable heat extent is analysed and coupled with an analysis of the growth rates of these technologies, as well as an analysis of planned larger geothermal energy and waste heat projects. This will provide the business as usual potential for the coming years.

Geothermal energy

Databases or statistics offer little useful information about the extent of geothermal energy in South-Holland, simply because this field has just begun to develop and most systems are just starting to deliver heat. To consider the current sustainable heat consumption the individual projects in South-Holland are analysed. A lot of the existing projects are still being optimised, in this part of the analysis only the output as proven will be taken into account, expected improvements will be considered in the business as usual potential.

Table 7. Existing geothermal energy consumption

	T (^oC)	Flow (m^3/h)	MW/hour	Gross final (TJ)
Van den Bosch 1 & 2	60	200	5.4	97
Van den Bosch 3 & 4	70	130	4.9	89
Aardwarmte Den Haag	75	150	Not operational, demand too low	
Green Well Westland	85	150	8.1	146
Duijvestijn	78	130	4.6	89
Ammerlaan	70	100	3.8	68
Total				**489**

Heat and cold storage

The most recent data about HCS in the Netherlands shows a gross final consumption of 2516 TJ in 2011. Using the substitution method, this amounts to 2576 TJ of avoided use of fossil primary energy, of which 66% would be used for heat production and 34% for cold production (CBS, 2012d). Because recent data about the number of projects and final consumption in the province of South-Holland is missing, the ratio of heat and cold storage projects in the different provinces is assumed to be the same as in 2008. In this year HCS in South-Holland made up 28% of the national consumption. Using this ratio, the final consumption of heat and cold storage in South-Holland, is assumed to be 704 TJ in 2011(CBS, 2009).

Biomass

The total gross final heat consumption through wood stoves installed at companies was 2778 TJ in 2011, the consumption in household wood stoves was a much larger 12503 TJ (CBS, 2012d). The share of South-Holland in this is difficult to estimate. Looking at the heat atlas and a biomass atlas of the Netherlands (Algemene Vereniging Inlands Hout, n.d.), the concentration of biomass projects in the Eastern half of the Netherlands is somewhat higher than in South-Holland. However the 13 projects in South-Holland are relatively large, even after excluding the waste incineration and co-firing facilities. In this analysis an assumption of 10% for the contribution of wood stoves in companies is used. For the use of wood stoves in individual households the number of houses with 4 or more rooms will be used as an indicator, assuming that the existence of wood stoves will be strongly biased towards bigger houses, this results in a share of 19.4%. The contribution of heat generated by burning biomass in South-Holland amounts to 2703 TJ gross final consumption and 1745 TJ avoided fossil primary energy use in 2011 (CBS, 2011b).

Solar thermal energy

In 2011 solar thermal energy accounted for a gross final consumption of 1041 TJ, or 1013 TJ avoided use of fossil primary energy in the Netherlands (CBS, 2011b). In order to make an assumption about the use of solar thermal energy in South-Holland, data about subsidy requests for solar water heaters per inhabitants of the different provinces in 2008 is used. This data shows that people in South-Holland make relatively few requests for these subsidies, it is assumed that this ratio of subsidies is equal to the ratio of investments and that this remained unchanged. Using this ratio and the number of inhabitants of each province, the assumed share in air-source heat pumps is calculated to be 10.6%, or 110 TJ gross final energy consumption. (Energieraad, 2009; CBS, 2013e).

Heat from milk

According to the CBS, about half of the dairy farms use devices to use heat from milked milk, yielding a total of 296 TJ gross final energy consumption in 2011 and 375 TJ avoided fossil primary energy use (CBS, 2011b; CBS, n.d.). Using the number of milk cows in all the provinces as indicator, South-Holland can be accounted for 6,0% of this energy consumption (CBS, 2013d). This shows that the heat that can be recovered from milked milk can at best make a marginal contribution to the sustainable heat consumption in the Netherlands and especially South-Holland. Therefore it will not be taken into account in the future potential of sustainable heat.

Waste heat

The use of waste heat in South-Holland is very limited at the moment. In Delft a 1.2 MW_{th} heat pump was installed in May 2012 that delivers heat from an industrial water treatment facility to houses and offices. Using a load factor of 4500 hours, as used by the government in SDE subsidy calculation examples based on district heating, this project results in 19 TJ gross final energy consumption (AgentschapNL, 2012a).

Total

Combining all of the above estimates of the existing sustainable heat consumption results in 4043 TJ of gross final energy consumption and 3119 TJ of avoided fossil primary energy. From this it can be concluded that the current consumption of sustainable heat fulfils only 20% of the 2020 sustainable heat targets. In other words, another 16 TJ/PJ still needs to be realised in the years until 2020.

Table 8. Existing sustainable heat and cold production

Technology	Gross final energy consumption (TJ)	Avoided fossil primary energy (TJ)
Geothermal	489	485
Heat and cold storage	704	721
Biomass	2703	1745
Solar thermal	110	107
Heat from milk	18	22
Waste heat	19	19
Total	**4043**	**3099**

4.6.2 *Business as Usual trend lines*

Looking at the growth trends of the different measures, trend lines can be constructed, where possible from the points of linear growth. One exception is made, the sustainable heat production from household biomass stoves is assumed to remain constant. This production has been fluctuating to a great extent over the past 20 years, for instance in 1990 the production from household biomass stoves was comparable with that in 2010. Below the different trend lines can be seen.

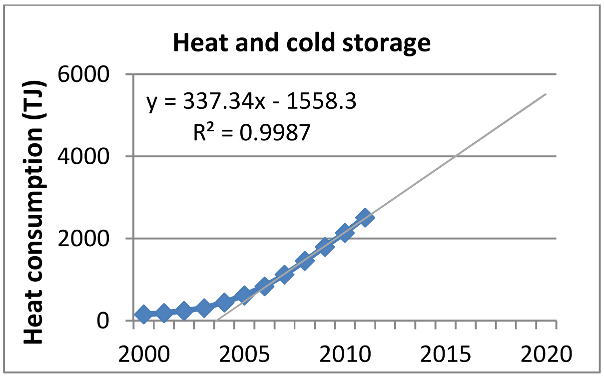


Figure 18. Baseline HCS heat consumption

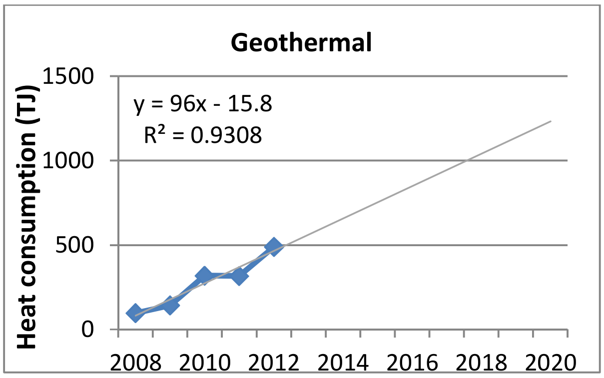


Figure 19. Baseline geothermal heat consumption

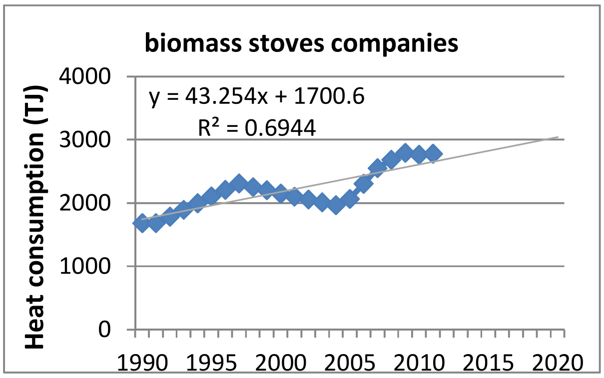


Figure 20. Baseline biomass heat consumption

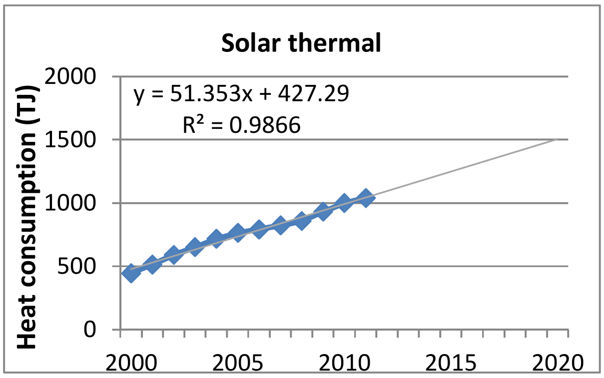


Figure 21. Baseline solar thermal consumption

4.6.3 *Impact of planned projects*

Geothermal energy

When considering the planned geothermal projects, a distinction must be made between the various stages of these respective operations. Until January 1st 2013, SDE+ subsidies were granted to 18 different possible geothermal energy projects in South-Holland. However, it seems likely that a large part of these projects will not be carried out as a result of barriers, such as financing difficulties. Therefore only planned installations that are actually initiated will be taken into account. Also planned optimisations of existing systems will be counted in this analysis, furthermore the assumption is made that if needed additional users will be found for all geothermal installation so that all systems can run on maximum capacity. The cap on the maximum SDE+ subsidy output, which has been applied since 2003, may have a significant effect on the realisation of bigger geothermal projects. This cap limits the subsidy revenues of these larger projects and therefore forms a significant barrier.

Table 9. Planned geothermal heat production

	T (°C)	T back (°C)	Flow (m^3/h)	MW*	Gross final TJ**
Van den Bosch 1 & 2	60	35	200	5.4	97
Van den Bosch 3 & 4	70	35	130	4.9	89
Aardwarmte Den Haag	75	35	150	7.3	132
Green Well Westland	85	35	150	8.1	146
Duijvestijn	68	35	130	4.6	89
Ammerlaan	70	20	200	10.8	195
Harting Holland	78	35	152	7.1	127
Geopower Oudcamp	95	35	290	18.8	475
Flora Holland	95	35	214	13.9	250
Geomec-4P	85	35	410	22.2	400
High temperature heat storage Geomec-4P				20	144
Noordland/Kapittelland				33.9	611
Total					**2755**

** assuming a load factor of 5000 h, based on the monitoring protocol renewable energy 2010 update (AgentschapNL, 2010)
*** assuming reference heat production η = 0,90, COP = 20, reference electricity production end user η = 0,408 (Gonzalez, 2012)

In combination with the geothermal project Geomec-4P in Brielle a high temperature storage pilot project is planned. Although the installed capacity of this project is considerable, about 20 MW, the total gross final energy consumption is significantly lower because of the low load factor of heat and cold storage systems, a load factor of 2000 h is assumed, somewhat higher than the load factor of normal HCS systems (1100h) (Geomec-4P, n.d.; AgentschapNL, 2010).

Waste heat

There are several big waste heat projects under construction in South-Holland, which could have a big impact on the 2020 targets. The following three projects are initiated and should start to deliver waste heat in the coming two years.

Rotterdam South – AVR

This pipeline is under construction and is planned to be finished at the end of 2013, the 26 km long trace will supply about 100 MW heat from the waste incineration plant in the Rotterdam harbour area to houses and offices in Rotterdam South. The project is commissioned by WBR (heat company Rotterdam), in which the province is shareholder.

Rotterdam North – AVR

From this same waste incineration plant a second trace is planned to carry 160 MW heat to the existing thermal grid in Rotterdam North and will partly replace the CHP unit now used to supply heat to the district heating grid. The construction of this project is planned to start in August 2013 and the first heat is planned to be delivered around October 2014 in Rotterdam and around October 2015 in Schiedam and Vlaardingen (Eneco, n.d.).

The number of load hours determines the total sustainable heat consumption from these two sources. However in this case a different approach is used, based on the total heat demand in the Rotterdam district heating grid. It is assumed that waste heat is used for base load heating, thereby making optimal use of the continuous heat availability, this leads to the assumption that 80% of the grids heat use will be supplied by district heating (Aardwarmte Den Haag, 2010). It is thus assumed that these projects supply 3.6 PJ sustainable heat, this can be translated into about 3850 hours a year, this seems reasonable.

Dordrecht - HVC
A 12 km pipeline will deliver about 20 MW heat, from the waste incineration plant to about 5.000 houses and offices, the project should be finished end of 2013/ beginning of 2014. On a longer time scale the delivery of heat can be expanded to the surrounding area and supply 25.000 houses with 50 MW heat from the waste incineration plant (HVC, n.d.). It is assumed that the load hours in Dordrecht will be higher than in the Rotterdam case because there is only one heat source, making it more suitable to be used for longer times, taking 6000 load hours this leads to 432 TJ sustainable heat in 2020.

4.6.4 *Total business as usual potential*

Together with the business as usual trend lines for the other sustainable energy technologies the planned geothermal energy and district heating systems would lead to the following sustainable heat mix in 2020.

Table 10. Business as usual and planned potential sustainable heat and cold

Technique	Gross final energy consumption
Geothermal	2755
Heat and cold storage	1555
Solar thermal	159
Biomass	2724
Waste heat	4032
Total	**11225**

Looking at these figures it becomes clear that even if all planned projects follow through and the existing district heating networks are made sustainable, the potential would still fall short. This table clearly shows the need to increase the efforts in order to reach sustainable heat and cold targets in South-Holland.

5 Transitional analysis

As seen in chapter 4 the business as usual potential lies well below the target of 20 PJ in 2020. Furthermore, future scenarios show that in order to reach the 2050 targets, much more effort is needed. In order to steer these efforts in the direction towards a system transition and in order to increase the effectiveness of policies, the barriers that hinder sustainable heat must be explored.
Chapter 5.1 starts with recapping the opportunities to sustainable heat in South-Holland as a starting point to identify those areas that offer the greatest potential. These opportunities are mainly the large potential for geothermal heat as well as the large availability of waste heat and geographical match between heat availability and use in the Rotterdam, The Hague and Westland areas.
Chapter 5.2 shows an analysis of the complex field of stakeholders. The activities of the many stakeholders can be considered an opportunity, since this creates the possibility of shared increased efforts, however it also complicates the process of overcoming barriers. The complexity of the network must be analysed in order to understand what the role of stakeholders can be in reducing the different barriers in place.
In chapter 5.3 these obstacles are analysed, based on transition and innovation theories. The most important barriers for the province to overcome are the complexity of the network, the coordination of policies and the lack of demand articulation. There are numerous other barriers identified that also play a negative role, in principal all barriers will be taken into account when proposing policy measures.
However, understanding that the role of the province is limited when it comes to solving the barriers, chapter 5.4 analyses the influence of the stakeholders on the different obstacles. Numerous barriers, such as the over-exploitation of commons, the externalising of costs and the lack of infrastructure and capabilities, originate at a national or EU policy level and are therefore difficult to address by the province alone.

5.1 Opportunities to sustainable heat in South-Holland

There are plenty opportunities in South-Holland when it comes to sustainable heat. First of all the demand for heat is higher than in any other province in the Netherlands, because of the large provincial population, and the large horticultural and industrial sectors in the region. Next to the high demand for heat there is also a lot of heat available in South-Holland. Because of the extensive industrial sector, largely consisting of energy companies located in the Rotterdam harbour area, the availability of waste heat is large. Industrial heat supply is in general characterised by a large insecurity of supply, taking into account the insecurity of future operations and the fluctuation of heat availability with variable production processes. However, the organisation of the coal plants in the region safeguards a certain stable amount of waste heat availability in the future because of the large capital investment in coal plants and the relatively stable operational characteristics of coal fired electricity production. Although it is questionable whether waste heat from a coal plant can also be called sustainable, this heat can play a role in the transition to sustainable heat through supporting a regional thermal grid. Any waste heat that is fed into the grid and is generated in coal plants can in time be replaced with renewable heat.
The second opportunity is that the heat supply and demand in the region is not only large but also shows good geographical proximity, this makes the construction of a regional thermal grid feasible. The heat

flows in the province are especially centred around the Zuidvleugel area, consisting of the largest cities Rotterdam and The Hague, the large industrial sector in Rotterdam, the large horticultural sector in the Westland and secondary cities such as Leiden and Dordrecht.

The considerable potential of geothermal energy in the region forms a third opportunity. The ground layers below South-Holland are largely suitable for the application of geothermal energy. The Cretaceous layer below the province is a proven source for geothermal heat with outputs higher than expected from geological data. This potential shows a near perfect match with the horticultural activities in the Westland municipality. This is considered especially promising since the horticultural sector is in general known for a great interest in sustainable development, a culture of strong knowledge and information diffusion between companies, good understanding of autonomous energy supply systems and a desire to be independent of energy companies. These ingredients make for an extremely receptive target group for sustainable heat initiatives.

The interest of the province of South-Holland in sustainable energy in general and sustainable heat in particular forms another opportunity. Because the province recognises the possibilities in the region and actively targets sustainable heat, the above opportunities have a greater chance of being seized.

5.2 Barriers to sustainable heat in South-Holland

5.2.1 *Barriers*

Even though there are plenty opportunities for sustainable heat in South-Holland, only a small part of the technical potential will be reached if the barriers in place will not be overcome. Barriers traditionally provide rationale for interventions and policies, however a sub-optimal identification of barriers can lead to sub-optimal policies. In the next section the impact of the different barriers on sustainable heat in South-Holland is analysed. The analysis of these barriers is done based on literature review, on interviews with stakeholders and on following the process of working towards sustainable heat and the setting up of the program office at the province of South-Holland.

Information asymmetries

The uncertainty about geological conditions and possible returns hinders the development of geothermal energy. Furthermore barriers arise from uncertainties about the lifetime of sustainable heat technologies, the long-term performance of systems and the future gas prices (AgentschapNL, 2013; T. Zwinkels, personal communication, 12 March 2013; Builddesk, 2011).

Knowledge spill-over

The knowledge generated through exploratory drilling in the Triassic layer will benefit all parties interested in geothermal energy whereas the costs are borne by the party executing the drilling (Energiek2020, 2012).

Externalization of costs

For electricity producing companies discharging CO_2 and waste heat to the environment is relatively cheap. Internalising these costs would make the reference situation more expensive, making it more attractive to supply waste heat or CO_2 to third parties (University College London, 2002).

Over-exploitation of commons

The common good can in this sense be defined as fossil fuels, but also as the clean atmosphere or the environment. The carrying capacity of the environment to buffer the extra anthropogenic CO_2 emissions is limited, however this does not limit the fossil fuel use of individuals and businesses (World Trade Organisation, 2010).

Infrastructural failure

The missing physical infrastructure in the form of a thermal grid, slows down the diffusion of sustainable heat. On the other hand the gas grid is extremely well developed, reducing the necessity to use sustainable heat. Also the financial infrastructure to deal with the specific long term financing and risk management of sustainable heat projects is largely non-existent. Knowledge infrastructure also falls short, for example geo sciences academic education and research still focusses predominantly on fossil fuels, and not on geothermal energy. Research in general lacks strategic direction defined in cooperation with industries and sustainable heat users (Builddesk, 2011; Interview met Ammerlaan).

Institutional failure

Geothermal energy regulations concerning by catch, plus the need for separate permits for exploitation and exploration hinder the diffusion of this technology, the 30 °C limit on the other hand is a barrier to High Temperature Storage. The cultural resistance towards collective heating in general and towards waste heat in particular hinders sustainable heat use in the residential and services sector (Builddesk, 2011; ECN, 2010; Huisman, 2010).

Interaction or network failure

The sustainable heat field in general lacks interaction and the sharing of resources. The geothermal energy and district heating sub sectors are organised, this could however lead to the other extreme, inward focused interaction and lock-in of trajectories (CE Delft, 2002; ECN, 2010).

Capabilities failures

There is plenty of oil and gas drilling capacity, however the slightly different expertise of drilling for geothermal heat is not yet developed to a great extent and does not yet completely meet the demand. The lack of skilled HCS installation and managing personnel contributed to underperformance of a large share of the existing systems (Rijkswaterstaat Leefomgeving, n.d.; LenteAkkoord, 2013).

Directionality failure

Differences between the goals and focus areas of EU, national and provincial policy form a barrier. In particular the focus on renewable energy of the Dutch government conflicts with the focus on CO_2 reduction of the EU. Furthermore Dutch innovation policy is not aimed at transition, by stimulating the so called top sectors of the Netherlands, innovation support mainly goes towards incumbents (Van der Hoeven, 2013).

Demand articulation failure

The demand for sustainable heat is not yet articulated enough and the existing sustainable heat sources match poorly with the existing heat supply system in houses. Too little attention is given to the difference between sustainable heat supply to existing houses and new and renovated houses. Furthermore sustainable heat is not promoted in the market as it should (Servicepunt Duurzame Energie, n.d.).

Policy coordination failure

The lack of a shared EU, national and provincial vision on the importance of sustainable heat and a shared approach to reach shared targets weakens sustainable heat policies. Societal problems or challenges for which solutions need to be developed, as bases for policy design, are poorly identified (SER, 2010).

Reflexivity failure

The monitoring of sustainable heat in South-Holland falls short. Although the amount of sustainable energy is monitored, this is not done frequently and detailed enough. Furthermore there is no articulated plan to evaluate the effectiveness of policies and to change policies if needed (PZH, 2011b).

5.2.2 *Barriers resulting from internal process Province South-Holland*

The internal process at the province is important to analyse since this poses a specific barrier. The way in which targets are set and progress is monitored could be more structured around reaching a transition to sustainable energy.

Targets setting

The role of the province in certain fields of sustainable energy is limited, for instance the extent of bioenergy depends foremost on national policy. The province however also acknowledges the opportunities in the region when it comes to sustainable energy. The existing policy of the province focuses on three different applications, wind energy, bio based economy and biogas, and sustainable heat.
The provincial target of 14% sustainable heat in 2020 is of course not randomly chosen but is based on a rough identification of the possibilities for sustainable heat in the residential and the horticultural sectors. This target is also in line with the 14% national sustainable energy target. By not awaiting national top down policies enforcing this target but by proactively seizing opportunities the province aims to keep a tighter grip on spatial issues and challenges in the region.
Although the target setting of 14% sustainable heat, translated into 20 PJ, has clear benefits, it generates momentum and it provides a clear mark, there are also clear risks resulting from this strong focus on the

target. By focussing on a specific sustainable heat output, instead of focussing on the system transition, policies could lead to quick wins instead of measures that are on the long term preferred from a transition point of view. The short term focus until 2020 does not match the transition process which usually takes more than one generation. The risk arises that the focus on sustainable heat is reduced after 2020, whereas long term stable policies are so much needed.

Monitoring sustainable heat

As discussed above the monitoring in South-Holland falls short. At this moment the overall progress in the field of sustainable energy is monitored on behalf of the province by the DCMR Environmental Protection Agency, one of the provincial environmental agencies. In this biennial report the sustainable energy consumption as well as the CO_2 emissions in the province and the different sub regions are highlighted. Although this report is a useful tool to quick scan the success of sustainable energy policy it is less useful for the monitoring of detailed sustainable heat efforts (PZH, 2011b).
One of the shortcomings of this report is the lack of detail, for instance data for solar energy and biomass energy are given, without specifying whether this is heat or electricity production. Geothermal and HCS are shown as separate components, however there is no way of analysing the entire extent of sustainable heat out of the given data.
Another important issue is the delay between the use of sustainable energy and the publication of the report. The most recent report, of March 2011, displays the state of sustainable energy in 2009. This means that at any given time the data is at least two years old. Considering the fast changes in the sustainable energy field and the short cycled national sustainable energy policies in the last years, this delay limits the usefulness of the data in policy feedback mechanisms.

5.3 Analysis of stakeholders in sustainable heat system

There are numerous stakeholders involved in the (sustainable) heat system. Whereas this could be seen as an opportunity, creating the possibility of strong efforts by committed partners and large availability of resources, without proper management these opportunities cannot be seized and the network can become a threat to the realisation of sustainable heat. By analysing the role of stakeholders and their possible role in reducing barriers or seizing opportunities, the potential for sustainable heat can be enlarged.

National government

The Dutch government plays in many different ways an important role in the sustainable heat field. For instance the SDE+ subsidy scheme plays a crucial role in the implementation of technologies. On top of this the geothermal heat guarantee scheme further benefits the implementation hereof. On an institutional level the government has an important role, through laws and regulations concerning the EPC and energy labels, energy taxes, use of the underground, the price of heat but also the discharge of heat to the environment the government can have a big effect on the potential of sustainable heat. Furthermore the government can also influence norms and culture associated with sustainable heat, by providing information and setting examples.

Province

The province has limited regulatory power, except when it comes to HCS for which the province decides on the maximum injection temperature of water. Also the monitoring of these systems and the implementation of larger HCS system is assigned by the province, although executed by regional environmental agencies. Additionally the province can influence the behaviour of actors in the region by providing monetary support, by providing knowledge and information and by directing and bringing together network partners in the region. Also the province has an influence on the perception of sustainable heat and can improve this through information provision and examples.

Municipalities

Municipalities can exert influence through spatial planning procedures and can for instance make requirements of new building projects. Also the permits for HCS systems, biomass stoves and solar boilers are granted by municipalities, although this happens according to national procedures. Sustainable heat can be stimulated by providing resources, especially in the form of guarantees through participation in public-private partnerships and through subsidies. Furthermore municipalities are often in closer contact with sustainable heat users and can therefore play a role in identifying specific problems and finding solutions through bringing actors together on a small scale.

Industrial companies/ Energy companies

These companies lack statutory power but can exert influence through their lobbying force and important economic position. This influence is rewarded with low energy prices and other monetary benefits, this reduces the incentive of these companies to invest in sustainable energy. Local plants are often to a great extent influenced by the plans and processes of their parent companies, this reduces investment possibilities.

Knowledge institutions

These institutes offer knowledge and information and can increase familiarity with, and insecurities about, sustainable heat technologies. Furthermore they play an important role in advising the government about subsidy requests and permits.

Sector organisations

These organisations can manage the multi-stakeholder process of moving towards sustainable heat. Sector organisations form lobbying and negotiation partners and offer advice, knowledge and cooperation.

Investors

Investors can play a decisive role because in the end they provide the necessary capital to implement projects. Next to providing money investors can cooperate further by sharing knowledge about making business cases and minimizing risks. Choosing the appropriate type of investor can be of key importance for the possible implementation of sustainable heat projects. (Huisman, 2010).

Insurance parties

Investors usually require the insurance of financial risks, in this sense insurance parties, private companies or in the form of public guarantee funds, have a role of influence together with investors. The current lack of private insurance companies specialised in sustainable heat hinders the business cases of sustainable heat project and thereby forms a barrier for the execution of projects.

Heat consumers

In the end it all comes down to the individuals or companies using the heat. House-owners, housing cooperatives or horticulturists are on the other end of the power deal and hold the power to say yes or no to sustainable heat initiatives. Sustainable heat will in the end only be implemented when this is attractive enough for the users of heat.

5.4 Role of stakeholders in barriers

The barriers to sustainable heat projects are of a multi-stakeholder nature and can in general not be solved by one stakeholder, it is therefore important to identify the stakeholders that can play an important role in overcoming the barriers. The analysis of the role of stakeholders can be seen in the below table x.

Table 11. Stakeholders that can play a role in overcoming barriers

Barrier	Needed to overcome barriers	Stakeholders
Information asymmetries	Sharing of information between sectors and users of heat, developing more knowledge, sharing successful examples. This also includes the sharing of successful examples by governments and stakeholders.	sector organisations knowledge institutions province national government
Knowledge spill-over	In order to avoid knowledge spill-overs, research and knowledge development should be undertaken collectively.	sector organisations horticulturists knowledge institutions
Externalization of costs	The costs, in the form of environmental damage, resulting from heat use, can be internalised through laws and regulations enforced by governments on national, European or worldwide level.	national government European Union
Over-exploitation of commons	Regulations and laws can prevent the over-exploitation of commons, knowledge and research is needed to identify the allowable exploitation level	national government European Union knowledge institutions
Infrastructure failure	Investing in the necessary infrastructure can be done for instance through setting up a governmental revolving fund and by setting up a learning program. The lack of financial infrastructure can for the time being be overcome by governmental financing programs.	national government, province sector organisations, knowledge institutions financial institutions
Institutional failure	Laws and regulations that hinder the development of sustainable energy need to be evaluated and adapted. For instance use of waste heat needs to be included in energy labels. Communication between governments and sector	national government province sector organisations

	organisations is crucial in order to identify opposing regulations and evaluate desired changes.	
Interaction or network failure	Interaction between parties can be stimulated through stakeholder management and the setting up of strong sector organisations, it is crucial that these organisations remain outward orientated and open to new entrants and external developments.	province sector organisations interest groups
Capabilities failure	The needed capabilities need to be articulated, preferably through sector organisations or strong user groups such as united horticulturists. Training needs to be promoted and a program needs to be determined in order to make the best use of existing capabilities, this in consultation with the companies that should deliver the capabilities, such as installation companies.	horticulturists sector organisations installation companies
Directionality failure	To start with, the EU and national policy goals should be more aligned, the national government should be more focussed on aligning these goals. Innovation policy should be more focussed on supporting a transition by keeping a clear direction in mind.	national government province knowledge institutions
Demand articulation failure	Continuous demand side research is needed to better suit technologies to the needs of users. Sustainable heat should be promoted by the national and provincial government. Demand can also be enforced by the government, for instance through the banning of boilers, like the Danish government did.	national government province knowledge institutions sector organisations
Policy coordination failure	Different government levels and sector organisations should discuss a shared vision, the direction of policy and the aimed end goals. Shared societal problems should be identified to form the base for policy intervention. Policies at different governmental levels should be designed to complement each other.	national government province sector organisations industry
Reflexivity failure	The results of different policies should be extensively monitored and the results need to be communicated. Policies should be continuously evaluated to steer these towards more effectiveness. Ineffective policies should be reduced. The policy program should be targeted at the entire heat use sector instead of specific technologies.	national government province heat users

5.5 Reducing barriers

When considering the reduction of the barriers in place, both the limitations and the opportunities of the role of the province in the heat supply network must be taken into account. Also the impact of barriers on the technologies must be considered in order to focus on the most important barriers.

5.5.1 *Classic market failures*

The classical market failures are to a large extent difficult to tackle by the province, these are largely based on less than optimal functioning of the market, resulting for instance in a price of fossil fuels that does not take the negative effects on the environment into account. However, there are some measures that can contribute to a reduction of these barriers, thereby increasing the sustainable heat potential.

Information asymmetries

Information asymmetries can partly be overcome by monitoring the performance of sustainable heat systems and setting-up a database with this information. This can provide the necessary information about the sustainable heat production and the payback times of technologies.

By setting-up a database of geological log data the information about expected heat output based on geological conditions can be increased, this can be used by horticulturists as bases to apply for a geothermal exploration permit. Furthermore this database can be used to monitor and publish the output of existing geothermal systems thereby in time reducing the uncertainty regarding long term output. Ideally this database should also incorporate the log data from the NAM (Dutch Oil Company), the province should try to get this data openly available.

Knowledge spill-over

The most important barrier resulting from knowledge spill-over concerns is the barrier to Triassic geothermal energy. There are numerous parties interested in drilling for geothermal heat from the Triassic aquifer. However the permeability of this aquifer is uncertain and the costs of exploratory drilling are substantial whereas the knowledge generated can be used by other parties and therefore has little monetary value for any party performing such a drilling.

At this moment attempts are being made to overcome this barrier, with support of the province. The current approach consists of a consortium interested in Triassic drilling that is going to explore this option using subsidies of the province of South-Holland and the Dutch government. Although this requires some public investment, the outcome is valuable and this assures a quick process leading to quick answers.

In general it is important to stimulate innovation activities in the region, for instance as an answer to the overcapacity of sustainable heat in the summer. By using this heat in other valuable ways, by producing electricity in an Organic Rankine Cycle, or by using it to distillate water in horticultural companies, the value of heat projects can be increased. Innovation should in general be promoted by coupling innovative parties, such as the universities in the region, with businesses that can work on practical applications for these innovations and can bring these to the market. By combining stakeholders, the negative spill-over effect can be reduced.

5.5.2 *Structural system failures*

Of the structural system failures especially the network failure, lack of infrastructure and the institutional failure play an important role. Some of these barriers are difficult to address, such as the lack of physical thermal grid infrastructure, however other types of infrastructure can be influenced by the province.

Infrastructural failure

Financial infrastructure should be created in order to deal with the specific uncertainties of sustainable heat projects. For instance in the form of a financial strategy stating which funds are most applicable to sustainable heat projects and which national and EU subsidies are there to obtain. By helping parties to as much external funds as possible, the province provides financial stimuli without having to use own monetary resources.

Specifically the financial insurance possibilities of geothermal energy must be improved. Through setting up a geothermal guarantee fund the geological risks of these projects could be covered. Although the geological risks are minimal, considering the available knowledge of the underground, the financial impact of a failed geothermal project is large. By spreading these risks over a large portfolio of projects this impact is reduced. The national government has partly overcome this risk by setting up a national geothermal guarantee fund, however this is in general thought to expensive and complicated.

Setting up a provincial guarantee scheme would serve as a financial measure to improve the business case of geothermal projects. By guaranteeing the output of projects, these can be financed more easily and the costs can be kept low. A concrete proposal for the scheme would consist of a premium of 5% of the guaranteed sum, to be paid afterwards, once the expected outcome is reached. Projects that do not reach this output (maximum P90) will be paid the entire different between the actual and expected output. Included in the guarantee scheme can be everything concerning the drilling process (including supervision, preparation etc.) and the preceding logging process (tests, reports, evaluation of data etc.), just as is the case in the existing scheme (AgentschapNL, 2012b).

Assuming that geothermal projects are guaranteed for an average amount of €8 million, against 2.8% interest (return on government loans +0.5%) every geothermal project would cost the province in interest €224.000 per year (Staatslening, n.d.). However, for each successful project the interest can be paid using the premium, the additional €176.000 can in the end be used to fund those projects that do not reach the expected output, any additional money can be used to set-up a revolving fund which in the end could be used for additional financial measures.

Although the possibilities are limited, the province should also steer towards a better physical infrastructure by aiming to work towards a thermal grid in the region. By supporting small scale thermal grids that are being developed, for instance to deliver geothermal heat to residential areas, the province can promote the organic creation of a thermal grid. By participating in thermal grid projects and by bringing parties together, the province can steer this process into the direction of a regional grid.

The province can also assist in making the existing grids sustainable by supplying continuous effort to help in the business case developments of replacing the gas fired sources for sustainable alternatives.

Institutional failure

The province should research the possibilities of allowing high temperature heat storage. The province is partly already doing so by allowing high temperature pilot projects; these projects should be carefully researched and evaluated.

There as several institutional failures that are difficult to address by the province, however the province can support the lobby in favour of changing these rules and regulations. For instance there is at the moment little incentive for energy companies to supply their waste heat to other parties instead of discharging this to air or water. The national government could change this by either regulating the maximum allowable discharge of heat to the environment or by providing subsidies for the supply of waste heat. Also the SDE+ cap for larger geothermal energy projects should be removed in order to stimulate the transition to larger projects supplying more heat.

Also the culture and values surrounding sustainable heat can be influenced by the province. The perception of collective grid heating by consumers is for instance not that positive, by promoting this type of energy and by highlighting positive examples the province can stimulate the use of industrial waste heat in district heating grids.

Network and interaction failure

This barrier is very important and requires the constant managing of stakeholders and activities in the region. The province is perfectly suited to manage the different stakeholders and to bring parties together to create added value and to facilitate the implementation of projects and strategies. By combining capabilities and resources business cases can be made that can be applied to multiple similar projects thereby increasing the probability of successful execution and reducing the costs. The province should actively manage those projects that involve numerous stakeholders in larger projects by sorting out the network complexity and by bringing together those parties that have a responsibility. Projects that are difficult to carry out as a result of varying interests and perceptions should be smoothed in order for these to be realised. By elimination opposing activities, the province could create win-win situations.

By the setting-up of the program office the sustainable heat activities become better structured and to a larger extent left to the stakeholders involved. This should increase the involvement of parties and should make it easier for parties to work together. There is however also a risk of the network becoming too strong. The network must remain open to possible entrants that can offer something new to the network. By allowing the joining of new parties, and by actively approaching parties that play a role in the field but are not yet included, the program office can assure a good representation of the field. The province should also keep track of those parties that are not joining in the program office, but still could have something valuable to offer. This accounts for instance for new innovative partners, new entrants are often the driver of change in a transition phase, this should be recognised in order to make use of this.

5.5.3 *Transformational system failures*

The transformational system failures form barriers to the transition towards a sustainable heat regime, especially the policy coordination failure and the demand articulation failure must be overcome in order to increase the sustainable heat potential.

Directionality failure

In order to stimulate the change to a different regime, based on sustainable heat, the province should start with creating a vision about the transformative pathway towards sustainable heat supply. This vision can serve as a guideline for internal and external plans and policies, and should be consulted with the national government and regional stakeholders in order to created shared plans and perspectives. This shared approach should be used to create a coherent policy package aimed at stimulating and enhancing those activities benefitting the transition. Crucial is to also share this vision in the own organisation and to include different provincial departments in the process in order to embed the policy vision in provincial practices and thereby safeguard long-term stable policies.

It is important to explicitly take into account the directionality failures in current policies. An important example is the difference between a focus on CO_2 reduction on an EU level and the national focus on renewable energy. These different focus points have a large impact on the justification of the direction of policy and the stimulation of certain technologies. It would be best, in the light of system transition, to follow the line of the European Union and focus more on CO_2 reduction. It is however important to align this with the national government in order to work to a shared future goal.

Policy coordination failure

The concrete policies and activities of the province, the national government and the European Union should be better aligned in order to maximise the returns. Through discussing the sustainable heat strategy with the national government and by more extensively taking note of the existing opportunities and possibilities within the national and EU policy frameworks, benefits of the provincial policy package can be increased. By matching activities and creating uniform targets and plan, policies have a greater chance of being successful. This should eventually lead to the tackling of those issues that are beyond the control of the province. Crucial in this is that the province does not lose focus on its transformative goals by compromising its policy to better suit the policies of the national and EU governments.

Reflexivity failure

In order to evaluate and change policies if necessary, a monitoring and evaluation scheme must be created and executed on a regular base, aimed at monitoring the transition towards a sustainable heat regime. Indicators could for instance be the extent of sustainable heat used, the perception of sustainable heat, the strength of the fossil fuel regime and the CO_2 emissions for heat supply. The evaluation plan should analyse whether the policies are still the most effective way to reach the stated end goals. The plan should consist of ways to timely adjust or eliminate policies that prove to be less useful or effective than expected.

Demand articulation failure

By carrying out demand side research, in order to analyse the preferences and objections of users of heat towards different sustainable heat measures, the available technologies can be made better suitable to these wishes. This can also be used as base for a communication and promotion strategy in order to activate the interest of heat users for sustainable alternatives. Demand side research should first be focussed on those areas of promise, such as services buildings that are being renovated or large scale residential new build.

Overcoming this barrier is crucial since in the end it all comes down to the users of sustainable heat. Through setting up a marketing strategy the sustainable heat can be better sold to users. This would ultimately also lead to a better prospective for heat suppliers.

6 Results

This chapter will take the findings of chapters 4 and 5 and combine these in an effort to answer the research question raised at the beginning of this report. In chapter 6.1 the baseline sustainable heat and cold consumption shows that there is a long way to go in order to reach the targets. Chapter 6.2 makes use of the barriers analysis of chapter 5 and provides measures to overcome the barriers to the implementation of sustainable heat. Chapter 6.3 shows the effect of the proposed measures, in this chapter it becomes clear that these measures, although thought to result in a sharp increase in sustainable heat and cold consumption, will only lead to 18.3 PJ in 2020 and 48 PJ in 2050. When considering the limitations of the provincial role, in chapter 6.4, it is shown that more sustainable heat consumption can be achieved if other parties, such as the national government, also implement supporting measures. An estimated 18.3 PJ could be reached under favourable external circumstances. Although this is still somewhat below the target, this does show that 20 PJ is within reach and it is worth striving for this with united stakeholders.

6.1 Sustainable heat supply in South-Holland

Observing the sustainable heat system in South-Holland led to some insights. The heat system is under pressure to change. This pressures comes from within the system as well as from outside the system. For instance gas based CHP systems are becoming too expensive as a result of high gas and low electricity prices and there is a general pressure to move towards more sustainable energy.
The system is reacting to this pressure to change, there are a lot of innovative and experimental sustainable heat projects in the region, however these are all experiencing barriers and problems. For instance the Geomec-4P project that wants to combine high temperature heat storage with geothermal energy had difficulties with making a business case. The geothermal energy projects in The Hague has filed for bankruptcy because the demand for heat was too low as a result of planned building projects that did not follow through. There are a lot of active parties in the province working on sustainable heat, however all on their own projects and their version of the sustainable heat future.
All of the above leads to the believe that the heat system in South-Holland, as well as the Netherlands and probably on a larger scale, is indeed in transition. This transition leads to uncertainties about the future role of stakeholders and what the future heat system will look like. This requires a party to actively direct this transition, in order to drive it towards a desired end goal and in order to pull other parties on board of moving towards this transition. This role could be the province’s, considering its central role in the stakeholder field and its interest in making the province sustainable.

South-Holland is the most populated province of the Netherlands, and has by far the largest heat use. The type of heat use creates opportunities for the provision of sustainable heat. Large shares of the low temperature heat use are consumed in the form of residential heating in densely populated urban areas, such as in the large cities of South-Holland, mainly Rotterdam and The Hague. These sources of high concentrated heat demand can easily be targeted by sustainable collective heating. Another large heat sink is the horticultural sector in the province, mainly the concentrated companies in the Westland

municipality. This heat consumption furthermore forms a great match with the available Cretaceous aquifers usable for geothermal energy supply.
However, more important for this analysis is the observation that there is a lot of heat available in South-Holland to be supplied to users, for instance in the form of large point sources of industrial waste heat and the large geothermal heat potential. This creates possibilities to supply a substantial part of the heat demand in South-Holland with sustainable alternatives.
However, the opportunities left aside, the actual production of sustainable heat consumption lags behind. The current sustainable heat consumption amounts to an estimated 4.3 PJ in South-Holland. Furthermore this is largely made up of biomass use in residential wood stoves and fireplaces, it can be argued whether this should be counted as sustainable heat production. Without this the consumption would reduce to 1.6 PJ. This leaves a large sum of sustainable heat to be produced if the targets are to be met in 2020. 16 PJ of sustainable heat consumption is the equivalent of about 160 geothermal energy projects, compared to the 6 projects realised in South-Holland.
Considering the growth trend of sustainable heat in South-Holland, and including the large planned sustainable heat projects, such as large geothermal heat projects in the Westland municipality and the thermal grid projects in Rotterdam and Dordrecht, the business as usual potential amounts to a mere 11.2 PJ, just over half of the 20 PJ target. To make the step from this current baseline sustainable heat production to a significantly higher realized production in 2020 the factors that slow down or hinder the development of sustainable heat should be guiding.

6.2 Effect of overcoming barriers

By overcoming the barriers to the development of sustainable heat the potential can be increased. As stated earlier it is crucial that these barriers are identified from a transition and innovation perspective, ensuring the focus on the needed transition away from fossil fuel use. These barriers can be divided into three categories: market failure, structural system failures and transformational system failures.

6.2.1 *Impact of barriers*

The market failures have a large impact on the attractiveness of sustainable heat, however they are largely out of the scope of provincial policies, examples are the externalization of costs and the over-exploitation of commons. Structural system failures play an important role, for instance through the absence of infrastructure and capabilities and the existence of institutional failures. The most important structural barrier is the interaction or network failure. The complex heat supply network can be considered an opportunity but is also a great risk when it comes to projects that are not followed through because stakeholders cannot agree upon operationalization. Furthermore the extensiveness of stakeholders in the region limits the feelings of responsibility of individual stakeholders, leading to ideas and initiatives that are not taken up by parties.
The impact of the third group of barriers, the transformational system failures, is arguably the biggest. These barriers inhibit the transition to the sustainable regime and increase the possibility of opposing policies. The most important barriers in this category are the policy coordination failure and the demand

articulation failure. The first of these two limits the effectiveness of policies by not aligning these policies at different governmental and sectoral levels. Because of a lack of coordination between policies on different governmental levels, opportunities are not recognised and the implementation of policy measures becomes a time consuming and difficult process. Furthermore there is a risk of opposing policies the clarity of policies towards external parties is reduced.

The lack of demand articulation poses probably the greatest risk of all barriers. By ignoring the demand for sustainable heat in policies, the demand for sustainable heat will seriously lag behind. No matter how much the attractiveness of sustainable heat supply is improved, this is pointless without the generation of demand.

To make matters more complicated, the sustainable heat technologies are each to a different extent influenced by the barriers and the impact of barriers is complex since barriers depend on several factors and influence each other. Below table x is a visual representation of the impact of the different barriers on the different technologies, the darker the colour the greater the impact of the specific barrier on the sustainable heat technology. This table is based on the literature sources that are used to identify the barriers, on the interviews with stakeholders and especially on observing the process of stimulating sustainable heat by the province of South-Holland.

Table 12. Influence of barriers on sustainable heat measures

	Geothermal	**Waste heat**	**HCS**	**Biomass**	**Solar thermal**
Information asymmetries					
Knowledge spill-over					
Externalization of costs					
Over-exploitation of commons					
Infrastructural failure					
Institutional failure					
Interaction or network failure					
Capabilities failure					
Directionality failure					
Demand articulation failure					
Policy coordination failure					
Reflexivity failure					

This table illustrates that the technologies that are most influenced by the barriers are geothermal energy and waste heat delivery, this while these technologies can potentially be used to supply large shares of sustainable heat. In the next chapter it is shown that the proposed policy measures will lead to additional opportunities for these sustainable heat measures.

6.3 Effect of provincial policy

If all of the proposed measures in chapter 5.4 are to be implemented, this will have a large effect on the potential for sustainable heat. By implementing these measures the chance of the below technologies being taken up by the market increases. In the end this would support the transition to sustainable heat. In this section some specific measures are highlighted that are considered important to implement. It is attempted to translate these policies into specific increased sustainable heat potential.

Waste heat

An increased potential can be reached if the province manages the network of stakeholders, furthermore the province should lobby for a national and international policy base in support of waste heat use, leading to effective national and provincial policies. Lastly the province should also work on the demand articulation by creating a promotion and communication strategy for thermal grid heating and by researching whether thermal grid heating can be made better suitable to users' needs.

The reduction of fossil fuel use for heat supply through the use of (industrial) waste heat is limited, mainly by the existing heat supply systems in houses and offices. The best approach to supplying waste heat in the region is through thermal grids and the best ways to do so is by first replacing the existing thermal grid sources.

Policy coordination as well as managing the network of stakeholders is necessary to increase the interest of parties to supply waste heat. In Rotterdam the availability of waste heat should form no barrier. Considering the interest of the municipality of Rotterdam in waste heat and the projects under realisation that will supply heat to the existing grid, it is considered possible to supply 80% waste heat to the existing grid in 2020, this is assumed to be 3.6 PJ.

The case of the district heating grid in Leiden is substantially different. The circumstances are far less optimal considering the limited availability of sustainable alternatives in the region. However the need to replace the existing heat source is also greater since this installation is loss making and depreciated. If the province manages to steer this process, with its multiple stakeholders involved, it is considered possible to replace the district heating source in Leiden with a sustainable source before 2020, this would make an additional 0.8 PJ sustainable heat.

The district heating grid in The Hague is presumably not going to be connected to waste heat sources, at least not on the short term. The municipality of The Hague is pursuing an energy supply system independent of fossil fuels; waste heat from fossil sources is from their point considered undesirable. On the longer term the existing grid will presumably be fuelled by sustainable heat, however this could just as well be geothermal heat instead of waste heat.

Next to these three larger thermal grids, the plans to deliver waste heat in Dordrecht to a new district heating grid are also considered to follow through, leading in total to about 4.8 PJ in 2020.

It is assumed that until 2020 only the existing planned projects will be realised. This considering the current economic climate, the reluctance of companies to supply industrial waste heat and the lack of stick or carrots in national and international regulations. If the province would succeed in aligning policies in such a way that the national government and the industries involved support waste heat delivery, it is considered possible to supply 100% sustainable heat to the existing and planned grids in

Rotterdam, Leiden and Dordrecht, leading to an approximate 6 PJ in 2050 (CE Delft, 2009). If the demand side will receive more attention, it is also considered possible to start building new grids from 2020. Assuming the construction of new grids consisting of 1000 housing units, consuming an average 30 GJ of heat per house per year, slightly under the current average of 35 GJ (Energie-Nederland, 2011), it is considered possible to build one grid of 300 TJ on average every two years. This would lead to a total of 5000 TJ through new grids in 2050, totalling 11 PJ sustainable heat through thermal grids in 2050.

Geothermal energy

Creation of a geothermal guarantee scheme, coordination of Triassic geothermal energy drilling, increasing the information availability through a database and removal of the SDE+ cap is expected to result in an increased potential, especially for larger geothermal energy projects.

The creation of financial infrastructure, such as the set-up of a geothermal guarantee scheme is expected to highly benefit geothermal projects. Together with other beneficial circumstances, such as more knowledge and information generation and availability, this will result in an increased potential. In 2014 and 2015 three finalised Cretaceous projects per year are considered possible, increasing to four projects per year between 2015 and 2020. Assuming an average sustainable heat consumption of 100 TJ per project per year, this would lead to 2.8 PJ in 2020.

At the same time more knowledge about Triassic geological conditions, more agreement about the interpretation of geological data and the creation of financial infrastructure would lead to the realisation of one Triassic project of 400 TJ per year from 2016 on, resulting in 1.6 PJ in 2020.

If the SDE+ cap on larger projects is removed, which can be achieved if the province would support the lobby to reach this, this would induce a shift towards larger Triassic geothermal projects. This will presumably lead to a reduced realisation of Cretaceous projects, only two per year between 2020 and 2030 and no more of these projects after 2030. Triassic projects will become more attractive as the costs of the technology go down in time, however the heat demand and the concentration of heat demand in the areas not yet served by geothermal energy will also go down. Taking the above into account it is assumed that between 2020 and 2050 on average still one Triassic project per year is realised in the province. This would lead to 14 PJ geothermal energy in 2050.

Heat and cold storage

Through a general sustainable heat promotion and communication strategy the province can increase the demand for heat and cold storage. Furthermore the existing high temperature storage projects must be evaluated closely in order to evaluate whether HT HS can be allowed on large scale. Although no other specific policy measures are proposed, since these are considered outside the scope of the province, it must be said that the generation of the necessary capabilities and information is of key importance to ensure that HCS systems are effectively used.

The application of heat and cold storage can be divided into high temperature storage in addition to Triassic geothermal energy sources and the use of heat and cold storage in the residential and services sector in the form of low temperature HCS systems similar to the ones already in use.

The application of HT HS systems will only be possible if research shows this does not damage soil properties, if this proves to be the case, information about the long term benefits must become insightful in order to increase the attractiveness of this technology. Furthermore the added value of HT

HS must not be exaggerated considering the loss of a large part of the heat stored and the possible implementation of other technologies that use excess heat. Taking the above into account the use of HT HS is assumed to be limited to one system of 100 TJ in every two Triassic projects, leading to a potential of 200 TJ in 2020 and 1.5 PJ in 2050.
The potential of HCS in the residential sector is assumed to be zero since the demand for cold is too limited and the technology cannot be implemented cost effectively in existing houses The increased promotion of sustainable heat for the residential sector could result in a potential of 5% of the total heat demand in 2020, or 2.3 PJ. In 2050 the potential could have grown to 20% of the service sector heat demand, 9.3 PJ, possibly in combination with other heat supply systems such as thermal grids.

Biomass heat supply

Provincial policy should be steered towards the limitation of the use of imported biomass for energy generation, however this is mainly considered a matter for the national government. It is assumed that the use of biomass for energy production will be limited to local biomass.
As explained earlier the potential of biomass based heat supply is limited to the biomass production in the province of South-Holland. Considering the focus on other types of sustainable heat with larger potentials and the lack of growth of biomass use in the last years, there is presumably no additional potential until 2020. Taking the developments towards 2050 into account, the aim to make better use of sources of energy and the focus on making the local environment energy neutral, it is assumed that only 50% of the available biomass will be used to produce heat, leading to a sustainable heat production of 1.1 PJ.

Solar thermal energy

Solar thermal energy will also benefit from a sustainable heat communication strategy aimed at improving the culture and values surrounding sustainable heat and aimed at providing information about the long term benefits of measures.
The contribution of solar thermal energy is expected to be limited, considering the long payback time of the technology. However, taking into account that there always will be some sustainability minded individuals or companies that can accept a longer payback time, it is assumed that the technology can still serve 5% of the residential and services sector heat demand in 2050, leading to 5.6 TJJ.

Total

All of the above contributions would result in a gross final energy consumption of over 18 PJ in 2020 and 48 PJ in 2050. This is clearly within reach of the sustainable heat targets and would be a clear step towards a transition to a sustainable heat regime.

Table 13. Achievable potential of sustainable heat in South-Holland in 2020 and 2050

	Gross final energy consumption (TJ)	
	2020	**2050**
Waste heat	4.8	11.0
Geothermal energy	4.4	14.0
Heat and cold storage	2.5	10.8
Biomass heat supply	1.0	1.0
Solar thermal energy	0	5.6
BAU small technologies	5.5	5.5
Total	**18.3**	**48.0**

Although the actual effect of the reduction of barriers is impossible to predict considering the importance of external factors such as the availability and price of fossil fuels and the economic climate, the possible effect of the measures on the individual technologies is analysed regardless.

6.4 Limitations of role province

The transition to a sustainable heat regime can in the end only be accomplished with the combined efforts of parties. Especially the national government but also the EU and municipalities can play a role in overcome the barriers that are out of the scope of the province. By doing so these parties can contribute to the desired transition.

Benefits of sustainable heat technologies

The benefits of sustainable heat technologies are influenced by the price of the reference system and by the additional benefits in the form of subsidies. The price of fossil fuels can be influenced through the CO_2 pricing mechanism and through the fossil fuel tax system. The failed EU CO_2 trading scheme should ideally be tackled by the European Union by removing the oversupply of CO_2 permits from the scheme. Alternatively the national government can choose to complement the European scheme with a national scheme, for instance through the setting of a price floor for CO_2 emission credits, similar to the British government (HM Revenues & Customs, n.d.). The national government could also choose to change the fossil fuel tax rates in order to stimulate sustainable heat. Also the pricing structure of heat is controlled by the national government. Through the Warmtewet (Heat law) the government determines the maximum price for heat, linked to the maximum gas price. In time it might be necessary to change this in favour of an independent trade of heat. Subsidy policies influence the attractiveness of sustainable energy technologies in absolute terms but also influence the relative attractiveness of certain technologies. For instance the cap on geothermal energy in the SDE+ scheme can be seen as a subsidy regulation hindering the specific development of Triassic geothermal energy. Although analysing the positive and negative impact of above measures lies outside the scope of this report, fact is that the above changes could have a large impacts on sustainable heat use.

Regulating the availability of waste heat

The companies that produce a lot of waste heat are in general reluctant to deliver this to market parties because there is little benefit in supplying the heat whereas there are clear risks in the form of long term agreements that match poorly with the flexible operational structure required at companies. The national government can reduce this barrier by tempting or forcing companies to deliver waste heat. This can for instance be achieved by crediting the use of waste heat at the users' side, through the energy labelling system of houses, this would increase the value of industrial waste heat. On the other hand the government could also directly reward the supply of waste heat or penalise the discharge of waste heat.

Steering the direction of innovation

Innovations in the energy field need to be specifically aimed at promoting the transition to sustainable heat. The national innovation policy is however focussed as well on the incumbent fossil energy system. By adjusting the national innovation policy in such a way that only sustainable technologies are promoted the national government can stimulate the sustainable heat transition.

Enforcing sustainable heat

The province also lacks the possibilities to enforce the use of sustainable heat. For instance municipalities could help to articulate a demand for heat through enforcing housing associations to use sustainable heat measures. Limiting the use of gas boilers, similar to the Danish government, would also increase the demand for sustainable heat. The observation is made that these measures lie outside the influence of the province however it is not analysed whether these measures are desirable.

4.6.5 *Effects of specific policy measures national government*

Some specific policy measures are proposed and their assumed effect is analysed in order to illustrate the need to align policies on all institutional levels. If the cap on geothermal energy in the SDE+ scheme is removed, thereby eliminating the disfavouring of Triassic geothermal energy projects and increasing the benefits of this type of sustainable heat. This is expected to result in another project realised every other year, leading to an additional 800 TJ in 2020 and 6 PJ in 2050.

By focussing more on waste heat delivery, for instance through penalising the discharge of heat to the environment, the build of new thermal grids will be stimulated. By doing so, new grids can start to deliver sustainable heat before 2020. The stimulation of the development of thermal grids can play a large role in making the heat system sustainable. National policies are considered decisive when it comes to the attractiveness of new grids. It is estimated that one additional district heating grid will be built per year from 2016, leading to an additional 1.2 PJ in 2020 and 10.2 PJ in total in 2050.

Lastly by increasing the focus on sustainable heat, by providing increased and constant subsidies, by focussing on sustainable innovations, as well as assuring a focus on CO_2 reduction and associated high fossil fuel prices, the implementation of small sustainable systems in general will be stimulated. This could lead to a doubling of the business as usual growth, which amounts to 1.2 PJ in 2020.

If all of the above would be implemented, a potential of 20.3 PJ would be reached in 2020, in 2050 this would lead to 65.4 PJ. This shows that aligning provincial and national policies is crucial to meet the targets and move towards a sustainable heat system.

7 Discussion

The province has set a very ambitious 2020 target and is heavily focussing on sustainable heat, this focus is well deserved considering the opportunities in the region. Furthermore because South-Holland makes up a large share of the national energy use, every per cent of energy saved in the region is also of importance to reach the national targets. This importance creates opportunities in the form of attention, support and stakeholder participation.

This ambitious target setting however also creates risks. The 20 PJ ambition is widely communicated to stakeholders in the heat field and is expressed in the Green Deal agreement with the government. The announced ambition creates expectations when it comes to the role of the province, this role is however not yet defined by the province itself and the possibilities at the province are limited. Although the province is trying to shift some of the responsibilities to other parties and to get stakeholders involved, through the program office that is to be set up, the province will still be seen as initiator by other parties. In response to the ambitious targets being set by the province alone, instead of through a multi-stakeholder process, the pressure to meet the targets lies with the province. By singly setting an ambition, without specifying the specific possibilities and limitations of provincial policy, the province created an expected role for itself. The question is whether speaking out the ambition created a role for the province that it is unwilling to play, and whether the role that the province is willing to play is enough to meet the targets.

The other risk of strongly propagating the 20 PJ target is the possible impact of failing to reach this target. If the target is not met, which is a real risk with these ambitious goals, the future of sustainable heat policy is under pressure. The negative associations of failing to reach targets might pull focus from achievements that are benefitting the cause but do not directly result in sustainable heat consumption. By focussing solely on sustainable heat consumption as a measure of success, and by not strongly communicating the limited influence of the province in this, the risk arises that the cause for not meeting the target is sought within the policies of the province.

The third risk of the ambitious target setting is a too strong focus on results and not enough focus on the process. The focus on the targets might actually stand in the way of achieving a transition to a sustainable heat regime. By losing sight of the trajectory and the process, a risk arises of focussing on quick wins instead of measures that add significantly to the long term sustainable heat supply. The question is whether the benefits of the ambitious target setting, in the form of created momentum and support, are offset by the negative aspects of a focus on short term gains, possibly leading to opposing activities and difficulties of making the transition on the long term.

8 Conclusion

The consumption of increasingly more fossil fuels and the associated emissions of greenhouse gasses has already led to measurable greenhouse effects. As a result, the risk of surpassing the 2 ^oC temperature rise, the temperature level up to which eco-systems are believed able to adapt to the changing climate, is significant. However, even ignoring environmental aspects, the fact that fuel use keeps increasing and the supply of fossil fuels is limited leads to concerns about the future availability hereof. Insecurity of supply, leading to speculations, will furthermore have its effect on the price of electricity and gas, making this increasingly more volatile and expensive. The above provides rational to reduce the dependence on fossil fuels and to develop affordable alternatives. This recognition led to a national renewable energy target of 14% in 2020. At the moment however, the contribution of renewable energy in the Netherlands is still hovering around 4.5%.

In South-Holland both the effect of climate change as well as the impact of policies to demote fossil fuel use and CO_2 emissions form clear risks. Climate change may lead to extra spending on water management or reduce the attractiveness of the province. On the other hand the position of energy intensive industries in South-Holland makes rising energy prices, either market or policy driven, highly undesirable. Furthermore, the grip of the province on these matters is small.
Taking into account the above, the province has set its own ambitious sustainable energy targets. By meeting targets in a cost-effective way, while keeping a grip on provincial spatial planning issues, the province can respond to current and future developments while at the same time ensure the attractiveness of the region. The sustainable heat targets in South-Holland aim for the consumption of 20 PJ sustainable heat in 2020, including waste heat. The technical and economic potential of sustainable heat delivery in South-Holland in 2020 amount to respectively 47 and 23 PJ, showing it would in principal be possible to reach the targets. However empirical research shows that according to the business as usual growth, even including the planned geothermal and waste heat projects, a potential of only 11.2 PJ will be reached, just over half the targeted amount.

This potential can be increased by overcoming the barriers in place. The most important barriers were found to be the complexity of the network of heat supply parties, the lack of demand articulation and the lack of policy coordination, mainly between the national government and the province. Also the lack of existing infrastructure, in the form of physical grids but also a financing strategy is found to have a limiting effect. The program office that is being set up by the province and 25 other public and private parties will help to manage the complex network and coordinate policies. However, the necessary focus on the demand for heat, in the form of demand side research and marketing, as well as the generation of financial infrastructure must also be guaranteed to increase the chances of reaching the targets.

In the end it might be most important to keep on focussing on the transformative nature of the developments, this means focussing more on the process and less on petajoules. By focussing on activities that will add to the transition to sustainable heat, the long term sustainable heat supply is guaranteed in a manner that corresponds to reaching this new sustainable system.

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Interviews

Frank Schoof, managing director VOF Aardwarmte Den Haag, 25 February 2013

Victor van Heekeren, chairman Stichting Platform Geothermie, 26 February 2013

Co Hamers, managing director Warmtebedrijf Rotterdam, 5 March 2013

Fokke Goudswaard, corporate staff Eneco, 7 March 2013

Ted Zwinkels, horticulturist within Green Well Westland, 12 March 2013

Rob Kemmeren, sustainable heat and cold municipality of Amsterdam and Waternet, 13 March 2013

Gaby Duijndam, staff member sustainable energy and CO_2 supply LTO Noord Glaskracht, 21 March 2013

Leon Ammerlaan, horticulturist with a geothermal energy source, 26 April 2013

Roelof Kooistra, accountmanager Grontmij,

Marc van der Steen, advisor transition issues Rebelgroup