Realising a just transition to gas-free heating in the Dutch social housing sector

Integration of energy poverty considerations into decision-making

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Energy poverty and the heat transition in the social housing sector in the Netherlands

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“*The obligations to the present generation must not be obscured by our commitment to future generations and they do not have to be”*

- B. Boardman (2010, p. 121)

Preface

I wrote this thesis as part of the MSc programme Urban Environmental Management at Wageningen University. The thesis-writing process was supervised by two Chair Groups; the Environmental Systems Analysis Group (ESA) and the Environmental Policy Group (ENP).

My summer job at the project *Energiebox* has been a main source of inspiration for writing this thesis. Energiebox tries to engage renters in the energy transition by showing them how energy-saving appliances and small adjustments in behaviour can decrease energy consumption. In doing so, Energiebox shows that making a contribution to climate goals does not require high financial investments.

Several people have helped me in bringing about this master's thesis. First and foremost, I would like to thank my supervisors, Karen and Mattijs, for their enthusiasm, support and constructive criticism. Second, my thanks go to all the interviewees, who spend time to contribute to the outcome of this thesis. Finally, I would like to thank Birgit and Teun for proofreading this thesis.

Summary

Because of climatic, economic and social reasons, the Dutch government has expressed a need to diverge from gas as the main resource to provide heat for the built environment. This process is called the 'heat transition' (Dutch: *warmtetransitie).* However, when natural gas prices increase or when the investment costs of alternative energy sources are passed on to end-consumers, this transition probably expands energy poverty. Energy-poor households are those households that experience inadequate energy services due to high energy prices, low household incomes, inefficient buildings and appliances, and specific household energy needs, vulnerabilities and practices. Households in the social housing sector are likely more vulnerable to energy poverty, because they generally have less financial resources - or lack motivation - to invest in improving the energy performance of their homes.

Therefore, this thesis' aim was *to analyse how energy poverty and the heat transition are related in theory and practice, to guide Dutch municipalities and housing associations in incorporating energy poverty considerations in their heat transition decision-making processes for the social housing sector.* I formulated research questions on the relation between the heat transition and energy poverty in the literature; the factors considered in tools and models used in heat transition decision-making; and the role of energy poverty in the heat transition in the district of Overvecht-Noord (Utrecht, the Netherlands). The answers should lead to the necessary guidelines. I used various methods to address these questions, including literature review, assessment of nine tools and models, expert interviews, and a case study (with content analysis and stakeholder interviews) in Overvecht-Noord.

I found that energy poverty is still poorly understood and recognised in the Netherlands. This is demonstrated by the absence of a national definition. Such absence probably limits addressing the problem. Another major finding is that insulation is necessary to allow for gas-free low-temperature heating techniques. It is at the same time a no-regrets measure that can contribute to reducing energy poverty and achieving climate goals. However, insulation leads to actual energy savings that can be lower than predicted. This is generally referred to as the rebound effect, which residents experience as increased comfort. Furthermore, the social housing sector includes multiple groups that are vulnerable to fall into energy poverty. Accommodating these groups' specific needs can be improved by their participation in decision-making. However, the extent to which these people are involved was disappointing. Finally, creating an affordable heat transition is an important topic.

My findings, derived from theory and practice, resulted in eight guidelines for incorporating energy poverty in heat transition decision-making for the social housing sector. The guidelines address the importance of creating a common understanding of energy poverty; prioritising insulation; anticipating the comfort effect after renovations; recognising vulnerable groups; ensuring affordability; facilitating participation in decision-making; creating a common understanding of sustainability; and having a clear division of roles and responsibilities.

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List of acronyms

Alliander DGO	Alliander Sustainable Area Development *Alliander Duurzame Gebiedsonwikkeling*
BZK	(Ministry of) the Interior and Kingdom Relations *(Ministerie van) Binnenlandse Zaken en Koninkrijksrelaties*
CBS	Netherlands Statistics *Centraal Bureau voor de Statistiek*
CW	Central Living Klopvaart *Centraal Wonen Klopvaart*
EPOV	European Union Energy Poverty Observatory
EPV	Energy Performance Compensation *Energieprestatievergoeding*
EZ	(Ministry of) Economic Affairs (*Ministerie van) Economische Zaken*
EZK	(Ministry of) Economic Affairs and Climate Policy (*Ministerie van) Economische Zaken en Klimaat*
Nibud	National Institute for Family Finance Information *Nationaal Instituut voor Budgetvoorlichting*
PBL	Netherlands Environmental Assessment Agency *Planbureau voor de Leefomgeving*
RVO	Netherlands Enterprise Agency *Rijksdienst voor Ondernemend Nederland*
RVV	Regulation Reduction Landlord Levy *Regeling Vermindering Verhuurderheffing*
STEP	Incentive scheme energy performance rented sector *Stimuleringsregeling energieprestatie huursector*
STUW	Foundation Housing Associations Utrecht *Stichting Utrechtse Woningcorporaties*

Chapter 1
Introduction

1.1 Transition of the Dutch residential heating system

Following the United Nations Framework Convention on Climate Change that was held in Paris in December 2015, the European Union (EU) agreed to decrease its greenhouse gas emissions by at least forty per cent by 2030, compared to 1990 levels (European Commission, n.d.). The Dutch government has set an even more ambitious goal and aims for a 49 per cent reduction in emissions by 2030 (Klimaatakkoord, 2018b). Since carbon dioxide (CO_2) is the main contributor to climate change, Dutch policy is especially focused on reducing emissions of this type of greenhouse gas (Klimaatakkoord, n.d.).

The built environment has an important role to play in achieving these climate goals, as the sector is responsible for 39 per cent of the total CO_2-emissions in the Netherlands.[1] Half of these emissions can be attributed to energy used in residential buildings,[2] of which more than seventy per cent is used for heating (Leguijt & Schepers, 2014). The majority of heat derives from fossil energy; 96 per cent of Dutch households use natural gas for space heating and warm water (Oei *et al.*, 2018).

Contribution to climate change is not the only problem associated with natural gas use in the Netherlands. Since natural gas is a non-renewable fuel, the Groningen gas fields are depleted and this increases the country's reliance on imported gas (van der Voort & Vanclay, 2015). On top of that, the earthquakes that followed gas extraction in the Groningen area have caused adverse societal effects such as damage to property and decline in house prices (van der Voort & Vanclay, 2015).

Because of these climatic, economic and social reasons, the Dutch government stated that the country needs to diverge from gas as the main heat resource and develop alternative ways to supply heat (Klimaatakkoord, 2018a). This process is referred to as the 'heat transition' *(*Dutch: *warmtetransitie)* and requires the adjustment of eight million buildings, of which about seven million homes. With the ambition to have all homes cut off from conventional gas supply by 2050, the heat transition will have a large impact on people's living environments (Klimaatakkoord, 2018b; Ministry of Economic Affairs [EZ], 2016).

Several authors have expressed their concerns about this transition towards natural gas-free heating and cooking (Leguijt & Schepers, 2014; Oei *et al.*, 2018). Many concerns are of a socio-economic nature. With a planned tax increase on gas and tax decrease on electricity, the government tries to encourage the implementation of energy-saving measures such as insulation

[1] In 2015, the built environment emitted 55.0 Mton CO_2, compared to total national CO_2-emissions of 142.4 Mton (Klimaatmonitor, 2015).
[2] Residential buildings were responsible for 27.9 Mton CO_2 (Klimaatmonitor, 2015).

and stimulate alternative ways of heat provision (Klimaatakkoord, 2018b). Oei *et al.* (2018), however, argued that households which do not have the means to invest in alternative heating systems (see Box 1), may experience difficulties paying the energy bill when gas prices increase. Stoerring (2017) even stated that when the investment costs of alternative energy sources are passed on to end-users through energy bills, energy transitions can lead to the expansion of energy poverty.

Box 1 Heating systems
Currently, the most common heating technique in the Netherlands is a condensing boiler (Dutch: *hoogrendementsketel* or *HR-ketel*), fueled by gas (CE Delft, 2019). A variety of alternative heating techniques exists, including the heat pump, solar thermal collector, district heating or biogas. In this thesis, I use the terms heating techniques and heating systems. A heating system encompasses more than a single heating technique. For example, the heat pump is a technique for producing heat, but to function efficiently, a heat pump typically requires insulation to improve a buildings' energy efficiency (CE Delft, 2019). In a similar way, to connect households to district heating, major infrastructural changes in the way heat is provided, are required. Heating *systems* thus encompass both single heating *techniques* and their associated *adjustments* in the built environment.

1.2 Energy poverty

The term energy poverty derives from the term fuel poverty. This term emerged in the United Kingdom (UK) and Ireland in the early nineties (Maxim *et al.*, 2016). In these countries, fuel poverty was principally seen as the inability of households to purchase affordable warmth (Bouzarovski, 2014; Maxim *et al.*, 2016). For a long time, the UK and Ireland have been the only European countries to explicitly address the problem, for instance by offering support schemes for investing in energy efficiency improvements (Bouzarovski, 2014). Recognition and knowledge of energy poverty in other European countries has remained less developed (Maxim *et al.*, 2016).

However, awareness of the issue of energy poverty is increasing and has gradually gained recognition among politicians and academics in the European Union (EU) (Bouzarovski, 2014; Maxim *et al.*, 2016; Thomson *et al.*, 2017). Thomson *et al.* (2017) even argued that energy poverty alleviation has been identified as a key policy priority in the EU. This is shown by the launching of the EU Energy Poverty Observatory (EPOV) by the European Commission in January 2018 (EU, n.d.). As a result, Member States are starting to pay more attention to the issue as well, for instance by giving financial support, implementing energy efficiency measures or raising awareness by providing information about energy-saving possibilities (Pye *et al.*, 2015; Thomson *et al.*, 2017).

The EPOV (n.d.) stated that energy poverty affects more than 50 million households in the EU. Energy poverty is associated with various consequences for human health, ranging from respiratory and cardiac illnesses caused by low indoor temperatures to stress from not being able to pay for high energy bills (EPOV, n.d.).

Despite growing interest in the issue of energy poverty, no international definition of energy poverty has been formulated (Thomson *et al.*, 2017). As mentioned, energy poverty initially emerged under the name of fuel poverty (Maxim *et al.*, 2016). Boardman (1991) was the first to introduce the term fuel poverty and used it to describe households whose fuel expenditure to heat their homes exceed ten per cent of their total income. Later, this definition was adjusted to households that *need to* spend more than ten per cent of their income on fuel, so as to include households that do not spend a disproportionate amount on fuel because they are restricting their consumption (Maxim *et al.*, 2016).

Even though the terms fuel poverty and energy poverty are often used interchangeably, they have slightly different meanings (Maxim *et al.*, 2016).[3] Bouzarovski (2014) argued that fuel poverty is a narrowly defined concept which reduces the problem to a lack of affordable energy for heating, whereas energy poverty also encompasses other energy services. Bouzarovski (2018) defined energy services as *"the benefits that energy carriers produce for human well being"* (p. 15). This shift in thinking in energy services instead of expenditure on energy carriers is based on the notion that people demand energy services such as cooking, heating and lighting rather than fuels such as coal, oil, natural gas or renewable energy resources (Bouzarovski, 2018). Hereby, energy services approaches highlight the flaws in existing frameworks measuring energy poverty, which are often focused on the amount of energy units consumed rather than achieving adequate levels of energy services such as heat and light (Bouzarovski, 2018).

In this thesis I use the definition of energy poverty that is used by the EPOV. According to the EPOV (n.d.), energy-poor households are those households that *"experience inadequate levels of . . . essential energy services, due to a combination of high energy expenditure, low household incomes, inefficient buildings and appliances, and specific household energy needs"*.

1.3 Energy poverty in the Netherlands

Straver *et al.* (2017) estimated that energy poverty affects around 750.000 Dutch households. However, a national definition of the term or policies aimed at abating energy poverty are not in place (Straver *et al.*, 2017). Netherlands Statistics (CBS, 2016) found that Dutch households with a low income[4] faced more difficulties in keeping their homes adequately warm and in paying for their gas, water and energy bills than households above the low-income threshold.

These findings show that Dutch low-income households face a higher risk of energy poverty than other households. This is because low-income households spend a larger proportion of their incomes on energy,[5] despite the fact that these households on average use less energy than households with higher incomes (National Institute for Family Finance Information [Nibud], 2009). Van Middelkoop *et al.* (2018) calculated that in the Netherlands, the twenty per cent of households with the lowest incomes spend an average of ten per cent of

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[3] Other words which are used interchangeably with energy poverty include 'domestic energy deprivation' and 'energy vulnerability'. Confusion might also arise as a result of the different usage of the term energy poverty in different countries. Whereas in less economically developed countries energy poverty implies inadequate access to modern energy services, energy poverty in countries that are more economically developed typically refers to issues of affordability (Maxim *et al.*, 2016).

[4] CBS (2016) defined low-income households as households with a standardised income (excluding benefits) under the low-income threshold of €9250 per year.

[5] This phenomenon is known as Engel's law (Haffner & Boumeester, 2015).

their incomes on energy, whereas the twenty per cent of households with the highest incomes spend only four per cent.

In addition to low-income households, tenants spend relatively large proportions of their incomes on energy (Nibud, 2009; van Middelkoop *et al.*, 2018).[6] Because of this, tenants will probably face higher changes of falling into energy poverty when energy prices increase (Haffner & Boumeester, 2015; Nibud, 2009). On top of that, thermal efficiency is related to tenure status; rented houses are often less energy-efficient (Bouzarovski, 2014; Healy & Clinch, 2004). Therefore, this thesis focuses on the social housing sector.

1.4 The Dutch social housing sector

In 2017, 43 per cent of all houses in the Netherlands were rented houses. The majority of rented houses (69 per cent; more than two million houses) were owned by housing associations.[7] Because of this, the Netherlands is the country with the highest percentage of social housing in the EU (Filippidou, 2018). In the Energy Saving Covenant for the Rented Sector, the national government, the national tenants' association and the umbrella organisation of housing associations called Aedes agreed that the average energy label for the Dutch social housing stock would be raised to a B level (or Energy Index 1.25) by 2020 (Ministry of the Interior and Kingdom Relations [BZK], 2012; Vringer *et al.*, 2014).

Progress towards this goal, however, falls short (Filippidou, 2018; Vringer *et al.*, 2014). Filippidou (2018) argued that this is because housing providers generally do not seem to execute major renovations. Instead, mainly small improvements in the energy efficiency of the dwellings take place. Also, actual energy savings are often lower than predicted because understanding the impact of combinations of energy-saving measures is difficult (Filippidou, 2018).

Because responsibility for large renovations lies with the housing associations, and low-income households often lack the required financial resources, renters in the social housing sector generally do not have the ability to invest in measures that improve the energy performance of their homes (Oei *et al*., 2018). On top of that, tenants may be less likely to have the motivation to invest in improving the energy efficiency of their temporary homes (Healy & Clinch, 2004; Maxim *et al.*, 2016). Maxim *et al*. (2016) argued that the owners of rented houses are also unlikely to invest in energy efficiency improvements, unless this entails that they can obtain more revenue from their tenants. The combination of relatively low incomes and energy inefficient houses puts tenants in the social housing sector at risk of falling into energy poverty, especially in the light of the heat transition which involves a tax increase on gas and investments in alternative heating systems.

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[6] 14 to 15 per cent of tenants spend more than 11 per cent of their incomes on energy, compared to 6 to 7 per cent of homeowners (van Middelkoop *et al.*, 2018).

[7] In 2017, the housing stock consisted of 7,592,748 houses, of which 4,318,794 were privately owned and 3,273,954 were rented houses. 2,251,495 rented houses were owned by housing associations (CBS, 2017b).

1.5. The heat transition in the social housing sector in Overvecht-Noord

Overvecht-Noord (see Figures 1 and 2) in Utrecht is one of the 27 districts in the Netherlands to start the heat transition. In fact, the municipality of Utrecht aims for Overvecht-Noord to be the first extant district to become gas-free (Gemeente Utrecht, n.d.-a). Considering its high percentage of social housing - seventy per cent of dwellings is in possession of housing associations (CBS, 2017a) - Overvecht-Noord is a suitable case to study how energy poverty plays a role in this heat transition.

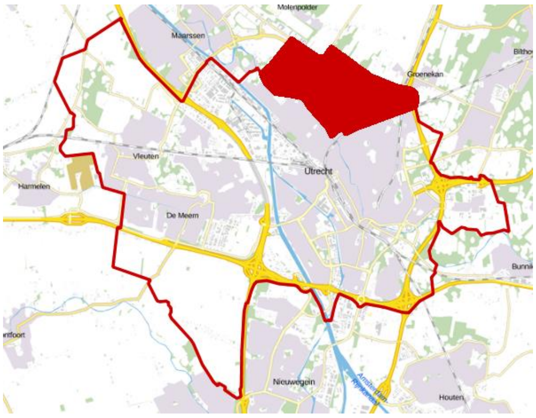

Figure 1 Location of Overvecht in the city of Utrecht (adapted from WelkomeWijken: http://www.welkomewijken.nl/index.php?kaart=2)

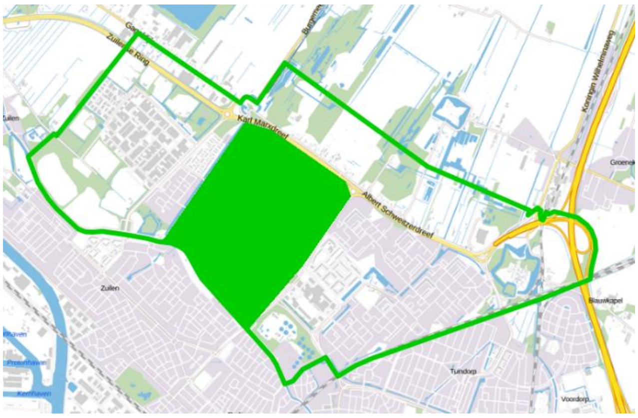

Figure 2 Location of Overvecht-Noord in the district of Overvecht (adapted from WelkomeWijken: http://www.welkomewijken.nl/index.php?kaart=2)

1.6 Aim and research questions

Energy poverty has only to a very limited extent been studied by academics in the Netherlands (Straver *et al.*, 2017). The heat transition is also a relatively new topic, not only in the Netherlands, but internationally as well. As a consequence, scientific knowledge about the heat transition is also very scarce. The two topics of energy poverty in the Netherlands and the heat transition have not been studied thoroughly, and have not been studied in combination either.

Multiple authors (Bickerstaff *et al.*, 2013; Santamouris, 2016; Stoerring, 2017; Ürge-Vorsatz & Tirado Herrero, 2012) stressed the importance of integrating the issue of energy poverty on the one hand, and energy transitions, marked by the decarbonisation of energy systems, on the other. Bickerstaff *et al.* (2013), however, argued that little has been written about the social and equity implications of low-carbon energy systems. Ürge-Vorsatz and Tirado Herrero (2012) stated that energy transitions and energy poverty are inextricably linked and therefore cannot be two disconnected fields of research.

Energy poverty is not only underrepresented in the transitions literature, but also in energy policy and the wider energy debate (Eames & Hunt, 2013; Sovacool *et al.*, 2016). According to Sovacool *et al.* (2016), energy discussions are typically focused on the domains of engineering and economics instead. In the Netherlands, a variety of tools and models is used to support heat transition decision-making. The factors included in these tools and models provide insight into the extent to which energy poverty is currently taken into account in the heat transition.

This thesis aims *to analyse how energy poverty and the heat transition are related in theory and practice, to guide Dutch municipalities and housing associations in incorporating energy poverty considerations in their heat transition decision-making processes for the social housing sector.* I formulated four research questions (RQs) to achieve this aim. Figure 3 shows these questions and their interrelations.

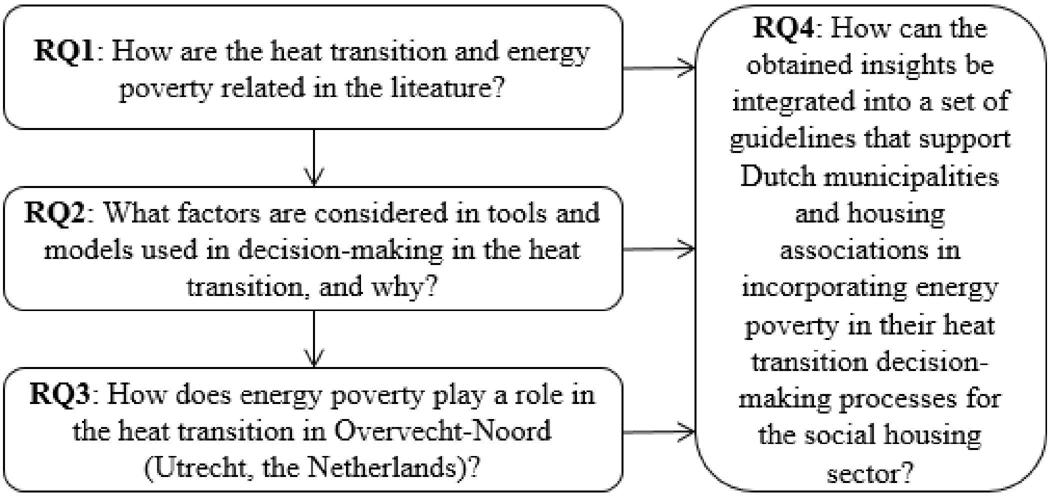

Figure 3 The research questions' connections

1.7 Structure of this thesis

This thesis is built up as follows. Chapter 2 discusses the methodologies I used to answer the different RQs. I address RQ1 on the relation between energy poverty and the heat transition in Chapter 3. In that chapter, I create an understanding of energy poverty, which serves as the foundation for the chapters to follow. Chapter 4 addresses RQ2 on the dominant factors in tools and models. Chapter 5 presents the results derived from the case study in Overvecht-Noord. In Chapter 6, I integrate the findings from the different chapters, and reflect on the results and on the methods I used. Chapter 7 concludes this thesis by showing how Dutch municipalities and housing associations can incorporate energy poverty into their decision-making processes for the heat transition.

Chapter 2
Methodology

To answer my RQs, I combined insights from several scientific disciplines, environmental and policy studies being the most important ones, and from practical experiences. To obtain these insights, I used a variety of methods.

2.1 Relation between heat transition and energy poverty

To answer RQ1 and relate the heat transition to energy poverty, I reviewed the literature and combined it with a policy analysis. To begin with, I created an understanding of energy poverty's underlying causes. Energy poverty can be placed within a wider body of literature on energy justice. Energy justice can be used as an analytical tool to resolve energy problems (Sovacool and Dworkin, 2015). I mainly used scientific literature about energy poverty and energy justice in the EU, since studies on energy poverty in the Netherlands and outside the EU are scarce.

To study how the heat transition and energy poverty relate, I performed two activities. First, I studied literature discussing how energy transitions have previously affected energy poverty. Literature was available on the energy transitions in the UK, Germany and the Netherlands. Second, I analysed policy documents and regulations concerning the heat transition by looking at the ways in which these are likely to impact energy poverty in the social housing sector. I integrated the obtained insights into a conceptual model, showing the interrelationships between the heat transition and energy poverty.

2.2 Factors considered in tools and models used in heat transition decision-making

RQ2 on the dominant factors in tools and models provides insight into the extent to which energy poverty is currently taken into account in decision-making in the heat transition. To answer RQ2, I used a combination of methods. First, I analysed nine tools and models[8] to get an impression of the dominant factors taken into account in the heat transition. Second, I interviewed experts working in the heat transition to find reasons for including or omitting certain factors in or from tools and models.

[8] A tools is *"something that helps you to do a particular activity"* (Tool, n.d.). Models are abstractions of reality and are used to analyse complex systems (Müller *et al.*, 2011). Models can be used as tools for understanding, to aid decision-making processes or as means for communication (Müller *et al.*, 2011). In short, tools are not necessarily models, however, models can be used as tools.

2.2.1 Factors in tools and models

I selected the tools and models from the toolkit *Energietransitierekenmodellen* (Energy Transition Calculation Models; ETRM). This toolkit consists of 23 models and tools that are used for multiple purposes in the energy transition (Netbeheer Nederland, n.d.). The toolkit was composed to help municipalities, housing associations and energy cooperations in addressing their energy-related issues (Netbeheer Nederland, n.d.). In my analysis, I only included those models and tools used to support municipalities or housing associations in their heat transition decision-making. This entails that I excluded tools and models with a focus on other actors (e.g. energy companies or grid operators) or different aspects of the wider energy transition. The experts I interviewed also introduced a tool and a model that were not included the ETRM toolkit. I decided to include these in my analysis as well. Figure 4 shows the selection process leading to the final set of tools and models included in this study.

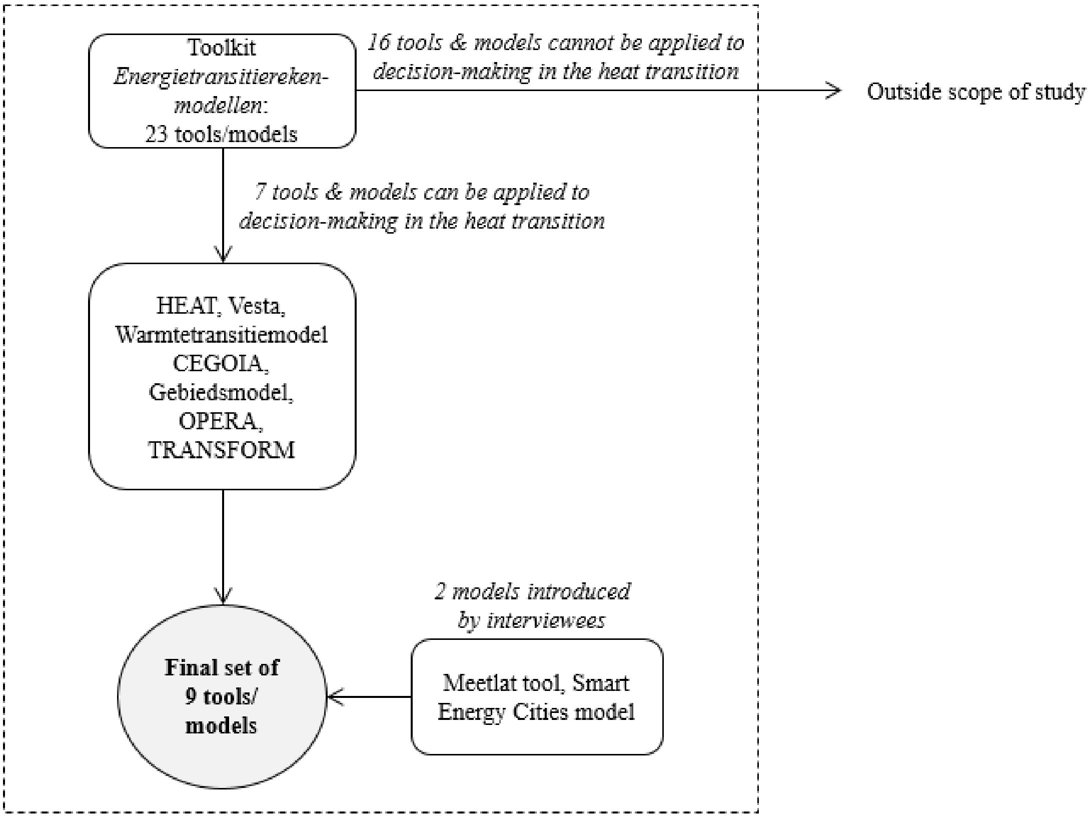

Figure 4 Selection process of tools and models

To check the statement made by Sovacool *et al.* (2016) that *"energy policy and technology discussions are limited to the domains of engineering and economics"*, and discover to what extent energy poverty considerations are taken into account in heat transition decision-making, I analysed what factors were included by the tools and models. To do this, I consulted reports published by the organisations that developed the tools and models, and background documents provided by the ETRM toolkit. I found factors in the categories 'economic factors', 'technical factors', 'environmental factors' and 'social factors'.

2.2.2 Expert interviews

To address the question of *why* certain factors are included in or left out from the tools and models, I conducted four expert interviews. I selected experts that work as professionals in environmental consultancies and make use of tools and models to guide municipalities and housing associations in the process towards a gas-free built environment. Table 1 gives an overview of the interviewed experts.

The interviews served multiple purposes, that is *(1)* to check whether the factors I derived from the tools and models reflected the experts' opinions about important factors to consider in heat transition decision-making, *(2)* to discover whether the experts considered other factors to be important as well, and *(3)* to identify reasons why certain factors are included in or omitted from tools and models.

I conducted two interviews face-to-face, and two by phone. I used a semi-structured interview guide (see Appendix A), so that the factors I distilled from the tools and models could be discussed and enough room was left for the experts to elaborate on other topics they considered important in the heat transition. Finally, I recorded, summarised and coded the interviews.

Table 1 List of interviewed experts

Expert interview No.	Name of interviewee	Position	Company
1	R. Geldhof	Consultant heat transition and developer of the *Warmtetransitiemodel*	Over Morgen
2	T. de Booij	Consultant	WarmteTransitieMakers
3	D. de Greef	Consultant and developer of the *Meetlat tool*	Greenvis
4	B. Schepers	Senior researcher/consultant and developer of the CEGOIA model and VESTA model	CE Delft

2.3 Energy poverty and the heat transition in Overvecht-Noord

I used the development of Overvecht-Noord into a gas-free district as a case for observing whether and how energy poverty plays a role in practice. The following section gives an impression of the study area. Subsequently, I go into the methods used for doing the case study.

2.3.1 Study area

Overvecht-Noord is part of the Overvecht district in Utrecht and consists of four neighbourhoods: *(1)* Vechtzoom-Noord, Klopvaart *(2)* Vechtzoom-Zuid, *(3)* Tigrisdreef and surroundings, and *(4)* Zambesidreef and surroundings (Gemeente Utrecht, n.d.; Gemeente Utrecht *et al.*, 2017). Table 2 shows the total number of dwellings and the number of dwellings in possession of housing associations for each of these neighbourhoods (CBS, 2017a).

Table 2 Dwellings in possession of housing associations in Overvecht-Noord (based on CBS, 2017a)

	No. of dwellings	**No. of dwellings in possession of housing associations**	**% Dwellings in possession of housing associations**
Vechtzoom-zuid	2304	1613	70.0
Vechtzoom-noord, Klopvaart	1479	873	59.0
Zambesidreef and surroundings	2216	1751	79.0
Tigrisdreef and surroundings	1921	1537	80.0
Overvecht-Noord (total)	**7920**	**5773**	**72.9**

The housing associations operating in Overvecht-Noord are Mitros, Portaal and Bo-Ex. Portaal possesses 2500 dwellings in Overvecht-Noord; Mitros 2200 and Bo-Ex 1000). The three housing associations are united in the Foundation of Housing Associations Utrecht (*Stichting Utrechtse Woningcorporaties*; STUW). The social housing stock in Overvecht-Noord is dominated by multi-unit dwellings with only about one tenth of the housing stock consisting of single-family dwellings (see Figure 5).

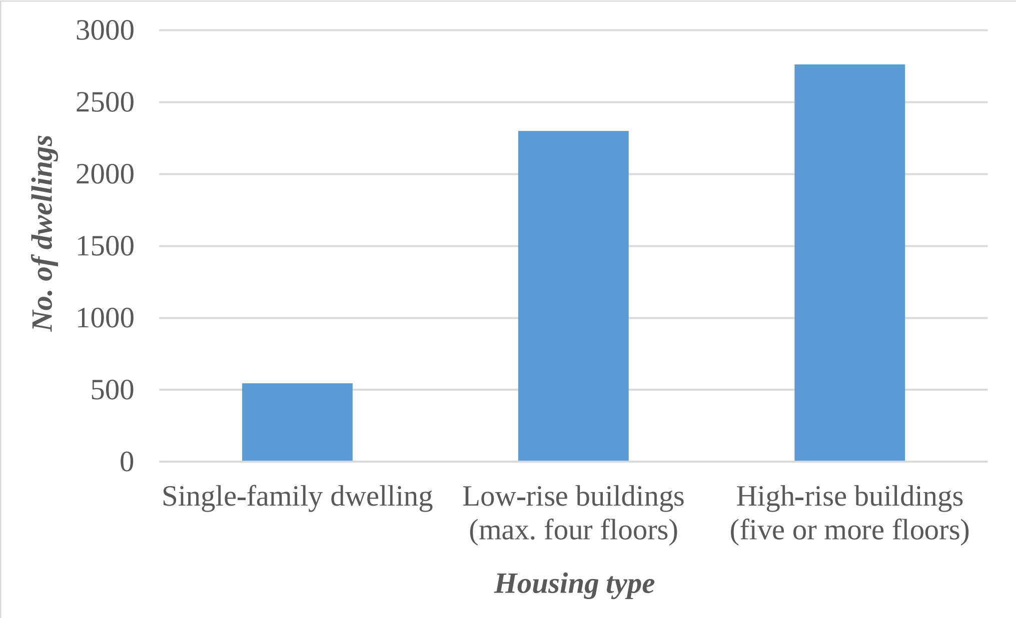

Figure 5 Distribution of housing types in the social housing sector in Overvecht-Noord (based on Gemeente Utrecht et al.*, 2017)*

To disconnect Overvecht-Noord from the gas grid, the municipality considers two alternative heating systems, that is *(1)* ‘all-electric’ by making use of heat pumps and *(2)* district heating (Gemeente Utrecht, n.d.-a). The former is an individual heating technique and requires homes to be well-insulated (CE Delft, 2019; Gemeente Utrecht, n.d.-a). The latter is a collective heating technique and can be achieved either by expanding the current district heating network or by creating a local heat grid based on a collective heat source (CE Delft, 2019; Gemeente Utrecht, n.d.-a).

2.3.2 Case study research

The use of a case study gives greater weight to the guidelines by making them more applicable to real-life situations. Siggelkow (2007) argued that a case study can be especially valuable when little theoretical knowledge exists concerning a certain phenomenon. Since the heat transition is a process that is still taking shape, examples of existing neighbourhoods that have been disconnected from the gas grid are scarce. Therefore, knowledge concerning this topic is not widely available. I performed several activities to do the case study, including *(1)* content analysis of relevant documents, and *(2)* stakeholder interviews. These methods are commonly used in case-based research (Metzler, 2014; Sofaer, 1999).

First, I carried out a stakeholder analysis. A stakeholder analysis serves to identify key actors or stakeholders and assess their respective interests (Oglethorpe, 2002). Stakeholders comprise groups and individuals that have an interest in and an influence on the outcome of a process or project. Key stakeholders in the heat transition in the social housing sector in Overvecht-Noord are: the municipality of Utrecht, housing associations Mitros, Portaal and Bo-ex, district heat provider Eneco, grid operator Stedin, and residents.

To do the content analysis, I gathered relevant documents concerning the heat transition in Overvecht-Noord. Sofaer (1999) argued that content analysis is helpful in highlighting the ways in which topics are perceived by different actors. The municipality of Utrecht published documents related to the heat transition in Overvecht-Noord, which helped me to capture the municipality's perspective. District heat provider Eneco published a road map for 'sustainable district heating', which I used to extract Eneco's viewpoint. Other documents I used include working papers, reports of meetings, news publications and research reports. Besides qualitative data, the case also provided with quantitative data derived from the CBS database.

The interviews served to discover how the heat transition in Overvecht-Noord is perceived by the other stakeholders. The selection of interviewees was an iterative process, since I recruited more respondents by making use of snowball sampling. In snowball sampling, successive respondents are identified from among the initial interviewees' acquaintances (Reed *et al*., 2009). Since the interviewees are actively involved in the heat transition in Overvecht-Noord, they possess networks of value to this research. I conducted a total of six interviews with eight stakeholders. Table 3 gives an overview of the interviewed stakeholders.

To capture the residents' viewpoints, I interviewed a member of the residents' platform for the Overvecht district. I chose not to interview individual renters living in the social housing sector in Overvecht-Noord, because I did not want my results to be biased by a few individuals' opinions, and because of the limited time frame of this study.

I conducted the stakeholder interviews face-to-face, with the exception of one, which I conducted by telephone. I used a semi-structured interview guide (see Appendix B) based on the main factors influencing energy poverty found in Chapter 3. I recorded, summarised and coded the interviews, which helped me find the main themes addressed in the case study.

Table 3 List of interviewed stakeholders

Case study interview No.	Name of interviewee	Position	Company
1	A. Tourné	Resident, member of energy cooperative, member of Bewonersplatform (Residents' Platform) Overvecht	Resident, Energie-U, Bewonersplatform Overvecht
	M. Sterk	Resident, member of energy cooperative	Resident, Energie-U
2	P. Meeuwis	Senior asset manager Utrecht	Portaal
3	W. de Vette	Property strategy and sustainability advisor	Mitros
4	E. Gruter	Communications advisor	Bo-Ex
	A. van Leeuwen	Project manager property and development	Bo-Ex
5	W. ten Zijthoff	Manager sustainability of the built environment	Stedin
6	Stakeholder 6	Sustainability advocate	Aedes

2.4 Integration of insights into set of guidelines

The final step involved addressing RQ4 by integrating the insights from addressing the first three RQs. RQ4 is a design-oriented question, because it is aimed at creating a new set of guidelines (Bakker, 2015). I used Repko's (2012) methodology for doing interdisciplinary research. Figure 6 concludes this chapter by showing what methods I used to answer the RQs.

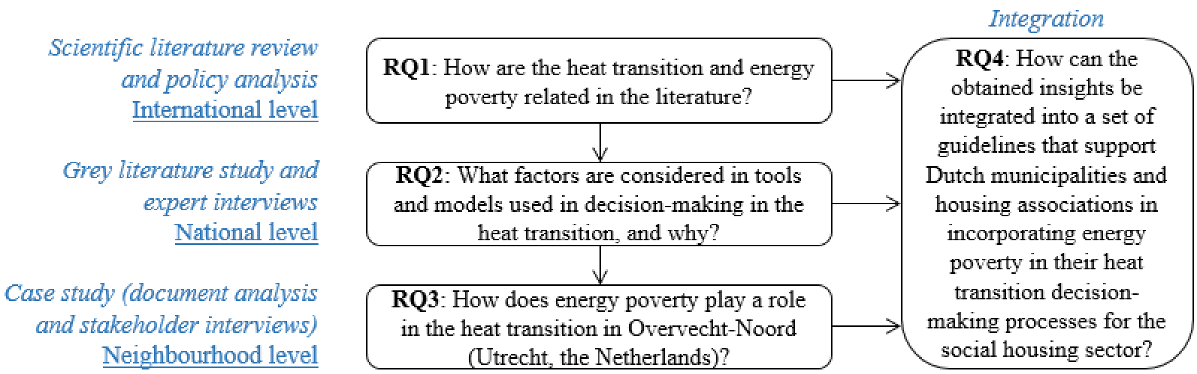

Figure 6 Research questions and methods used for answering them

Chapter 3

Relation between energy poverty and the heat transition

This chapter contributes to this thesis' main aim by analysing how energy poverty and the heat transition are related in the literature. I present the results of a literature review and policy analysis. This chapter is built up as follows. First, I create an understanding of what constitutes energy poverty and the main factors underlying the issue by using an energy justice lens. To discover how the heat transition and energy poverty relate, I discuss literature on the ways energy transitions have previously affected energy poverty in multiple countries and analyse policies and regulations that should facilitate the heat transition.

3.1 Understanding energy poverty

Energy poverty is part of the broader energy justice paradigm. According to Bouzarovski (2018), notions of justice have enriched traditional understandings of energy poverty. To understand energy poverty and discover the main factors underlying the issue, discovering what constitutes energy poverty is important.

3.1.1 Energy justice

Energy justice has its roots in the environmental justice movement (see Box 2) and carries the same basic philosophy (Bouzarovski, 2018; Jenkins *et al.*, 2014). Energy justice seeks to apply justice theories and principles to the understanding of energy systems, including topics such as energy policy, energy production and consumption, energy security and climate change (Bouzarovski, 2018; Jenkins *et al.*, 2016). The energy justice movement aims to provide everyone with safe, affordable and sustainable energy (Jenkins *et al.*, 2014). According to Gillard *et al.* (2017), justice principles are essential for creating fairer energy systems. Energy justice's core tenets, as in environmental justice, are *(1)* distributional justice, *(2)* procedural justice, and *(3)* justice as recognition (Agyeman *et al.*, 2016; Bouzarovski, 2018; Jenkins *et al.*, 2016).

Distributional justice relates to fairness in the distribution of goods and services across society (Bouzarovski, 2018; Gillard *et al.*, 2017; Sovacool *et al.*, 2016). Multiple authors have argued that energy poverty is principally an issue of distributional justice, because most concerns about energy poverty are on the unequal distribution of access to energy services and the distributional burden of rising energy prices (Jenkins *et al.*, 2016; Sovacool *et al.*, 2016; Walker & Day, 2012). Being able to obtain a sufficient level of energy services depends on the presence of other factors, such as income, energy price and efficient housing (Gillard *et al.*, 2017; Walker & Day, 2012). These factors each have their own distributions.

Box 2 Environmental justice

Environmental justice is at the interface of environmental sustainability and socio-economic equality and justice (Agyeman *et al.*, 2016; Schlosberg & Collins, 2014). Environmental justice came into existence in the United States in the 1980s when activists protested the siting of toxic waste facilities in or near low-income communities and communities that were predominantly African-American (Agyeman *et al.*, 2016; Schlosberg & Collins, 2014). These communities were disproportionately exposed to the poisons and environmental hazards deriving from these waste facilities (Agyeman *et al*., 2016; Sovacool *et al*., 2016). Environmental justice's initial focus was thus on the inequitable distribution of environmental risks and governmental protection, and on preventing these risks from being produced in the first place, especially in communities already burdened (Light & de-Shalit, 2003).

The concept of environmental justice started to globalise when industrialised countries started to outsource their externalities (for instance in the form of electronic waste, natural resource extraction or greenhouse gases) to less economically developed nations (Agyeman *et al.*, 2016). Also, themes are no longer limited to toxic waste, but nowadays include topics such as deforestation, climate change and access to parks for recreation (Agyeman *et al.*, 2016).

Walker and Day (2012) argued that besides distributional justice, *procedural justice* plays an important role in creating and sustaining inequalities in access to energy services. Procedural justice focused on stakeholder engagement in policy and governance and on fairness in decision-making procedures (Bouzarovski, 2018; Gillard *et al.*, 2017; Light & de-Shalit, 2003). It concerns the ways in which decision-makers have sought to engage with communities (Jenkins *et al*., 2016). Procedural justice is centred on the three principles of access to *(1)* information, *(2)* participation in decision-making and *(3)* legal rights (Gillard *et al.*, 2017; Walker & Day, 2012). Access to information is an important aspect of procedural justice, for different reasons. Firstly, knowing the scale of energy poverty is fundamental for addressing the issue, and for advocacy groups to promote energy-poor families' interests (Walker & Day, 2012). Also, having access to information can help vulnerable consumers to become more aware of energy prices or encourage them to adopt more sustainable consumption practices (Jenkins *et al.*, 2016; Walker & Day, 2012). Access to participation in decision-making is a second aspect of procedural justice and can enable the interests of people affected by energy poverty to be properly represented (Walker & Day, 2012). Finally, access to legal rights means that laws and regulations protecting the interests of energy-poor households are in place, and that these laws and regulations are enforced (Walker & Day, 2012). Jenkins *et al.* (2016) identified three mechanisms to achieving just outcomes, that is *(1)* mobilising local knowledge, *(2)* full information disclosure by government and industry, and *(3)* better institutional representation.

Finally, *justice as recognition* refers to the degree of respect given to different social groups and explores what sections of society are ignored or misrepresented (Bouzarovski, 2018; Jenkins *et al*., 2016). In the context of energy poverty, justice as recognition is about recognising differential needs for energy services and accommodating needs of vulnerable and marginalised social groups (Walker & Day, 2012). Recognition is not only about acknowledging the existence of vulnerable groups, but recognition justice also seeks to reveal the heterogeneity in energy needs and vulnerabilities - consequences experienced by a lack of these services - of individuals belonging to these groups (Gillard *et al.*, 2017).

Jenkins *et al.* (2014) argued that energy justice's three tenets are not always distinct. Instead, they have many overlapping issues and interlink (Gillard *et al.*, 2017; Jenkins *et al.*, 2014; Light & de-Shalit, 2003). Gillard *et al.* (2017) argued that distributional justice requires *"meaningful recognition and fair procedures"* (p. 54). Procedural justice and justice as recognition are also closely related. This is demonstrated by the connection between the failure to recognise the vulnerability of certain individuals and groups and their limited involvement in decision-making (Walker & Day, 2012). Sovacool *et al.* (2016) even regard justice as recognition as a part, or precondition, of procedural justice. Research by Snell *et al.* (2015) showed that energy poverty in England disproportionately impacts people with disabilities. This is a distributive injustice driven by the misrecognition of this group's needs and vulnerabilities. Because of these interlinkages, multiple authors argued that energy justice (and thereby energy poverty) is in need of a 'whole systems approach' (Bouzarovski, 2018; Jenkins *et al.*, 2014). Such approach can highlight that injustices experienced at the household level can be the result of processes or injustices taking place in a different component of the energy system. Figure 7 visualises the interrelatedness of energy justice's three tenets and their connections to energy poverty.

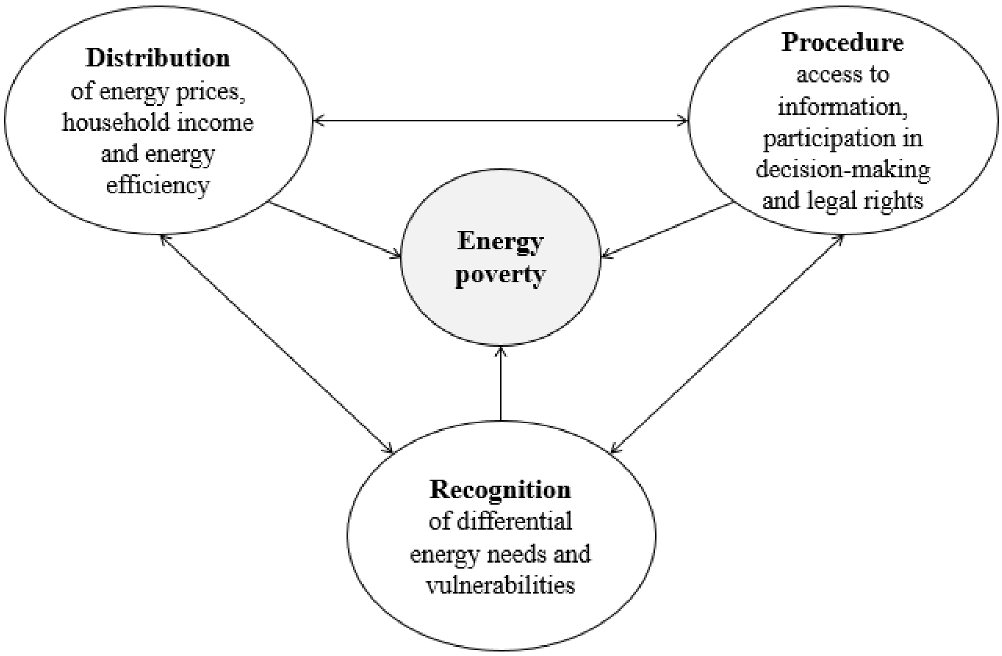

Figure 7 Three types of interrelated energy justice influencing energy poverty (adapted from Gillard et al.*, 2017)*

3.1.2 Factors underlying energy poverty

Multiple scholars have argued that the most important factors putting a pressure on energy poverty are *(1)* low household incomes, *(2)* high energy prices, *(3)* inefficient buildings and appliances, and *(4)* specific household energy needs, vulnerabilities and practices (Bouzarovski, 2014; Bouzarovski & Tirado Herrero, 2017; Thomson *et al.*, 2017). This is in line with EPOV's definition of energy poverty that I use in this thesis. Figure 8 shows these factors in relation to energy poverty.

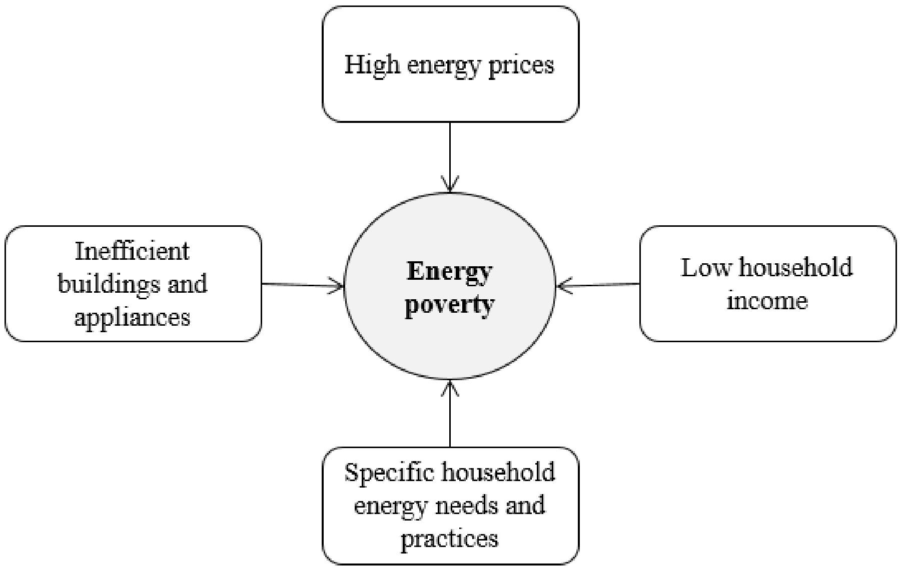

Figure 8 The four principal drivers of energy poverty

The first factor influencing energy poverty is *household income*. Not all income-poor households are also energy-poor. However, energy services are less affordable to low-income households because they will have a lower amount of income available for this purpose (Bouzarovski, 2014; Maxim *et al.*, 2016). Also, low-income households on average have to spend a higher share of their incomes on their energy consumption than households with higher incomes (Haffner & Boumeester, 2015; Schaffrin & Reibling, 2015).

Together with household income, *energy prices* influence the affordability of the energy bill for households (Maxim *et al.*, 2016). Scarcity of fossil energy resources and taxes imposed on the energy bill to stimulate energy conservation, lead to increases in energy prices. Low-income households are more affected by these increases in energy prices because of the relatively large share the energy bill takes in their total expenses (Schaffrin & Reibling, 2015).

Energy inefficiency is another important factor underlying energy poverty, and refers to the efficiency of buildings and appliances. Inefficient houses and appliances require more energy to achieve the same levels of energy services (Gillard *et al.*, 2017; Walker & Day, 2012). Bouzarovski (2018) argued that the built environment, including the efficiency of homes, heating systems and appliances, is crucial in shaping vulnerability to energy poverty. Agyeman *et al.* (2016) also argued that *"a functioning environment provides the necessary conditions to achieve social justice"* (p. 335). Walker and Day (2012) argued that especially low-income households live in low-quality housing. The efficiency of the housing stock can be increased by energy efficiency retrofits. Retrofitting measures include, for instance, roof and wall insulation, double or triple glazing and draught proofing (Clinch & Healy, 2003).

Finally, households with above-average energy needs have shown to be more susceptible to energy poverty (Stoerring, 2017). For instance, pensioners and people with disabilities or chronic illnesses often have higher energy needs (Bouzarovski, 2014; Snell *et al.*, 2015; Stoerring, 2017). Pensioners are likely to consume more energy than others for heating their homes, for physiological reasons and because they generally spend more hours of the day at home than people of working age (Walker & Day, 2012). People with disabilities may have higher energy needs to heat their homes to comfortable temperatures or for using medical equipment (Snell *et al*., 2015). Besides differing needs, households or their individual members experience different vulnerabilities to a mismatch between energy needs and access to energy services (Thomson *et al.*, 2017). Also, household-specific practices shape energy use and are therefore important to consider in studying energy poverty (Thomson *et al*., 2017). Household practices refer to the ways in which energy is used in the home, for heating, cooling, lighting and running electric appliances (Schaffrin & Reibling, 2015). Energy practices are not just a matter of individual behaviour, they are also impacted by social energy practices embedded in cultural and institutional contexts (Schaffrin & Reibling, 2015).

The four factors influencing energy poverty do not exist completely independently from one another. For instance, households with low incomes are not only more susceptible to energy poverty because energy is less affordable to them, but also because these households have less resources or opportunities to invest in energy efficiency improvements (Walker & Day, 2012). Snell *et al.* (2015) added that the higher prevalence of energy poverty among households containing people with disabilities in England, is probably not only because of their higher energy needs, but also because people with disabilities typically have lower incomes due to higher chances of being unemployed, working fewer hours or earning lower wages.

3.2 Energy transitions and energy poverty

Energy transitions are processes of fundamental change in the energy sector, often marked by processes of decarbonisation (Bickerstaff *et al.*, 2013; Bouzarovski, 2018). Bouzarovski (2018) argued that energy transitions may increase the vulnerability of particular social groups. Jenkins *et al.* (2018) even stated that *"failure to adequately engage with questions of justice throughout the transition process is dangerous"* (p. 67). On the contrary, Ürge-Vorsatz and Tirado Herrero (2012) argued that the adoption of low-carbon technologies can also be a way to reduce disparities. Since energy transitions can decrease inequalities but at the same time can create new or widen existing inequalities, it is worth studying whether and in what ways energy transitions have impacted energy poverty before. Therefore, this section presents the results of a literature review on energy transitions in three countries and their effects on energy poverty.

3.2.1 Germany

Frondel *et al.* (2015) argued that the German energy transition or so-called *Energiewende*, which led to an increase in the share of renewable electricity at an unprecedented rate, has been accompanied by a near doubling of energy prices for households. This is because the key element of the German energy transition was the introduction of a feed-in tariff system in 2000, a subsidy funded by a levy on the consumer electricity price (Frondel *et al.*, 2015; Grösche & Schröder, 2014). The feed-in tariff subsidy system financially compensated households for producing renewable energy and supplying it to the public grid (Frondel *et al.*, 2015). Grösche and Schröder (2014) found that ownership of solar panels is positively related to income, and therefore especially higher-income households benefit from the feed-in tariff system. This subsidy system thus caused regressive distributional effects, meaning that low-income households suffered more from increases in their energy bills than wealthier households, because they needed to spend increasing proportions of their incomes on energy and did not benefit from the feed-in tariff system (Frondel *et al.*, 2015; Grösche & Schröder, 2014; Neuhoff, *et al.*, 2013). Frondel *et al.* (2015) suggested unconditional cash transfers to energy-poor households to offset these regressive impacts.

3.2.2 United Kingdom

As early as the 1990s, Boardman (1993) worried that policies put into place in the UK to reduce the greenhouse effect, would negatively affect low-income families. This is because a commonly advocated approach to reducing carbon emissions is increasing fuel prices by a carbon tax (Boardman, 1993; Ürge-Vorsatz & Tirado Herrero, 2012). Boardman (1993) argued that a carbon tax would disproportionately affect low-income families because these families spend a larger proportion of their incomes on energy and because they have less capital to invest in energy-saving measures. Almost two decades later, Boardman (2010) is still convinced that if climate change policy results in higher fuel prices, this can aggravate energy poverty. However, Boardman (2010) also argued that strong policy synergies exist between reducing energy poverty and reducing CO_2-emissions. If policies ensure access of energy-poor households to the capital required for installing micro-generation technologies, feed-in tariffs can be an important source of income for these households (Boardman, 2010).

3.2.3 The Netherlands

Similar findings derive from the Dutch energy transition before the plans for a heat transition were introduced. The government has been trying to stimulate renewable electricity generation and energy conservation through subsidies and tax reduction. According to Rooijers (2016), low-income households benefit less from these decarbonisation-related measures than households with higher incomes. Vergeer (2017) calculated that about eighty per cent of the €750 million in the form of subsidies and tax reduction, went to the fifty per cent households with the highest incomes, and only twenty per cent was of benefit to the fifty per cent households with the lowest incomes. This is because the largest amounts of financial benefits of Dutch climate policy have been granted as tax reduction for possession of efficient cars and the net metering policy[9], which both require financial investments (Vergeer, 2017). The only subsidy policy studied by Vergeer (2017) that has been of benefit to low-income households, albeit in an indirect way, is the incentive scheme for improving the energy performance of buildings in the rented sector called STEP. STEP was put into practice so that housing associations can receive a subsidy for improving the energy performance of their property. Renters can profit from this policy in the form of reduced energy bills (Vergeer, 2017).

Rooijers (2016) argued that the costs of Dutch climate policy are related to the amount of energy used. Low-income households on average consume less energy, and therefore spend a smaller amount on energy tax than households with high incomes (Rooijers, 2016).[10] On top

[9] The net metering policy (Dutch: *salderingsregeling*) ensures that electricity produced by solar panels that is not consumed directly by the household, can be delivered to the electricity grid and consumed at a different time, at no cost (Londo *et al.*, 2017).

[10] In relative terms, however, low-income households pay more for energy (Rooijers, 2016).

of that, households that consume less than 700 m^3 gas and 1600 kilowatt hours (kWh) electricity, do not have to pay energy tax at all (Rooijers, 2016). Rooijers (2016) concluded that even though the costs of Dutch climate policy are proportional to the amount of energy consumed, the benefits are mostly received by higher-income households.

3.3 Relation between energy poverty and the heat transition

The heat transition is part of the wider energy transition towards low-carbon energy supply by 2050 (EZ, 2016). To stimulate the heat transition, the Dutch government has adopted several policies. First, the government implemented a tax increase on gas and decrease on electricity to discourage gas use and stimulate the adoption of insulation and alternative heating techniques (Klimaatakkoord, 2018). As of 2019, the energy tax on gas will increase with €0.03 per m^3 and the energy tax on electricity will decrease with €0.0072 per kWh.[11] The proposal for the Climate Agreement stated that the tax shift would be designed in such a way that it would imply a reduction in energy tax expenses for households (Klimaatakkoord, 2018). However, calculations by the government show that households with an energy consumption similar to the national average will face a tax increase on their energy bills of around €130 per year (Government of the Netherlands, n.d.-a).

Besides a tax shift, as of 2020 the net metering and STEP policies will cease to exist. No alternative to the net metering policy has been put forward. The STEP policy will be replaced as of 2020. Its successor will be the Regulation Reduction Landlord Levy (*Regeling Vermindering Verhuurderheffing;* RVV), which compensates housing associations by decreasing the landlord levy, based on improvements in the energy performance of dwellings (Netherlands Enterprise Agency [RVO], 2018). To qualify for the cut in landlord levy, housing associations have to improve the energy performance of the dwelling with at least three steps in the Energy-Index to a maximum of 1.40 or energy label B (RVO, 2018).

Another measure is the Energy Performance Compensation (*Energieprestatievergoeding;* EPV). This measure entails that housing associations that have renovated dwellings to become (almost) net-zero energy, can ask renters compensation for the investments made (RVO, n.d.). The EPV should stimulate housing associations to make their property more energy-efficient by carrying out renovations (RVO, n.d.).

Figure 9 shows how the policies introduced to accelerate the heat transition are likely to impact energy poverty. On the one hand, the RVV and EPV should stimulate housing associations to renovate their property. Thereby, the energy efficiency of these dwellings increases, which contributes to reducing energy poverty. On the other hand, the policies can increase energy poverty among households in the social housing sector, following an increase in energy tax and because households may have less income available for the energy bill after paying for the EPV. However, the EPV is likely to be accompanied by a decrease in energy costs.

[11] In 2018, energy tax for gas is €0.26001 per m^3 and electricity €0.10458 per kWh (Government of the Netherlands, n.d.-a).

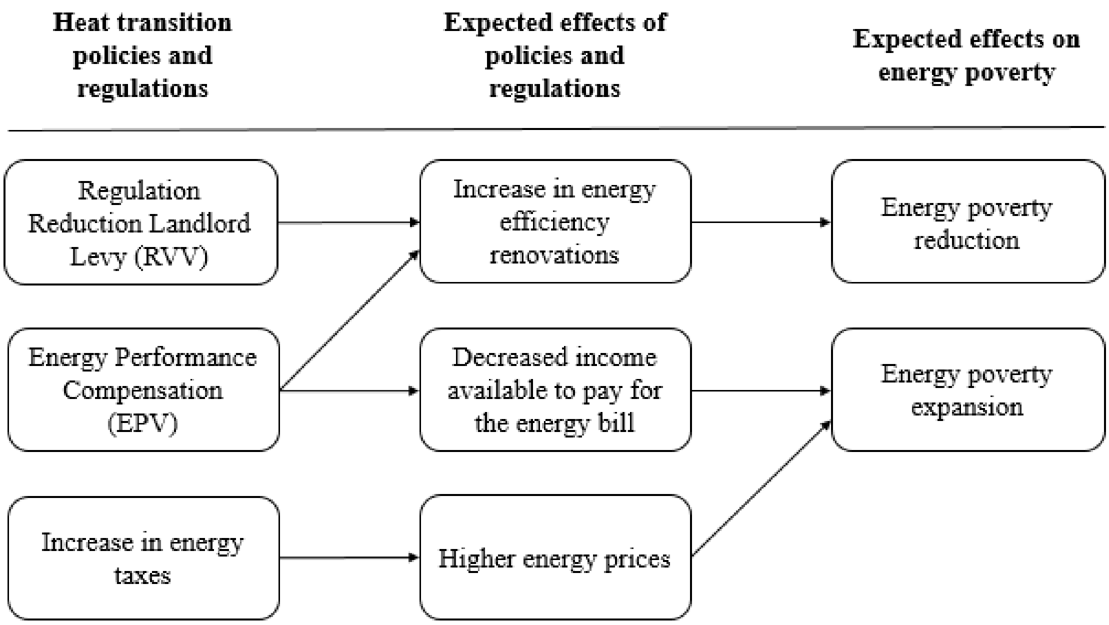

Figure 9 Relation between policies to accelerate the heat transition and energy poverty

3.4 Conclusion

This chapter showed that three types of injustice are underlying energy poverty. First, the distributional injustices of high energy prices, low household incomes and low energy efficiency of buildings and appliances play a role. Second, procedural injustices, such as insufficient access to information, participation in decision-making and legal rights, can push households into energy poverty. Finally, misrecognition of specific household energy needs, vulnerabilities and practices can cause energy poverty.

Experience from the energy transitions in Germany, the UK and the Netherlands showed that taxing (e.g. a carbon tax) energy bills, which is generally thought of as an effective measure to stimulate energy conservation, can lead to the expansion of energy poverty. This is because such tax increases use a relatively high share of low-income households' incomes. In a similar way, funding subsidies for low-carbon technologies by means of levies on energy bills can increase energy poverty (Bouzarovski, 2018). Thomson *et al.* (2017) stressed the importance of acknowledging the social and distributional impacts of energy policies to prevent the expansion of energy poverty.

Energy justice is not only about the distribution of the burdens, but also about the distribution of benefits from subsidies and policies related to energy transitions. The majority of Dutch policies aimed at reducing CO_2-emissions are of benefit to the fifty per cent of households with the highest incomes (Vergeer, 2018). Since low-income households are often lacking the financial resources to invest in renewable energy technologies, they are less likely to benefit from certain subsidies (Grösche & Schröder, 2014; Rooijers, 2016). To offset climate policies' regressive effects, multiple authors have argued for compensating low-income households.

My analysis heat transition policies showed that the heat transition provides opportunities for increasing the energy performance of dwellings in the social housing sector.

Low-income households often lack the financial means to invest in improving the energy efficiency of their homes (Walker & Day, 2012). However, in the social housing sector, housing associations generally take responsibility for improving the energy efficiency of their property. This is likely to have beneficial effects for their renters, because well-insulated homes require less energy to achieve similar levels of energy services. Because energy poverty and CO_2-emissions following energy consumption are both rooted in the inefficient use of energy in buildings, multiple authors argued that improving energy efficiency is the most important long-term synergy between energy poverty reduction and climate mitigation efforts (Bouzarovski, 2018; Ürge-Vorsatz & Tirado Herrero, 2012).

From an energy justice perspective, the heat transition can also bring about challenges. The heat transition is accompanied by an increase in energy taxes imposed by the national government. This tax increase is likely to have a relatively large effect on low-income households. In addition, if renovations are accompanied by an EPV, renters will have a smaller amount of income available to spend on the energy bill.

Whether the heat transition will lead to an increase or decrease in the prevalence and severity of energy poverty, is thus difficult to assess. To shape the heat transition so that it contributes to reducing energy poverty, energy justice's three linked tenets must be considered. This implies that recognition of households' specific energy needs – for social, cultural or health reasons – and ensuring procedural justice are crucial in preventing or addressing distributive inequalities that may follow climate policy. Energy justice's tenets form the basis for the following chapters, which address how energy poverty plays a role in practice.

Chapter 4

Factors considered in tools and models used in heat transition decision-making

A variety of tools and models is being used in the heat transition to give guidance to actors ranging from municipalities and housing associations to energy companies or cooperatives. This chapter aims to answer the question of what factors are considered in these tools and models, and why. In doing so, I assess the extent to which energy poverty is currently taken into account in heat transition decision-making. This provides input for the guidelines.

This chapter presents the results of an analysis of nine selected tools and models and expert interviews. It is built up as follows. First, I give an overview of the selected tools and models. Then, I give an account of the main factors included in these tools and models. In the third part of this chapter, I assess to what extent energy poverty is considered in the examined tools and models. Finally, I go into the reasons for inclusion or exclusion of certain factors in heat transition tools and models.

4.1 Description of tools and models

Table 4 briefly describes the nine tools and models I examined. For each tool or model, I described who its developer or initiator is, by whom and for what it is being used. Appendix C gives a more elaborate description of the selected tools and models. The tools and models are developed by consultancies, research institutes and energy companies.

The tools and models are used by municipalities and housing associations, or the companies advising them, to assist in decision-making in the heat transition. This is done, for instance, by creating transparency or identifying the heating alternative with the lowest costs. Because the tools and models have varying objectives, they take into account different factors.

4.2 Factors currently used in tools and models

This section discusses the factors that are taken into account in the selected tools and models. Table 5 gives an overview of the factors considered in the different tools and models.

4.2.1 Economic factors

As becomes clear from Table 5, economic factors are incorporated in all tools and models. Especially investment costs and, to a lesser extent, operating costs are taken into account. Infrastructural costs include, for instance, increasing the capacity of the electricity grid (ETRM, n.d.-g).

Benefits are included by Vesta and the *Warmtetransitiemodel* (Heat Transition Model). Vesta calculates the financial benefits for different actors (ETRM, n.d.-g) and the Warmtetransitiemodel performs cost-benefit analyses based on the investment costs and benefits in the form of savings (Over Morgen, 2018).

Table 4 Description of tools and models used to support decision-making in the heat transition

Name of tool/ model	**Developer(s)/ initiator(s)**	**Users**	**Objective**
HEAT	Alliander DGO	Housing associations, homeowners associations, municipalities, business parks, etc.	Create transparency, trust, support and effective interaction between stakeholders, which should lead to process acceleration in the development of new heat infrastructures (Alliander DGO, n.d.-b; ETRM, n.d.-d)
Vesta	PBL	PBL, and recently open access to be used by municipalities, energy companies, etc.	Explore possibilities to decrease energy use and CO_2-emissions in the period until 2050 and analyse the effects of measures taken in the field of heat supply (PBL, n.d.; Wijngaart *et al.*, 2017)
Warmte-transitie-model	Over Morgen	Municipalities, provinces, housing associations and grid operators	Give insight into the alternative to gas with the lowest societal costs and identify areas that are promising to become gas-free (Over Morgen, 2018)
CEGOIA	CE Delft	Municipalities, provinces, energy companies, grid operators	Determine the most cost-efficient energy infrastructure on a neighbourhood level (ETRM, n.d.-a)
Gebieds-model	Alliander and D-Cision	Policy advisors and energy experts	Quantify and visualise the effects of measures taken in the light of the energy transition (ETRM, n.d.-c)
OPERA	ECN part of TNO	Policy makers	Determine which configuration of the energy system has the lowest costs, given certain constraints imposed by the user (ETRM, n.d.-e)
TRANS-FORM	Accenture, AIT, Macomi	Municipalities	Support decision-making by analysing energy data and simulating plans in terms of CO_2-emissions, renewable energy and costs for different scenarios (ETRM, n.d.-f)
Meetlat tool	Greenvis	Municipalities	Give insight into district heating opportunities that are technically, economically, socially and politically feasible (Greenvis, n.d.)
Smart Energy Cities model	EZK and BZK, Grid Management the Netherlands, TKI Urban Energy, TKI ClickNL	Municipalities, grid operators, residents, housing associations	Accelerate the energy transition in districts in the Netherlands (Smart Energy Cities, n.d.-b)

The interviewed experts acknowledged that economic factors play an important role in the tools and models they use or developed. Geldhof[12] (interview 31 October 2018) argued that the Warmtetransitiemodel's main aim is to calculate the heating alternative with the lowest 'societal' costs, by calculating the costs and savings of building measures and alternative heating systems on a neighbourhood level. The CEGOIA model gives insight into the heating alternative with the lowest 'integral' costs, taking into account production, distribution, savings and consumption (Schepers[13], 13 November 2018).

4.2.2 Technical factors

Together with economic factors, technical factors underlie many of the calculations in the examined tools and models. The following citations illustrate this:

> *"the model is based on financial and technical calculation rules"* (Over Morgen, 2018, p. 4);
> *"the Vesta model maps out the technical-economic potential (*van den Wijngaart *et al*., 2017, p. 6);
> "*HEAT connects technological and economic knowledge . . . The tool makes use of real data and technical and financial calculation models* (Alliander Sustainable Area Development [Alliander DGO], 2016).

What these technical factors exactly constitute, is not always clarified. A technical factor included in OPERA, for instance, is the efficiency of technologies (ETRM, n.d.-e). Reliability, expressed as security of supply or availability of resources, is included by HEAT and OPERA (ETRM, n.d.-d, n.d.-e).

The interviewed experts provided more clarity concerning the technical factors included in tools and models. For instance, a building's year of construction or heat demand are technical factors (de Booij[14], interview 1 November 2018; Geldhof, interview 31 October 2018). Furthermore, urbanity or density is a technical factor to consider (de Booij, interview 1 November 2018; Geldhof, interview 31 October 2018). According to Schepers (interview 13 November 2018), the availability of energy sources such as green gas or residual heat is an important technical factor as well.

[12] Heat transition consultant at *Over Morgen* and developer of the Warmtetransitiemodel
[13] Researcher and consultant at CE Delft and developer of the CEGOIA and Vesta models
[14] Consultant at *Warmtetransitiemakers*

Table 5 Factors considered in tools and models used in decision-making in the heat transition

	HEAT	Vesta	Warmte-transitie-model	CEGOIA	Gebieds-model	OPERA	TRANS-FORM	Meetlat tool	Smart Energy Cities model
Economic factors								■	■
Investment costs		■	■	■	■	■	■		
Operating costs					■	■	■		
Infrastructural costs	■	■		■					
Societal costs	■		■						
Benefits		■	■						
Technical factors	■	■	■					■	■
Efficiency			■			■			
Reliability	■					■			
Environmental factors									
Renewable energy					■	■	■		
CO_2-emissions	■	■			■	■	■		
Other emissions						■			
Energy use/consumption		■		■		■	■		
Social factors								■	■
Regional employment					■		■		
Socio-economic characteristics		■							
Political factors								■	

Note. Some tools' and models' descriptions did not specify what type of economic, technical or social factors are included. For instance, the Meetlat tool includes economic factors, but the types of economic factors were not specified. In such cases, I marked the overarching categories.

4.2.3 Environmental factors

Environmental factors also play a relatively large role in the examined tools and models. In this category, multiple tools and models included the factors CO_2-emissions and energy consumption. In addition, Table 5 shows that three tools and models include the factor renewable energy production.

De Booij (interview 1 November 2018) argued that a reduction in CO_2-emissions is the most important aspect of future heating systems, because this is *"the main goal, the reason why we are changing"*. Schepers (interview 13 November 2018) agreed that future heat sources cannot emit CO_2.

4.2.4 Social factors

When analysing Table 5, what is striking is that social factors are only to a very limited extent considered in the tools and models. In only two of the examined tools and models - the *Meetlat* (yardstick) tool and the Smart Energy Cities model – social factors take a central stage, alongside technical and financial factors.

De Greef[15] (interview 2 November 2018) explained that social and political factors that can be included in the Meetlat tool, are for instance the municipality's sustainability ambitions, residents' voting behaviour and the presence of local sustainability initiatives. The social factors incorporated in the Smart Energy Cities model are mainly centred around enabling a fair process, for instance by involving residents in the process, incorporating their wishes and needs, and creating awareness (Smart Energy Cities, n.d.-a).

Some of the other tools and models incorporate social factors as well. For instance, the *Gebiedsmodel* (Area Model) includes regional employment (ETRM, n.d.-c). Vesta also takes into account socio-economic characteristics, however, these characteristics are not further specified (van den Wijngaart *et al.*, 2017).

Schepers (interview 13 November 2018) is working on incorporating social aspects such as affordability - measured as the ratio of the neighbourhood mean house value to the neighbourhood mean household income - and employment in the CEGOIA model. On top of that, numbers on health and liveability can be included into the model by using integrated cost-benefit analyses (Schepers, interview 13 November 2018). Energy poverty is primarily a social issue. In the next section, I address to what extent energy poverty is considered in the tools and models.

4.3 Inclusion of energy poverty in tools and models

Chapter 3 showed that three types of justice are relevant when studying energy poverty: distributional justice, procedural justice and justice as recognition. Energy efficiency, a distributional aspect of energy poverty, is taken into account by a few tools and models. For instance, the Warmtetransitiemodel uses energy labels of buildings in its calculations, and

[15] Consultant and developer of the Meetlat tool

OPERA addresses the efficiency of technologies. The distributional aspects of energy prices and household income determine affordability of energy services. Multiple tools and models are aimed at identifying the alternative heating system with the lowest total costs. This can help in keeping energy prices as low as possible, however, the models did not give insight into how and by whom the investments should be paid.

Besides distributional injustices, procedural injustices play a role in creating energy poverty. Procedural justice can be achieved by involving stakeholders in policy and governance, and by fairness in decision-making processes (Bouzarovski, 2018; Gillard *et al.*, 2017; Light & de-Shalit, 2003). Some tools and models, including HEAT and the Smart Energy Cities model, are specifically aimed at including stakeholders in the decision-making process. HEAT is a simulation tool that was designed to create transparency and interaction between stakeholders in the design of new heat grids (Alliander DGO, 2016). Among the stakeholders are heat producers, municipalities and housing associations. Whether residents are also considered 'stakeholders', is not clear. The Smart Energy Cities model does specifically mention residents as important stakeholders in the heat transition. Involving residents and acknowledging their interests is part of the model's first step (Smart Energy Cities, n.d.-a). The majority of examined tools and models, however, are not focused on facilitating participation.

Finally, justice as recognition is about recognising differential needs, vulnerabilities and practices in relation to energy services. These differences in energy needs typically occur at the household level. The data used in the tools and models, however, are usually based on neighbourhood or national averages, because information on the household or building level is difficult to obtain.

In short, energy poverty considerations (as part of the wider 'social factors') are underrepresented in tools and models used in heat transition decision-making. The limited inclusion of energy poverty in the tools and models, however, does not imply that the heat transition's social aspect is considered irrelevant. This became clear during the expert interviews. Although Geldhof (interview 31 October) was of the opinion that *"the heat transition is a technical issue"*, the other experts agreed that the social part of the heat transition is also very important (de Booij, interview 1 November 2018; de Greef, interview 2 November 2018; Schepers, interview 13 November 2018). Schepers (interview 13 November 2018) and de Greef (interview 2 November 2018) even mentioned that the social component of the heat transition is at least as important, possibly even more important than the technical and economic dimensions, in achieving a successful outcome in the heat transition. Yet, social factors and energy poverty considerations are underrepresented in the tools and models. The expert interviews gave insight into the reasons why this is the case.

4.4 Reasons for underrepresentation of social aspects in tools and models

The Warmtetransitiemodel is one of the models based on financial and technical calculation rules. According to Geldhof (interview 31 October 2018) such calculations are *"straightforward, understandable and least controversial"*. De Greef (interview 2 November 2018) and Schepers (interview 13 November 2018) argued that economic and technological factors, besides being easily quantifiable, are more generic than social and political factors, which differ per project. De Greef (interview 2 November 2018) argued that because models are designed by engineers and people with technical-financial backgrounds, they are usually based on quantifiable data. On top of that, a degree of scepticism exists concerning dealing with social aspects in a data-driven manner (de Greef, interview 2 November 2018). The interview with de Booij confirmed this. De Booij (interview 1 November 2018) argued that developing a calculation tool to deal with social aspects is not necessary, because these aspects can be addressed by 'softer' ways of researching, for instance, in residents' meetings.

Another reason for the underrepresentation of social aspects such as energy poverty in tools and models, is that dealing with social aspects is considered to be the responsibility of other actors (e.g. the municipality or housing associations). According to Schepers (interview 13 November 2018), the responsibility for a fair process should be given to municipalities by initiating conversations, explaining why a certain heating alternative is selected and trying to involve people in the process towards gas-free heating.

Also, the interviewees argued that social aspects are taken care of in a different phase of the decision-making process. According to Schepers (interview 13 November 2018), the social aspect is addressed in meetings with residents, stakeholders and companies. These meetings typically take place after the model is applied. Schepers (interview 13 November 2018) mentioned that the model marks the start of the process. Afterwards, one should consider issues such as initiating conversations with residents and ways to finance the alternative heating system (Schepers, interview 13 November 2018).

Geldhof (interview 31 October 2018) argued that certain social aspects such as a comfortable heating system and liveable houses can also be incorporated as prerequisites in the model, meaning that only those alternative heating systems meeting these prerequisites are taken into account. This entails that heating systems that do not meet the criteria for comfort and liveability are excluded from the Warmtetransitiemodel. De Booij (interview 1 November 2018) and Schepers (interview 13 November 2018) do not make this selection beforehand. Instead, they do the calculations for all heating systems and do the optimisation afterwards.

4.5 Conclusion

Multiple authors argued that social and equity considerations are underrepresented in energy transition discussions (Bickerstaff *et al.*, 2013; Eames & Hunt, 2013; Sovacool *et al.*, 2016). To discover whether this is also the case in the heat transition in the Netherlands, I posed RQ2. This chapter showed that economic and technical factors play the most prominent roles in the selected tools and models used in the heat transition. The factors included in the heat transition tools and models reflect, to some extent, the experts' opinions about the important issues that should be considered in the heat transition. However, most experts acknowledged that the heat transition is not solely a technological, but also a social issue.

Aspects of energy poverty are underrepresented in most tools and models. Economic factors are the dominant factors in the tools and models, but the topic of affordability is largely neglected. Because the tools and models are based on quantifiable and generic information, consideration of household-specific energy needs is difficult. In addition, the models and tools are not focused on facilitating a fair process. This is probably because involving residents into the decision-making process typically takes place after the tools and models are applied, and is considered to be the responsibility of municipalities and housing associations.

Chapter 5

Energy poverty and the heat transition in Overvecht-Noord

This chapter addresses RQ3 on the role of energy poverty in the heat transition in Overvecht-Noord. As mentioned, the municipality of Utrecht aims for Overvecht-Noord to be the first extant district in the Netherlands to become gas-free (Gemeente Utrecht, n.d.-a). This chapter contributes to the main aim of this thesis by giving insight into how energy poverty and the heat transition are related in practice. I present the results of a case study involving content analysis of relevant documents and in-depth stakeholder interviews. I elaborate on the main themes that were discussed in the stakeholder interviews and in documents concerning the heat transition in Overvecht-Noord, giving attention to how these themes were perceived by the different stakeholders. I conclude this chapter by discussing how energy poverty plays a role in the transition towards a gas-free Overvecht-Noord.

5.1 Different interpretations and meanings of 'gas-free' and 'sustainable'

Based on the interviews and content analysis, I noticed that the stakeholders in Overvecht-Noord interpret the terms 'gas-free' and 'sustainable' in different ways. I identified differences in interpretations related to the municipality's strategy towards achieving a gas-free district, and related to heat provider Eneco's strategy to making its district heating system sustainable.

5.1.1 Municipality's strategy towards achieving a gas-free Overvecht-Noord

The heat grid in Utrecht is the oldest heat grid in the Netherlands (Gemeente Utrecht, n.d.-b). More than eighty per cent of dwellings in the social housing sector in Overvecht-Noord are connected to this grid.[16] The majority of dwellings connected to district heating also have a gas connection for cooking. Figure 10 shows the energy connections in the social housing sector in Overvecht-Noord.

To achieve a gas-free district, Gemeente Utrecht *et al.* (2017) argued that the houses connected to district heating and that do not use gas for, are beyond the scope of the project. This is because these houses do not use gas directly and therefore already meet the requirements for a gas-free Overvecht-Noord (Gemeente Utrecht *et al*., 2017). Furthermore, the first step that the municipality is planning to take in making Overvecht-Noord gas-free, is to remove the gas connection from those houses that use gas for cooking only, and are connected to the heat grid for their heat supply (Gemeente Utrecht *et al.*, 2017). The households living in these dwellings would therefore have to switch to electric (induction) cooking to become 'gas-free'. The interviewed stakeholders did not all agree that this is the right way to go, for several reasons.

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[16] 4587 houses of a total of 5607 houses in the social housing sector in Overvecht-Noord are connected to district heating (CBS, 2017). 4587 / 5607 * 100% = 81.8%

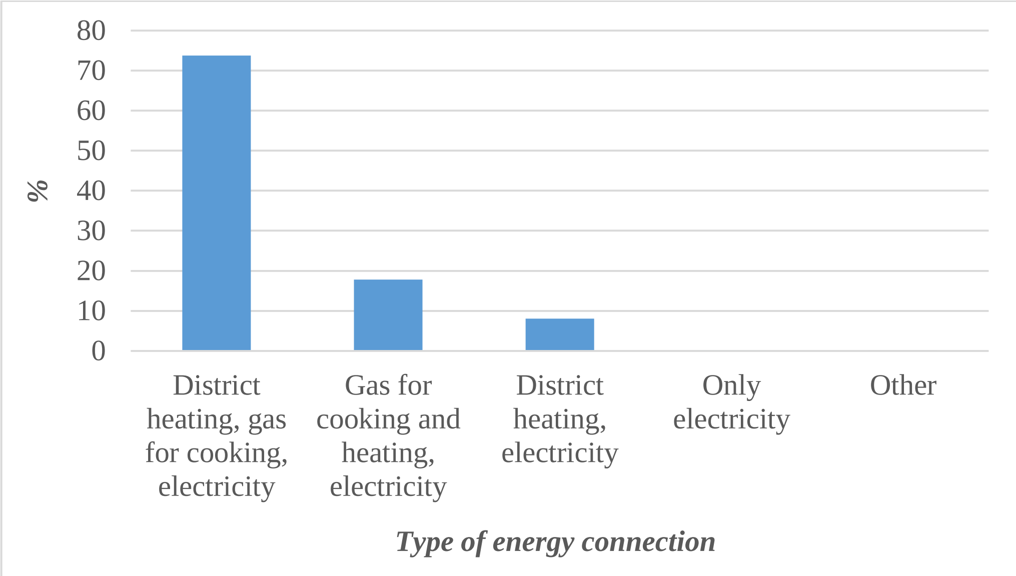

Figure 10 Energy connections in the social housing sector in Overvecht-Noord (based on Gemeente Utrecht et al.*, 2017)*

First, Meeuwis[17] argued: *"when a house does not have a gas connection, this does not imply that it is gas-free . . . and CO_2-free"* (interview 20 November 2018). Meeuwis referred to the primary heat source for district heating in Utrecht, which is natural gas (Schepers & van Valkengoed, 2009). Meeuwis (interview 20 November 2018) argued that even though Eneco uses gas for the two purposes of electricity and heat production, which implies that the produced heat can be considered residual heat, the present district heating system in Utrecht is not gas-free and therefore not future-proof. De Vette[18] (interview 21 November 2018) and Tourné[19] and Sterk[20] (interview 16 November 2018) described the present district heating system as unsustainable because of the CO_2-emissions related to natural gas use.

Another constraint of the present district heating system is its inefficiency. Meeuwis (interview 20 November 2018) and de Vette (interview 21 November 2018) argued that the efficiency of the district heating system in Utrecht is low, because it is a high-temperature heat grid. According to de Vette (interview 21 November 2018), a large amount of energy is needed to produce these high temperatures and high-temperature heat grids are associated with high transport losses[21].

Third, de Vette (interview 21 November 2018) argued that in the heat transition in Overvecht-Noord *"goal and means are sometimes confused"*. According to de Vette (interview 21 November 2018), the main goal should be the reduction of CO_2-emissions. This is why he questioned whether switching from cooking gas to using electricity for cooking, is an effective

[17] Senior asset manager Utrecht at housing association Portaal
[18] Property strategy and sustainability advisor at housing association Mitros
[19] Resident of Overvecht-Noord, member of Citizen Platform Overvecht and of energy cooperative Energie-U
[20] Resident of Overvecht-Noord and member of Energie-U
[21] Schilling *et al.* (2018) confirm that high-temperature heat grids have high transport losses, which decrease the efficiency of such heat grids.

thing to do. According to de Vette (interview 21 November 2018), this switch will not have a large impact in terms of contribution to climate goals, because gas used for cooking amounts to *"only a few m^3 per year"*. Moreover, the switch from gas to electricity for cooking may even increase CO_2-emissions, depending on the carbon intensity of the electricity mix (de Vette, interview 21 November 2018). Therefore, multiple stakeholders argued that decreasing heat demand by improving insulation levels should be given priority when transitioning to low-carbon heat provision (de Vette, interview 21 November 2018; Eneco, 2018; Meeuwis, interview 20 November 2018).

5.1.2 Eneco's strategy towards achieving a gas-free district heating system

Eneco is the district heat provider in Utrecht and Nieuwegein (Gemeente Utrecht, n.d.-b). Eneco (2018) created a road map for making its district heating system more sustainable. In this road map, sustainable entails fossil-free. Eneco (2018) demonstrated that currently, the majority of heat used for district heating in Utrecht derives from fossil fuels, and the intention is to achieve sustainable, or fossil-free, heat provision in the future. In the transition phase, Eneco (2018) plans to produce heat using a mix of fossil fuels, residual heat and renewable resources such as geothermal heat, and heat from surface water and biomass. However, little residual heat from industry is available and limited knowledge exists about possibilities for geothermal energy in the Utrecht area (de Vette, interview 21 November 2018; Eneco, 2018). Opportunities for using thermal energy from surface water and wastewater treatment plants are available (Eneco, 2018).

The stakeholders I interviewed had different opinions on how Utrecht's district heating system could become sustainable in the future. Meeuwis (interview 20 November 2018) argued that by installing a heat pump on a wastewater treatment plant and building a biomass heating system, Eneco is moving in the right direction. De Vette (interview 21 November 2018), on the contrary, believed that biomass does not produce sustainable heat and with little opportunities for residual and geothermal heat, developing a carbon-neutral district heating system is difficult.

To sum up, sustainability is an ambiguous term that means different things to different people. The interviewees used the term sustainability when referring to gas-free, fossil-free, efficiency and carbon neutrality. More clarity on the definition of sustainability could help in aligning the stakeholders and making sure that they move in the same direction. The definition of sustainability may determine, for instance, whether biomass can be considered a sustainable resource to be used for producing district heat. Also, gas-free is not inherently CO_2-free as well; converting a poorly-insulated dwelling to all-electric by installing a heat pump, without taking additional measures such as insulation, probably lead to an increase in CO_2-emissions. To prevent efforts to become gas-free from causing an increase in CO_2-emissions, the switch from cooking with gas to electric cooking can be combined with the installation of solar panels. Another reason for combining this switch with solar panel projects, is that such projects contribute to affordability for the renters (Gruter[22] & van Leeuwen[23], interview 22 November 2018).

5.2 Affordability of the energy bill for renters

Besides ensuring availability and quality of dwellings, providing affordable housing is a main goal of housing associations (de Vette, interview 21 November 2018). Housing costs include fixed costs such as monthly rent and service charges, and variable costs such as the energy bill. Two important themes in the case study were affordability of the present district heating system and the effect of the heat transition on the affordability of housing costs for renters.

5.2.1 Affordability of the present heating system

The previous section showed that the majority of dwellings in the social housing sector in Overvecht-Noord are connected to district heating. According to most interviewees, this heating system raises problems concerning affordability for the renters. The first problem relates to the standing charge, or fixed costs, charged by Eneco to their customers for connection to the heat grid and transport of heat through this grid. The standing charge is independent of the amount of heat consumed (Eneco, n.d.). The standing charge for district heating is higher than that of gas, and according to several interviewees (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 20181; Tourné & Sterk, interview 16 November 2018), this negatively affects affordability of district heat for renters. According to de Vette (interview 21 November 2018), the variable costs of district heat, or costs per unit of energy consumed, are comparable to the variable costs paid for gas. However, the standing charge for district heating is about three times as high as the standing charge for gas. De Vette (interview 21 November 2018) argued that this causes renters in Overvecht-Noord to pay about 50 per cent more for district heating than for heat produced by gas. Box 3 shows a study that compares the costs for district heating and heating by gas-fuelled condensing boilers in Utrecht.

Another reason why district heating is relatively expensive for renters, is that costs for the maintenance and replacement of condensing boilers are usually paid for by housing associations, since they are the owners of the dwellings (de Vette, interview 21 November 2018). The maintenance costs for the heat grid, however, are paid by the renter, rather than the housing association, in the form of standing charge (de Vette, interview 21 November 2018).

Another issue raised in the interviews concerning the relatively high amount of standing charge, is that this price structure does not stimulate people to conserve energy. This is because the proportion of standing charge in the energy bill increases with higher levels of insulation and reduced heat consumption (Tourné & Sterk, interview 16 November 2018). De Vette (interview 21 November 2018) added that for people living in well-insulated homes and

[22] Communications advisor at housing association Bo-Ex
[23] Project manager property and development at housing association Bo-Ex

therefore only need a small amount of heat, connecting their home to the heat grid may not be a smart choice.

Another way in which district heating affects affordability of heat for renters, is by Eneco's monopoly position (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018). Eneco is the only provider of district heating in the area, and as a consequence, renters do not have a choice between different heat providers.

Box 3 Affordability of district heating versus gas

Nuiten, den Dekker and Donze (2016) researched whether district heating is more expensive than having the house heated by a gas-fueled condensing boiler in Leidsche Rijn, a district in Utrecht. Nuiten *et al.* (2016) found that variable costs for district heating are higher than the variable costs charged for gas. However, this difference in energy costs is lifted by the electricity consumed by condensing boilers. The standing charge of district heating (€469 per year) exceeds the standing charge of a gas connection (€479 per year) by €10 per year (Nuiten *et al.*, 2016). Nuiten *et al.* (2016) concluded that district heating is not more expensive than heating by gas. However, this study did not include the maintenance and replacement costs of the condensing boiler.

5.2.2 Influence of the heat transition on the energy bill

The amount of the energy bill is dependent on multiple variables, including government taxes, costs for grid management, standing charge, and the amount of energy (gas, heat, electricity) used by the consumer. Chapter 3 already showed that the Dutch government has introduced a tax increase on gas and a tax decrease on electricity. This will result in an average increase in energy taxes of €130 per household per year (Government of the Netherlands, n.d.-a).

Besides government taxes, costs for grid management influence the energy bill. Costs for grid management are expected to rise because the heat transition requires investments to increase the capacity of the electricity grid (ten Zijthoff[24], interview 6 December 2018). On top of that, when more and more houses are disconnected from the gas grid, the costs for maintenance of the gas grid will be divided between fewer customers (ten Zijthoff, interview 6 December 2018).

The housing associations are improving the energy performance of their dwellings, so that renters are to some extent protected from this expected rise in energy costs (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018). However, uncertainty exists about the way energy prices will develop in the future (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018).

Most interviewees aim for a cost-neutral outcome for the renters (stakeholder 6,[25] interview 7 December 2018; Tourné & Sterk, interview 16 November 2018). This entails that when investments in alternative heating systems lead to a rent increase, this should be accompanied by a significant reduction in the energy bill, so that total housing costs do not

[24] Manager sustainability of the built environment at grid operator Stedin
[25] Sustainability advocate at Aedes, the national umbrella organisation of housing associations

increase (Tourné & Sterk, interview 16 November 2018). If a housing association improves the dwelling to net-zero energy, it may charge their renters a compensation (EPV) for its efforts. This can make an interesting business case for the housing associations (de Vette, interview 21 November 2018).

Whether the heat transition will lead to an increase or decrease in energy costs, depends on multiple variables. Ten Zijthoff (interview 6 December 2018) argued that the introduction of a carbon tax and utilisation of possibilities for renewable energy generation are also likely to influence the energy bill in the future. Ten Zijthoff (interview 6 December 2018) argued that when the costs and benefits of the heat transition can be balanced, the heat transition does not have to change the prevalence of energy poverty. Eventually, everyone will probably pay more for their energy bills (stakeholder 6, interview 7 December 2018).

In sum, the present district heating system is associated with high costs. This is primarily due to the relatively high amount of standing charge. Because Eneco has a monopoly position in the area, renters do not have a choice of other heat providers. High energy prices are a distributional injustice which can lead to or exacerbate energy poverty. Besides high energy prices, Chapter 3 showed that household income also influences energy poverty. Renovations done by the housing associations are likely to reduce heat demand. However, these investments might lead to an increase in rent, service charges or EPV. Because of this, the amount of household income available to pay for the energy bill decreases, which impacts energy poverty. Therefore, to make a contribution to reducing energy poverty, any increase in rent should be accompanied by a greater decrease in energy costs.

Uncertainty exists about the development of the energy prices, because they are composed of many factors. On top of that, renovations may not always lead to the predicted reduction in heat demand. Renovations improve insulation levels, and therefore less energy is needed for similar comfort levels. However, multiple stakeholders argued that a significant reduction of the energy bill can only be achieved if renters adjust their behaviour (Gruter & van Leeuwen, interview 22 November 2018; Tourné & Sterk, interview 16 November 2018).

5.3 Behaviour

All interviewees mentioned that behaviour is an important topic to consider in the heat transition, for multiple reasons. First, the housing associations believed that creating awareness among their renters by offering them an energy advice, contributes to decreasing energy consumption. This should keep energy bills affordable. Second, an important issue to take into account when doing renovations, is the rebound effect.

5.3.1 Energy advice

Meeuwis (interview 20 November 2018) argued that currently, the renters' housing costs (which include the energy bill) are quite high, and this is partly due to behaviour. The housing associations in Overvecht-Noord try to make their renters aware that behaviour affects the energy bill. To this end, the housing associations participate in a project which helps renters to decrease their energy consumption by offering them an energy advice and energy-saving products. According to Tourné and Sterk (interview 16 November 2018), the energy advisors can help in reducing energy poverty, because the project led to an overall decrease in energy bills. The grid operator Stedin also tries to contribute to increased energy awareness, by offering smart meters to its customers. Smart meters give insight into the amount of energy used in certain household activities and the associated costs (ten Zijthoff, interview 6 December 2018).

5.3.2 The rebound effect

Another way in which behaviour is important in the heat transition, is through the so-called rebound effect (ten Zijthoff, interview 6 December 2018; interviewee 6, interview 7 December 2018). Tourné and Sterk (interview 16 November 2018) argued that a gap exists between expected energy use based on model calculations and actual behaviour. Because of the rebound effect, renovations may not lead to the predicted decrease in energy consumption. According to Tourné and Sterk (interview 16 November 2018), the rebound effect occurs when, after renovations, people believe that energy is abundant. Gruter and van Leeuwen (interview 22 November 2018) added: *"the more comfortable the house, the more comfortably it is used"*.

In some cases, renovations may even lead to an increase in energy consumption. Some old houses are heated by a small gas heater in the living room only. When this heater is replaced by a central heating system with radiators in all rooms, energy costs are likely to increase rather than decrease (ten Zijthoff, interview 6 December 2018). Renovating low-quality dwellings is likely increase energy consumption and energy bills (stakeholder 6, interview 7 December 2018). However, the comfort and quality of the dwelling do increase considerably following such renovations (Gruter & van Leeuwen, interview 22 November 2018; interviewee 6, interview 7 December 2018).

To prevent or minimise the rebound effect, Tourné and Sterk (interview 16 November 2018) stressed the importance of education during and after renovations, to show renters how new technologies are used most efficiently. For instance, housing association Bo-Ex organises cooking workshops to learn renters about electric induction cooking (Gruter & van Leeuwen, interview 22 November 2018). Tourné and Sterk (interview 16 November 2018) argued that when renovations are accompanied by information provision, for instance in the form of an energy advice, they can lead to renters being more motivated to decrease their energy consumption or understanding the heating system better.

To summarise, behaviour is an important theme in the heat transition in Overvecht-Noord. Most interviewees agreed that education can lead to behaviour change and help to prevent the rebound-effect from occurring. In this way, education should lead to decreased energy consumptions, lower energy bills, and reduced energy poverty. However, as argued by Bouzarovski (2018), *"energy services cannot be understood in solely technological or social terms"* (p. 16). Cooking, for instance, is practice embedded in social and cultural contexts and is therefore not easily changed or influenced by education or greater awareness. This issue was also addressed by Gruter and van Leeuwen (interview 22 November 2018), who foresee the biggest challenges in disconnecting cooking gas, rather than in installing alternative heating techniques, because *"cooking is a culturally defined activity"*.

Education can contribute to creating greater awareness, however, it may not always bring about the desired behavioural change. Also, Tourné and Sterk (interview 16 November

2018) argued that the energy advice requires a minimum of interest and interaction. Gruter and van Leeuwen (interview 22 November 2018) added that many renters in the social housing sector have multiple problems, which can be a reason for them not to be involved in energy conservation.

5.4 Groups vulnerable to energy poverty

The social housing sector in Overvecht-Noord includes a large and increasing number of vulnerable people. This is because these people belong to the target group of social housing (Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018). From the case study, I identified several groups that already are or are likely to become vulnerable to energy poverty in the future.

First, Table 6 shows that in the four neighbourhoods in Overvecht-Noord, the percentage of households with low incomes is higher than the national average. This is probably due to the relatively large proportion of social housing, which is aimed at people with low incomes. People with low incomes and with debt issues are vulnerable to rising energy prices (de Vette, interview 21 November 2018).

Second, Tourné and Sterk (interview 16 November 2018) identified elderly people as vulnerable, because these people heat their houses to higher temperatures. The percentage of people aged 65 and above in Overvecht-Noord is lower than the national average (see Table 6). However, compared to the average in the municipality in Utrecht (10.2 per cent), Overvecht-Noord is home to a relatively large proportion of elderly people (CBS, 2018a; Gemeente Utrecht *et al.*, 2017). Tourné and Sterk (interview 16 November 2018) argued that ageing is an ongoing trend that can be witnessed in the Netherlands, and also in Overvecht.

Third, Overvecht-Noord is home to a relatively large proportion of people with a migration background. This proportion is considerably higher than the national average, as is shown in Table 6. The majority of these people is of non-western origin, including Turkey and the continents of Africa, Latin America and Asia (CBS, 2018b). Multiple interviewees mentioned that people with migration backgrounds may be more vulnerable to energy poverty when they are used to higher outdoor temperatures (Gruter & van Leeuwen, interview 22 November 2018; Tourné & Sterk, interview 16 November 2018).

Table 6
Inhabitants of Overvecht-Noord according to income, age and background (based on CBS, 2015, 2018a)

	Number of inhabitants	**% households with low incomes**	**% people aged 65 and above**	**% people with migration backgrounds**
Vechtzoom-zuid	4,820	24.6	16.4	56.7
Vechtzoom-noord, Klopvaart	3,295	15.6	19.0	46.4
Zambesidreef and surroundings	4,625	24.3	11.1	64.3
Tigrisdreef and surroundings	4,595	29.7	12.2	70.2
The Netherlands	17,181,084	8.2	18.9	23.1

Besides low-income households, elderly people and people with migration backgrounds, the interviewees identified some other vulnerable groups. For instance, de Vette (interview 21 November 2018) and Meeuwis (interview 20 November 2018) mentioned that people with medical problems are more vulnerable to energy poverty. Also, a number of dwellings is rented to care institutions so as to provide housing for people with psychological problems, who may also be more vulnerable to energy poverty (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018). Besides that, unemployed people spend more time at home and therefore are likely to consume more energy (Tourné & Sterk, interview 16 November 2018).

To sum up, energy justice literature showed that households which include people above the age of 65 and people with long-term illnesses, are more likely to be susceptible to energy poverty. The case study confirmed this, and expanded the list of vulnerable groups with people that have a migration background and people with psychological health issues. Overvecht-Noord includes many people with vulnerabilities. Tourné and Sterk (interview 16 November 2018) argued that the heat transition and the accompanying renovations provide an opportunity for the housing associations to visit renters and tackle other issues they might be facing. Another possibility is to redirect them to community workers or the care institutions that are renting out the houses (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018; Tourné & Sterk, interview 16 November 2018). Gruter and van Leeuwen (interview 22 November 2018) added that they take into account the needs of vulnerable people, for instance by approaching these people individually when informing them about renovations.

5.5 Creating public support by information provision and participation

Public support is another important theme in the heat transition in Overvecht-Noord. In the social housing sector, housing associations need to have the support of seventy per cent of their renters before they are allowed to carry out major renovations (de Vette, interview 21 November 2018; Meeuwis, interview 20 November 2018; Tourné & Sterk, interview 16 November 2018). This is a legally binding obligation for all housing associations (Government of the Netherlands, n.d.-b).

5.5.1 Information provision

Gruter and van Leeuwen (interview 22 November 2018) argued that while developing Overvecht-Noord into a gas-free district, communication with residents is very important. To achieve the required seventy per cent public support, housing associations provide their renters with information about planned renovations. This is usually done in the form of residents' meetings, and only when concrete plans for renovating a building exist (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018; Tourné & Sterk, interview 16 November 2018). Besides these meetings, residents of Overvecht-Noord can learn about gas-free in Overvecht-Noord through the local newspaper and a digital newsletter published by the municipality (Meeuwis, interview 20 November 2018; Tourné & Sterk, interview 16 November 2018). Also, individual conversations are held with those people that are not able to attend the residents' meetings (Gruter & van Leeuwen, interview 22 November 2018; Tourné & Sterk, interview 16 November 2018).

Despite these efforts, examples exist in which the required seventy per cent public support for renovations was not achieved. One reason for a lack of public support is a lack of trust in the housing association, possibly caused by past conflicts (Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018; Tourné & Sterk, interview 16 November 2018). Tourné and Sterk (interview 16 November 2018) argued that to gain confidence from the renters and achieve public support for a project, housing associations must first solve these conflicts. Other reasons for (a lack of) public support are: whether the renter is financially compensated (Tourné & Sterk, interview 16 November 2018); whether the induction stove and new pans will be paid by the renter or the housing association (Gruter & van Leeuwen, interview 22 November 2018; Tourné & Sterk, interview 16 November 2018); and whether the renovation is accompanied by a rent increase (De Vette, interview 21 November 2018). Not all reasons for a lack of public support are economic reasons. For example, older people in particular may not look forward to the disturbances caused by the renovation (Tourné & Sterk, interview 16 November 2018; de Vette, interview 21 November 2018). Tourné and Sterk (interview 16 November 2018) argued that another important issue to achieve public support, is involving renters in the development of plans, so that they can identify themselves with the plans.

5.5.2 Participation in decision-making

Meeuwis (interview 20 November 2018) introduced the example of the project called *Centraal Wonen Klopvaart* (Central Living Klopvaart; CW), in which housing association Portaal outsourced the development of the energy plan to the residents of CW, united in a residents' association. CW wants to be frontrunner and an example to others in the field of sustainability (Portaal, 2018). Meeuwis (interview 20 November 2018) argued that because the residents created the energy plan themselves, public support was automatically taken care of.

Other efforts to involve renters in making renovation plans exist. However, Tourné and Sterk (interview 16 November 2018) argued that contribution of residents' ideas is usually limited to marginal aspects, such as the colour of a kitchen or choice of pans. De Vette (interview 21 November 2018) argued that housing association Mitros uses surveys to include residents' opinions in decision-making and an advisory panel consisting of renters is in place. Gruter and van Leeuwen (interview 22 November 2018) also try to include the resident's voice in decision-making, because this is likely to increase public support.

Meeuwis (interview 20 November 2018), however, argued that renters are often not interested to take the initiative, for instance by demanding better-insulating windows. De Vette (interview 21 November 2018) was also disappointed by the amount of people willing to participate in projects set up by the housing association. Meeuwis (interview 20 November 2018) argued that a major obstacle in the heat transition is renters' indifference towards their houses becoming gas-free.

To summarise, the housing associations in Overvecht-Noord are undertaking multiple activities to create public support. Access to information, participation in decision-making and legal rights are aspects of procedural justice and are therefore important addressing energy poverty. The requirement of seventy per cent public support is enforced by law. To achieve sufficient public support, the housing associations provide their renters with information and stimulate them to participate. The majority of efforts are aimed at provision of information. Information about upcoming renovations is provided in multiple ways and is mainly done by housing associations, and to a lesser extent, by the municipality. However, the housing associations should be cautious with providing information only when concrete plans for a renovation exist. On the one hand, this can prevent unrest. On the other hand, however, involving residents after major decision are made, can also cause lack of public support.

Participation in decision-making is limited, for two reasons. First, Tourné and Sterk (interview 16 November 2018) argued that participation of renters is typically limited to marginal aspects, possibly because renters are only involved in a final phase of decision-making. Second, de Vette (interview 21 November 2018) and Meeuwis (interview 20 November 2018) argued that renters are not always interested in participating.

5.6 Collaboration and division of roles and responsibilities between stakeholders

Another theme brought up by multiple stakeholders, is the importance of collaboration in the transition towards a gas-free built environment. Related to this, I noticed that disagreement exists among the stakeholders about the division of roles and responsibilities.

5.6.1 Collaboration

Multiple interviewees emphasised the importance of collaboration between stakeholders. When Overvecht-Noord was selected to be the first district in Utrecht to be disconnected from gas, the municipality of Utrecht established a team in which it works together with the three housing associations Mitros, Bo-Ex and Portaal, grid operator Stedin, grid operator and heat provider Eneco, and energy cooperative Energie-U (Gemeente Utrecht, n.d.). In addition, the three housing associations in Overvecht-Noord are also united in STUW (Meeuwis, interview 20 November 2018). When housing associations aggregate demand, costs for installations are likely to decrease (stakeholder 6, interview 7 December 2018). Besides these collaborations, housing association Portaal and district heat provider Eneco are engaged in a partnership to stimulate renewable heat production (Meeuwis, interview 20 November 2018).

According to Gemeente Utrecht *et al.* (2018) and Meeuwis (interview 20 November 2018), working together in an effective manner requires actors to seek common interests. Meeuwis (interview 20 November 2018), however, argued that too often, the different actors in the heat transition are unintentionally hindering one another. Ten Zijthoff (interview 6 December 2018) also found that the stakeholders' different interests challenge them to collectively make decisions. For instance, expanding the present district heating system so that more houses can be connected, could be an interesting business case for Eneco. However, housing associations might not want their renters to be dependent on one commercial heat provider (ten Zijthoff, interview 6 December 2018). Apart from contradicting interests, disagreement exists about the division of roles and responsibilities between actors in the heat transition.

5.6.2 Disagreement about roles and responsibilities

The Dutch government wants housing associations to act as frontrunners[26] in accelerating the heat transition (de Vette, interview 21 November 2018; stakeholder 6, interview 7 December 2018). However, the housing associations do not fully agree that decreasing CO_2-emissions is their responsibility. De Vette (interview 21 November 2018) argued that the housing associations' principal role is to ensure availability, quality and affordability of houses. Therefore, the housing association's role in the heat transition is to help renters in keeping their energy bills affordable (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018). Ten Zijthoff (interview 6 December 2018) also argued that housing associations, together with the municipality, have a duty of care towards their renters and residents. Meeuwis (interview 20 November 2018), on the contrary, argued that housing associations do not have to provide full protection to their renters and deems it possible that energy bills are going to rise.

The stakeholders also had different ideas about who should be responsible for decreasing the carbon intensity of energy sources. De Vette (interview 21 November 2018) argued that besides insulating their property, housing associations should consider the sustainability of the resources used for energy production. Other interviewees, however, argued that energy companies' should ensure that the electricity and heat they deliver comes from a fossil-free and carbon-neutral source (stakeholder 6, interview 7 December 2018; Gruter and van Leeuwen, interview 22 November 2018). De Vette (interview 21 November 2018) pointed out that the Climate Agreement mentions that the electricity-producing sector will be responsible for more than fifty per cent of the reduction in CO_2-emissions, whereas the built environment only needs to reduce emissions with about seven to eight per cent. Therefore, the energy companies have a larger responsibility in reducing CO_2-emissions.

The housing associations argued that when the government puts forward the housing associations as frontrunners in the heat transition, the government should financially compensate them (interviewee 6, interview 7 December 2018). Meeuwis (interview 20 November 2018) argued that housing associations pay large amounts of landlord levy. This is at the expense of the financial resources needed to make their property gas-free. De Vette (interview 21 November 2018) also argued that a cut in the landlord levy could be a way for the government to stimulate housing associations to invest in the heat transition. Meeuwis (interview 20 November 2018) argued that besides financial compensation, modifications in legislation are needed to stimulate the heat transition, for instance to legally allow the differentiation in tariffs for heat. In addition, The *Woningwet* (Property Law) can constrain renewable energy production, because this law requires housing associations to stick to their

[26] The government uses the term *startmotor* (which can be translated as 'starter motor') to describe the role of housing associations in the heat transition.

key tasks of affordability and availability of housing (stakeholder 6, interview 7 December 2018).

In sum, collaboration can contribute to accelerating the heat transition. The housing associations are working together, and collaborate with other stakeholders as well. Yet, different interests are sometimes hindering effective collaboration. More clarity about the roles and responsibilities of actors involved in the heat transition can stimulate working together and creating trust between the stakeholders.

5.7 Conclusion

This chapter focused on the question of how energy poverty plays a role in the heat transition in Overvecht-Noord. Chapter 3 elaborated on three types of justice related to energy poverty, which are helpful to structure this chapter's findings.

5.7.1 Distributional justice in the heat transition in Overvecht-Noord

Distributional justice relates to the distribution of energy prices, income, and efficiency. First, the present district heating system in Utrecht is associated with high energy prices for the renters. These high energy prices are primarily caused by the standing charge. On top of that, residents are unable to change to another heat provider, because Eneco has a monopoly position in the area. The housing associations aim for a cost-neutral heat transition for their renters, by carrying out renovations. However, uncertainty exists about the way energy prices will develop in the future. The investments needed to facilitate the heat transition – for instance to increase the capacity of the electricity grid – are likely to increase energy prices.

Second, Overvecht-Noord is home to a large proportion of people with lower-than-average incomes. These people are the target group for social housing. Low-income households are more vulnerable to rising energy prices and therefore face a relatively high risk of falling into energy poverty.

Finally, the housing associations are renovating and insulating their property to achieve higher efficiency. The aim is to renovate to a higher than B-level energy label (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018). This can help in reducing energy poverty. The energy efficiency of the present district heating system, on the contrary, is low, because it is a high-temperature heat grid. Such heat grids are characterised by high energy losses.

5.7.2 Procedural justice in the heat transition in Overvecht-Noord

Procedural justice entails access to information, participation in decision-making and legal rights. Housing associations are required, by law, to obtain seventy per cent public support among their renters before carrying out major renovations. This law is complied with and stimulates the housing associations to provide information about planned renovations and involve renters in project decision-making.

According to Walker and Day (2012), having access to information can help vulnerable consumers to become more aware of energy prices or ways to consume energy more efficiently. The housing associations try to create awareness among their renters by offering them an energy advice. Information provision about upcoming renovations is mostly done through residents' meetings organised by the housing associations. However, information is provided rather late in the process - only when specific plans for renovating a buildings exist - so as to prevent unrest. Involving residents too late in decision-making processes, however, can cause a lack of public support and limits possibilities for renters to change anything substantial about the proposed plans. Furthermore, participation of residents in decision-making is typically limited to marginal aspects. The CW case, in which the residents were given the responsibility for developing their own energy plan, is an exception.

5.7.3 Recognition justice in the heat transition in Overvecht-Noord

Recognition of specific household energy needs, vulnerabilities and practices is needed to prevent and reduce the existence of energy poverty. Chapter 3 showed that groups vulnerable to energy poverty are for instance pensioners and people with disabilities. The case study of Overvecht-Noord identified similar groups, that is elderly and people with medical issues. Besides these groups, other vulnerable groups identified in the case study are people with psychological issues and people with migration backgrounds. The housing associations are aware of the vulnerabilities of these groups and take those into account when providing them with information concerning the heat transition, for instance by approaching them individually. This allows the housing association to also address other issues that may be present.

The housing associations try to change household practices by increasing awareness through education. The housing associations in Overvecht-Noord participate in a programme that offers energy advice to renters, and housing association Bo-Ex gives electric induction cooking workshops. More effort can be made to understand household practices as part of their social and cultural contexts, because these contexts make household practices difficult to change.

Chapter 6
Integration and discussion

In this chapter, I integrate my findings. Then, I discuss the methodologies I used for answering my RQs. This chapter concludes with recommendations for future research.

6.1 Integrating the findings

In this section, I integrate my findings by addressing the similarities and differences between insights from the different chapters, and comparing these with other studies. This section directly feeds the guidelines presented Chapter 7.

6.1.1 Lack of understandings of energy poverty

Recognition and knowledge of energy poverty among academics and politicians outside the UK and Ireland is limited, but increasing (Maxim *et al.*, 2016). Initially, energy poverty was seen as an issue of affordability, but the definition has expanded to describe households that lack essential energy services, due to high energy prices, low household income, inefficient houses and appliances, and specific energy needs (EPOV, n.d.). This definition shows that energy poverty is not only characterised by high energy bills, but can also occur in households restrict their energy consumption with the intention to keep energy bills low. Energy justice literature further unravelled the complexity of energy poverty by identifying the different types of injustice underlying the issue.

Energy poverty is not (yet) recognised as a major problem in the Netherlands. The following findings support this. First, no national definition of energy poverty exists. Second, reducing and preventing energy poverty are no specific goals in the heat transition in Overvecht-Noord. Third, some of the experts and stakeholders I interviewed, had not heard of the term energy poverty before the interviews took place.

Among the interviewees that had heard of energy poverty before, different perceptions of energy poverty were present. Most interviewees associated energy poverty with high energy bills. Meeuwis (interview 20 November 2018), however, argued that damp and mould in the dwellings due to insufficient usage of space heating is an expression of energy poverty as well. Gruter and van Leeuwen (interview 22 November 2018) also noticed that some renters do not use heating, in order to save money.

Without a comprehensive and widely accepted definition of energy poverty, identifying households suffering from energy poverty and addressing the problem is difficult. Energy poverty's complexity should not be reduced to an issue of affordability. Moore (2012) also stressed that a definition of energy poverty in policy formulation is important, for instance to determine the scale of the issue and ensure that resources are effectively used to tackling issues underlying energy poverty. Energy inefficiency of buildings and appliances is one of those underlying causes of energy poverty, and many interviewees advocated improving insulation levels so as to increase energy efficiency of buildings.

6.1.2 Increased efficiency by insulation

In the energy poverty and justice literature, multiple authors argued that increased energy efficiency in buildings is the most important synergy between addressing energy poverty and reducing CO_2-emissions (Bouzarovski, 2018; Ürge-Vorsatz & Tirado Herrero, 2012). Neuhoff *et al.* (2013) even added that the most effective way to address the distributional impact of regressive policies, is to support energy efficiency improvements. Increased energy efficiency in buildings can be achieved by insulation and by the installation of energy-efficient appliances or heating systems. A study by Nibud (2009) on gas and electricity use in the Netherlands supports these findings by showing that absence of floor insulation and double glazing is associated with higher gas consumption.

Multiple stakeholders in the Overvecht-Noord case study agreed that improving insulation should be priority in the heat transition (de Vette, 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018). The stakeholders put forward several reasons for prioritising insulation. First, with higher insulation levels, households need to consume less energy to achieve similar levels of energy services. Therefore, insulation can contribute to decreasing energy consumption and, thereby, decreasing CO_2-emissions. Second, most gas-free heating techniques are low-temperature heating techniques and only perform well in dwellings with high insulation levels. Third, insulation is considered a no-regrets measure which allows for flexibility (de Booij, interview 1 November 2018; de Vette, 21 November 2018; Meeuwis, interview 20 November 2018). The housing associations indicated to prefer investing in insulation - and are already doing so - rather than in alternative heating techniques such as heat pumps. They argued that the heat pump needs to be further developed.[27]

Geldhof (interview 31 October 2018) added a critical note to these praises of insulation, arguing that investments to improve insulation levels by far exceed investments in alternative heating techniques such as the installation of a heat pump or connection to a heat grid. Ürge-Vorsatz and Tirado Herrero (2012), on the contrary, argued that insulation addresses the two goals of energy poverty eradication and climate change mitigation simultaneously, which can facilitate mobilising the required resources for improving insulation levels.

In sum, both in literature and in practice, insulation was seen as an important measure to decrease energy poverty and contribute to achieving climate goals. However, improved energy performance of buildings does not always lead to the predicted or desired reduction in energy consumption. This is a phenomenon that is often referred to as the rebound effect (Majcen *et al.*, 2012).

6.1.3 The rebound effect

Even though in the literature improved energy efficiency in buildings is seen as the best solution to eradicate energy poverty, multiple stakeholders raised the issue of the rebound effect

[27] According to de Vette (interview 21 November 2018) and Meeuwis (interview 20 November 2018), the heat pump takes up a large amount of space in the house and its costs are high.

(stakeholder 6, interview 7 December 2018; Gruter & van Leeuwen, interview 22 November 2018; ten Zijthoff, interview 6 December 2018; Tourné & Sterk, interview 16 November 2018). In brief, the stakeholders argued that the energy consumption after renovations often turns out to be lower than expected. In some cases, energy consumption even increased after a renovation. A study on the energy consumption of labelled dwelling in the Netherlands by Majcen *et al.* (2012) also found discrepancies between theoretical (model-predicted) and actual energy consumption. Majcen *et al.* (2012) found that actual energy consumption in energy-efficient dwellings is higher than theoretical energy consumption.[28] According to Majcen *et al.* (2012), the rebound effect occurs when more efficient technologies cut energy bills but thereby encourage increased consumption. Filippidou (2018), who also studied labelled dwellings in the Netherlands, found a discrepancy between theoretical and actual energy consumption as well. Filippidou (2018) did not attribute this difference to the rebound effect, but to the difficulty of predicting the energy savings effect of some measures.

Ürge-Vorsatz and Tirado Herrero (2012), proponents of increasing energy efficiency in buildings to reduce energy poverty, also addressed the issue of the rebound or takeback effect. They argued that the efficiency gains following renovations may be expressed as comfort improvements rather than as decreased energy bills (Ürge-Vorsatz & Tirado Herrero, 2012). Sovacool (2015) takes a similar stance by explaining the discrepancy in expected and actual fuel consumption in renovated dwellings by 'take back' or comfort factors: *"households 'take back' the benefits of improved energy efficiency as increased warmth and comfort rather than as fuel savings particularly following the installation of a new heating system"* (p. 369). Partly because of this, Tirado Herrero *et al.* (2013) assessed efforts to alleviate energy poverty not only on market benefits (energy savings), but also on non-market benefits such as avoided energy poverty-related mortality or improved comfort.

In short, the discrepancies in modelled and actual energy consumption can often be explained by higher levels of energy services and comfort. Therefore, reducing the prevalence of energy poverty is not only or always about lowering high energy bills, but also about matching access to energy services with household-specific energy requirements. Households with higher-than-average energy requirements (for social, cultural or health reasons) are more vulnerable to energy poverty.

6.1.4 Groups vulnerable to energy poverty

Energy justice literature stressed the importance of recognising differential needs for energy services and accommodating the needs of vulnerable and marginalised social groups in addressing energy poverty (Walker & Day, 2012). In addition, heterogeneity exists between households in the consequences experienced by a lack of energy services (Gillard *et al.*, 2017).

[28] Not only did Majcen et al. (2012) find a discrepancy in actual and theoretical energy consumption in well-insulated dwelling, but also in poorly insulated dwellings. Strikingly, *"dwellings with a low energy label actually consume much less energy than predicted by the label"* (Majcen et al., 2012, p. 125). This issue was also addressed by multiple stakeholders (Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018)

Finally, Bouzarovski (2018) and Thomson *et al.* (2017) argued that specific household practices (e.g. cultural practices) can cause above-average energy consumption.

From the energy poverty literature, I identified several groups that are likely to be vulnerable to energy poverty. First, pensioners on average have higher energy needs, for physiological reasons and because they spend more time at home (Walker & Day, 2012). Second, people with disabilities or chronic illnesses may also have high energy needs, to heat their homes to comfortable temperatures or for using medical equipment (Snell *et al.*, 2015). Finally, Bouzarovski (2014) and Stoerring (2017) argued that families with children often have higher energy needs, which makes them more susceptible to energy poverty.

The groups identified by the stakeholders in Overvecht-Noord largely coincide with the vulnerable groups identified from the literature. First, the stakeholders in Overvecht-Noord also mentioned elderly people or pensioners as more vulnerable to energy poverty (Tourné & Sterk, interview 16 November 2018). A study by Nibud (2009) on the household characteristics influencing electricity and gas consumption, also showed that households with a retired family member use more gas. Second, Tourné and Sterk (interview 16 November 2018) argued that unemployed people spend a relatively large amount of time at home and are therefore likely to consume more energy. Another third vulnerable group identified from the case study includes people with a migration background, because these people may be used to higher temperatures (Tourné & Sterk, interview 16 November 2018). Gruter and van Leeuwen (interview 22 November 2018) added that cooking practices related to culture can also cause high energy consumption, and are difficult to change with the planned switch to electric cooking. Fourth, the stakeholders mentioned people with mental and physical health issues as potentially vulnerable to energy poverty (de Vette, interview 21 November 2018; Gruter & van Leeuwen, interview 22 November 2018; Meeuwis, interview 20 November 2018).

Bouzarovski (2018) and Healy and Clinch (2004) argued that thermal efficiency of rented homes is relatively low and therefore renters are more vulnerable to energy poverty than homeowners. Nibud (2009) also found that 95 per cent of owner-occupied houses in the Netherlands have double glazing, compared to 83 per cent of rented houses. Also, 61 per cent of owner-occupied houses have floor insulation, compared to only 55 per cent of rented houses (Nibud, 2009). According to Nibud (2009), wall and roof insulation were not related to tenure status. Renters do not only live in less energy-efficient houses, they also have lower incomes than homeowners, thus spending larger proportions of their incomes on energy (Nibud, 2009). Household incomes and the amount spent on the energy bill impact affordability of energy services which, in turn, affects energy poverty.

6.1.5 Affordability

Literature on energy poverty and energy justice showed that the distributional injustices of low households income and high energy prices lead to unaffordability of energy services. The heat transition is expected to change energy prices and can thereby influence a household's ability to pay for energy services. The importance of energy costs in determining affordability of living costs, is stressed by Haffner and Boumeester (2015) in their study on the impact of rent and housing costs on housing affordability in the Netherlands. They found that *"even energy* *expenses by themselves can push households over the affordability threshold, in the situation where rents are considered as affordable"* (Haffner & Boumeester, 2015, p. 293).

One way in which energy prices are changing in the heat transition, is by a tax increase on gas. By imposing a tax increase on gas, the Dutch government tries to discourage natural gas use, because the government considers gas to be 'more polluting' than electricity (Government of the Netherlands, n.d.-a). In this way, the Dutch government acts according to the polluter pays principle (PPP), which is the commonly accepted principle that *"the costs of pollution should be borne by those who cause it"* (Joseph, 2014, p. 24). The PPP typically takes the form of a tax collected by governments, levied per unit of pollution. The carbon tax is a well-known example of a measure based on the PPP. Ürge-Vorsatz and Tirado Herrero (2012) also argued that a carbon tax can be a powerful tool in decreasing demand. Therefore, they expect that such measures will be increased when moving towards carbon-constrained economies (Ürge-Vorsatz & Tirado Herrero, 2012).

However, literature on energy transitions and energy poverty in European countries showed that increasing tax on the energy bill disproportionately affects low-income households, because this tax forms a greater proportion of their incomes. This shows that energy justice principles - focused on creating fairer energy systems - are in conflict with the widely accepted PPP. The polluter pays principle gives insight into who should pay, but not into who has the ability to pay. Therefore, this principle should not be implemented without considering its social justice implications.[29] Eames and Hunt (2013) argued that increased tax rates on energy bills can be introduced without disproportionately impacting low-income households. They proposed that the money generated through (carbon) taxes be recycled back to low-income households (Eames & Hunt, 2013).

All tools and models I studied in Chapter 4 consider the economic factor 'costs' in their calculations. On top of that, multiple tools had the primary objective to identify the heating alternative with the lowest overall costs. However, one cannot assume that the cheapest alternative will also be the most affordable to renters. Knowing how and by whom the heat transition will be paid, is probably more insightful to renters in the social housing sector.

The investments done to facilitate the heat transition[30] and the rise in energy taxes, will probably lead to an increase in energy prices. In the meantime, the planned renovations will lead to better-insulated homes that require less energy consumption for energy services, which is why renters can still profit from lower energy bills. However, the housing associations can charge their renters compensation for the investments made, for instance in the form of an EPV or by increasing rents or service charges. De Vette (interview 21 November 2018) argued that the EPV can contribute to affordability of renovations for the housing associations.

[29] When the PPP is applied, the costs of climate damage are paid for by the ones who cause it. Rooijers (2016) found that households pay tax per unit of energy consumed; higher incomes consume more gas, and therefore pay more tax. However, taking an income perspective, households with lower incomes need to spend a larger proportion of their incomes on this tax, which can be considered socially unjust.

[30] For instance to increase insulation levels, install a heat pump, connect to district heating, or increase the capacity of the electricity grid

To summarise, affordability is not only about choosing the cheapest option, insight is needed into how and by whom the heat transition is paid. Housing associations have a responsibility to provide affordable housing. This also includes energy costs. The municipality of Utrecht aims for a cost-neutral approach, meaning that an increase in rent should always be accompanied by a significant reduction in energy costs. Housing associations should be careful when charging their renters compensation. Hoppe (2012) - who did a study on the factors that influence the adoption of innovative energy systems (IES) in eight large-scale renovation projects in the social housing sector in the Netherlands - found that renters *"do not accept an increase in rent, although they are informed to gain a net benefit* (p. 800). Hoppe (2012) also put forward two possible causes for this lack of acceptance, that is a lack of trust in the housing association and too little or late involvement of renters in project decision-making. This stresses the importance of participation in decision-making.

6.1.6 Participation in decision-making

Energy justice and energy poverty literature showed that engagement in policy and governance and fairness in decision-making procedures are important to ensure procedural justice, and therefore, are crucial in reducing or preventing energy poverty (Bouzarovski, 2018; Gillard *et al.*, 2017; Light & de-Shalit, 2003). The interviewed experts also emphasised the importance of a fair process - to create a heat transition in which everyone can take part and to achieve public support (de Greef, interview 2 November 2018; Schepers, interview 13 November 2018).

In the Dutch social housing sector, large-scale renovations need seventy per cent public support among renters. The stakeholders in Overvecht-Noord stressed that information provision and participation in decision-making are important to achieve public support. Following the interviews, I conclude that the focus seems to be at information provision rather than participation. Tourné and Sterk (interview 16 November 2018) argued that participation is typically limited to marginal aspects such as choice of a new kitchen's colour. In addition, housing associations provide information - for instance through residents' meetings - only when concrete plans for starting a renovation of a certain building exist, to prevent unrest among the renters. This limits possibilities for renters to changing anything substantial about the proposed plans. Hoppe (2012), also stressed the importance of timely involvement of renters to achieve public support for projects. De Vette (interview 21 November 2018) and Meeuwis (interview 20 November 2018), however, argued that their renters often do not take the initiative to be involved.

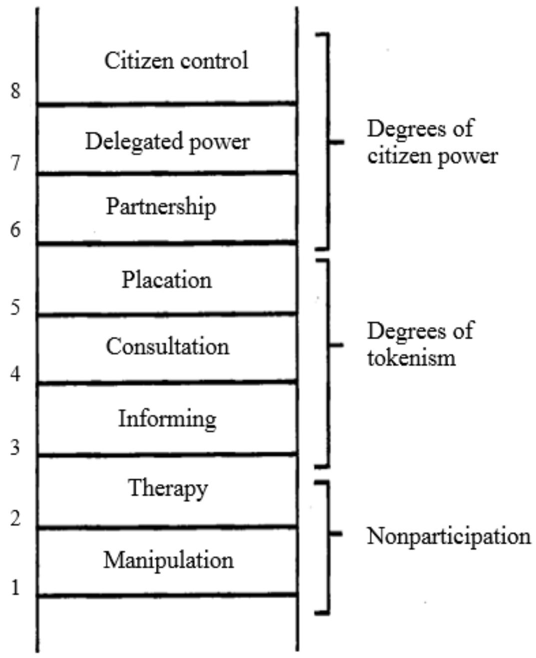

Figure 11 Eight rungs on a ladder of citizen participation (adapted from Arnstein, 1969)

A dominant framework for assessing participation of citizens in decision-making, is Arnstein's (1969) ladder of participation (see Figure 11). This ladder identifies eight levels of (non-)participation. With the exception of one project in which residents were involved in the designing of an alternative heating system, I would describe participation of renters in decision-making in the heat transition in Overvecht-Noord as placation (degrees of tokenism). This is because renters are allowed to advise, yet the right to decide remains in the hands of the housing associations.

6.1.7 Disagreement about roles and responsibilities

To facilitate the transition towards a gas-free Overvecht-Noord, the housing associations are investing in alternative heating techniques and in the energy performance of their property. The housing associations in Overvecht-Noord stressed that becoming sustainable or gas-free is not their priority, instead, they need to ensure availability of affordable homes. If the government wants housing associations to be frontrunners in becoming gas-free, it should contribute financially, according to the housing associations (de Vette, interview 21 November 2018; stakeholder 6, interview 7 December 2018; Meeuwis, interview 20 November 2018). Multiple housing associations proposed that the government could, for instance, cut the landlord levy by half to compensate the housing associations for making investments that contribute to the national goal of CO_2-reduction. Hoppe (2012) also found that the housing associations in his study perceived an *"unfairly distribution of costs and benefits. Governments have many requirements, but little to offer in terms of finance"* (p. 800) and concluded that this can lead to a lack of trust between stakeholders, which is an important reason for non-adoption of IES.

Besides disagreement about responsibilities for decreasing CO_2-emissions, unclarity exists concerning the level of protection housing associations should provide their renters. Housing associations have a responsibility to provide affordable housing and, according to de Booij (interview 1 November 2018), energy costs should be part of this. The present district heating system in Overvecht-Noord is expensive for renters, mainly because the maintenance costs are included in the energy bill. In houses without district heating, housing associations take the responsibility to install and maintain condensing boilers. When connecting dwellings to district heating, de Booij (interview 1 November 2018) proposed that housing associations take on (part of) the heat provider's maintenance costs, so as to take control of the energy prices charged to the renters.

Besides decreasing CO_2-emissions and ensuring affordability, creating a fair process is an important topic in the heat transition. The majority of tools and models that I studied are not focused on facilitating participation in decision-making processes. Schepers (interview 13 November 2018) argued that this is the municipality's responsibility.

6.1.8 Confusion between goal and means

A last theme, which at first glance may not be directly related to energy poverty, is the existence of different interpretations of sustainability, leading to confusion between goal and means. To achieve the climate goals of 49 per cent reduction in CO_2-emissions by 2050, the national government has decided that there is a need to diverge from gas as the main heat source in the built environment. In that sense, becoming gas-free is a means to achieving the goal of lower CO_2-emissions. The case of Overvecht-Noord showed that sometimes, gas-free is equated to sustainable or CO_2-free. This is why dwellings that do not use gas directly (because they are connected to district heating and cook on electricity) are excluded from the project Overvecht-Noord gas-free. On top of that, multiple projects in Overvecht-Noord are focused on switching to electric cooking in order to become gas-free.

De Vette (interview 21 November 2018), however, argued that in this way, no significant contribution will be made to reduction of CO_2-emissions. This view is supported by the following numbers. With cooking on gas, a household on average uses 37 m^3 gas per year, which equates to about seventy kilograms of CO_2-emissions (Milieu Centraal, n.d.-b). To compare, total gas consumption of the average Dutch household is about 1470 m^3 gas (Milieu Centraal, n.d.-a), meaning that gas used for cooking amounts to only three per cent of total gas consumption. Because about eighty per cent of gas is used for space heating (Milieu Centraal, n.d.-a), more progress can be achieved in that domain, for instance by insulation.

Gruter and van Leeuwen (interview 22 November 2018) argued that following a switch from cooking on gas to electric cooking, CO_2-emissions might even increase. Milieu Centraal (n.d.-b) also argued that as long as the electricity mix is made up of a majority of non-renewable resources, electric cooking is not preferable to cooking on gas. To address this issue, Gruter and van Leeuwen (interview 22 November 2018) argued that the switch to electric cooking should be combined with the installation of solar panels.

To sum up, the different interpretations of sustainability and confusion between goal and means lead to investments that do not contribute to the goal of reducing CO_2-emissions. The government's initial goal was to achieve climate goals, and a gas-free built environment should contribute to achieving this goal. The recurring earthquakes in Groningen have stressed that becoming gas-free is also a goal in itself, however, as long as the electricity mix consists mainly of fossil resources, gas-free should not be equated to environmental sustainability.

6.2 Methodology

I used a variety of methods to answer the RQs. Every method has its inherent limitations and uncertainties. In this research, I combined insights from several disciplines, including environmental science and policy studies, and from practical experience. Such interdisciplinary approach typifies Environmental Systems Analysis research. In this section, I first discuss the relevance of focusing on the social housing sector. Then, I discuss the main critiques of (singular) case study research and interdisciplinary research.

6.2.1 Scoping: focus on the social housing sector

Multiple authors have argued that tenure status is important in causing energy poverty (Bouzarovski, 2014; Healy & Clinch, 2004; Maxim *et al.*, 2014). Tourné and Sterk (interview 16 November 2018), however, questioned the relevance of focusing on energy poverty in the social housing sector. They argued that the issue of affordability in the heat transition in Overvecht-Noord is more relevant to homeowners than to renters, because homeowners have to invest in the renovation of their homes (Tourné and Sterk, interview 16 November 2018). Homeowners that do not have the financial means to invest in alternative heating options, will inevitably face the consequences of increased gas prices. Renters may even be better off than homeowners, because housing associations are obliged to invest in improving the energy performance of their property.

However, considering the costs of living[31] as a percentage of total household income, renters in the social housing sector spend a larger proportion of their incomes (38 per cent) on living costs than homeowners (28 per cent) (CBS, 2015). On top of that, 39 per cent of households in the social housing sector indicated to have difficulties in making ends meet, compared to only 6 per cent of homeowners (CBS, 2016).

A focus on the social housing sector provides an opportunity to make a positive societal impact. Occupying about thirty per cent of the total housing market, the potential to reduce or prevent CO_2-emissions and energy poverty is large. Part of this opportunity lies in the structure of ownership and buildings, which are less dispersed and fragmented than in privately owned or rented houses (Filippidou, 2018). According to Hoppe (2012), *"it is better to renovate 100 dwellings owned by one person (or legal entity) than try to renovate 100 dwellings which are all privately owned"* (p. 792).

6.2.2 Singular case study research

I performed a case study to give greater weight to my findings and make them more applicable to the real-life context. Many social scientists, as Thomas (2011) pointed out, have a critical attitude towards (singular) case study research. One of the main points of critique relates to generalisability. According to Flyvbjerg (2006), colleagues would argue: *"you cannot generalize from a single case"* (p. 219). Eisenhardt and Graebner (2007) are also in favour of multiple-case research, and argued that *"theory building from multiple cases typically yields more robust, generalizable, and testable theory than single-case research"* (p. 27).

My reason for including a case study was to investigate how energy poverty plays a role in practice. Practical knowledge is valuable, especially since no theoretical knowledge exists concerning energy poverty in relation to the heat transition in the Netherlands. Overvecht-Noord is one of the first districts to start the transition to gas-free. Not only are examples of other districts scarce, time constraints did not allow for another complementary case.

In creating a set of guidelines that can be used by municipalities and housing associations throughout the Netherlands, some form of generalisability is desirable. To make my findings more robust, I included an interview with a representative of the umbrella organisation of housing associations called Aedes in my stakeholder interviews. This interview showed that Dutch housing associations are facing similar challenges in the heat transition as the housing associations in Overvecht-Noord. These challenges related to, for instance, the investments the housing associations need to make in the heat transition, the rebound effect, and responsibility for decreasing CO_2-emissions (stakeholder 6, interview 7 December 2018). Besides that, I compared the findings from the Overvecht-Noord case with Hoppe's (2012) study on eight renovation project in the Dutch social housing sector. I did not identify any major discrepancies. Multiple findings were overlapping or complementary, for instance on timely

[31] Living costs are the total amount of rent or mortgage, and other housing costs such as home insurance and premiums for gas, water and electricity (CBS, n.d.-c).

involvement of renters in decision-making and the importance of financial compensation (e.g. subsidies) from the national government.

In sum, the guidelines would be less practically applicable if they were drawn up from scientific literature only. Rather than being fully generalisable, information obtained from the Overvecht-Noord case, in Flyvbjerg's (2006) words, can *"enter into the collective process of knowledge accumulation"* (p. 227).

6.2.3 Integrations of different insights

The methods I used for answering the RQs include literature review (on energy justice and energy poverty, and energy poverty in energy transitions in three European countries), an analysis of tools and models, interviews with experts, and a case study including content analysis of relevant documents and stakeholder interviews. These activities have yielded different types of information, and the integration process brought these findings together.

According to Repko (2012), interdisciplinary integration involves *evaluating disciplinary insights*, *creating common ground* (by resolving conflicts between the insights), and *constructing a more comprehensive understanding*. In section 6.1, I evaluated the different insights by addressing the similarities and differences between insights from the different chapters, and comparing these findings with the literature. Rather than trying to solve the differences or conflicts between the different insights, I argue that acknowledging their existence is important. I used both practical information and theoretical knowledge and therefore did not prioritise one type of information over another (in line with Flyvbjerg, 2006). Chapter 7 presents the outcome of the integration process. This is the more comprehensive understanding in the form of a set of guidelines.

6.3 Recommendations for future research

As mentioned, scientific literature about energy poverty in the Netherlands and the heat transition is scarce. Literature that combines these two topics is even more difficult to find. This thesis thus offers a first understanding of how these issues relate and shows how an energy justice framework can be used to study the heat transition.

This research can be further expanded to study the impact of the heat transition outside the social housing sector, for instance by looking into the way the heat transition impacts the prevalence and severity of energy poverty among homeowners or households in the private rented sector. Furthermore, expanding or transforming the energy justice framework to study the broader energy transition or other (sustainability) transition processes would be insightful. Besides that, more case studies can complement this study, for instance by testing the guidelines or by adding more guidelines.

Finally, some stakeholders indicated that participation of renters in projects initiated by the housing associations is limited. Involvement of renters in decision-making is crucial to achieve procedural justice. Therefore, research into the reasons for (non-)involvement of renters in projects in the social housing sector could provide valuable insights that can be used to encourage participation.

Chapter 7

Conclusions

Energy poverty is still poorly understood in the Netherlands. In the light of a heat transition that requires adjustments to millions of homes, households are subject to changing energy prices. This can put low-income households in particular at risk of falling into poverty. Analysing energy poverty through an energy justice lens showed that energy poverty is not merely an issue of high energy bills. Instead, energy poverty is the result of a mismatch between energy services and household-specific energy requirements.

This thesis's aim was *to analyse how energy poverty and the heat transition are related in theory and practice, to guide Dutch municipalities and housing associations in incorporating energy poverty considerations in their heat transition decision-making processes for the social housing sector*. To achieve this aim, I formed four RQs. I answer these questions below, after which I present my recommendations to Dutch municipalities and housing associations in the form of a set of guidelines.

7.1 Answers to research questions

In answering RQ1 - *how are energy poverty and the heat transition related in the literature?* - I found that energy poverty can be caused by the three types of injustice, that is *(1)* distributive inequalities in energy prices, household income and energy efficiency, *(2)* procedural injustices of insufficient access to information, participation in decision-making and legal rights, and *(3)* misrecognition of specific household energy needs, practices and vulnerabilities.

The heat transition mainly affects energy poverty's distributive aspects of energy prices and energy efficiency. Energy prices are expected to rise as a result of a tax increase on gas imposed by the national government. Experience from energy transitions in three European countries has shown that imposing a tax on energy bills to encourage energy conservation, disproportionately impacts low-income households. Hereby, the tax increase on gas is likely to increase the prevalence of energy poverty. As for energy efficiency, however, the heat transition calls for the implementation of efficient and renewable heating systems. These are typically low-temperature heating systems and therefore require buildings to be well-insulated. Insulation increases the energy efficiency of buildings and in that way can have a positive impact on reducing energy poverty.

RQ2 - *what factors are considered in tools and models used in decision-making in the heat transition, and why?* - served to discover whether social and equity considerations are underrepresented in energy transition discussions, as is argued in the literature. In tackling this question, I found that economic and technical factors play prominent roles in the examined tools and models. Environmental factors, such as CO_2-impact, are featured in multiple tools and models as well. Aspects of energy poverty are largely neglected in the tools and models I studied. The interviewed experts put forward multiple reasons for the underrepresentation of energy poverty considerations in these tools and models. For instance, engaging stakeholders in decision making - a precondition for procedural justice - often takes place after the model has been applied and is seen as the responsibility of municipalities and housing associations. Also, social factors - including energy poverty considerations - are less easily quantifiable and less generic than technical and economic factors and are therefore less easily incorporated into tools and models.

For RQ3, I addressed the question of *how energy poverty plays a role in the heat transition in Overvecht-Noord.* The case study showed that distributional injustices of low incomes and the relatively high energy prices charged for district heat, lead to unaffordability of the present district heating system. Renovations carried out by the housing associations are likely to have a positive impact on reducing energy poverty. The rebound effect, however, can lead to actual energy savings to be lower than predicted. Overvecht-Noord includes many people that are vulnerable to fall into energy poverty because of their specific energy needs. Participation in decision-making can be a way to accommodate such needs. However, information about upcoming renovations is provided rather late in the process, which limits possibilities of renters to change anything substantial about the proposed plans.

In Chapter 6, I integrated the different insights obtained by answering the first three RQs. In the integration process, I found many overarching themes between the findings, including the importance of building efficiency and affordability. These themes directly feed the guidelines for municipalities and housing associations.

7.2 Recommendations: set of guidelines

Table 7 presents the guidelines that municipalities and housing associations can use to incorporate energy poverty in heat transition decision-making for the social housing sector. Naturally, every district has its own specific characteristics. The guidelines should thus be used as a *frame*, to which area-specific considerations can be added. The guidelines give insight into processes underlying energy poverty and the principles that must be kept in mind in the transition towards a gas-free built environment.

In conclusion, the heat transition and reducing the prevalence of energy poverty are closely related processes that benefit from being studied simultaneously. Indeed, the transition to a gas-free built environment is likely to increase energy prices, which can lead to the expansion of energy poverty. However, if well-designed, the heat transition can lead to synergies with efforts to reduce of energy poverty.

My hope is that these guidelines contribute to affordable, renewable and clean energy - to ensure availability of and access to sufficient levels of energy services for the present generation and future generations.

Table 7 Guidelines for incorporating energy poverty in the process of decision-making in the heat transition

Guiding Principle (GP)	Explanation	Considerations
1. Create a common understanding of energy poverty	With the absence of a definition of energy poverty, the issue is more difficult to recognise and address.	• Energy poverty is a complex issue that is caused by injustices that interconnect • Energy poverty is not only recognised by high energy bills, but by a mismatch between access to energy services and households' specific energy requirements
2. Prioritise insulation to increase efficiency of buildings	Increased efficiency can reduce energy poverty while reducing CO_2-emissions and facilitating low-temperature heating techniques.	• Insulation is major investment, but it is a no-regret measure and can be used to address three goals simultaneously • Be aware of the rebound/comfort effect, see GP 3
3. Anticipate a comfort effect after renovations	Renovations are not always accompanied by a decrease in energy consumption. Efficiency gains may be expressed as comfort improvements rather than as decreased energy bills.	• Do not only assess the market benefits (energy savings) of improved insulation, but also non-market benefits such as energy-poverty related mortality or improved comfort
4. Recognise the existence of vulnerable groups	Misrecognition of groups with specific energy needs, vulnerabilities and practices can cause energy poverty.	• Renters are more vulnerable than homeowners • The following groups may be more vulnerable to falling into energy poverty: elderly people, unemployed people, people with (psychological) health issues, and people with migration backgrounds
5. Ensure affordability	Affordability is determined by household income and energy costs.	• Be aware of the regressive effects that the introduction of a carbon tax can have • Only allow rent increase or charge of EPV in when this is accompanied by a significant reduction in the energy bill • To prevent opposition from renters, facilitate a fair process, see GP6
6. Facilitate participation of renters in decision-making	Participation is an essential component of procedural justice, and is needed to achieve public support for renovations.	• Involve renters in an early stage of decision-making so their ideas can be taken into account • Participation of renters should not only be limited to marginal aspects
7. Create a common understanding of sustainability	With a common goal, those measures can be taken with greatest effect on improving sustainability.	• Differentiate between goal and means • Efforts to become gas-free should always imply a CO_2-reduction
8. Create a clear division of roles and responsibilities	Clarification is needed about who is responsible for ensuring affordability and for facilitating participation in decision-making.	• Housing associations may need to take on costs associated with the heat transition, to ensure affordability of the heat transition for renters • Financial compensation helps housing associations to create an affordable heat transition • The municipality and housing associations are key actors in facilitating participation

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Appendices

A. Interview guide expert interviews
B. Interview guide stakeholder interviews
C. Description of tools and models used in Chapter 4

Appendix A

Interview guide expert interviews

Important factors (according to interviewee)

<u>On specific tool or model</u>

How did the model come into existence?

What factors are considered in the model?

What are the strengths/advantages of the model?

Is the model complete? Is something missing from the model? Are there other factors you believe should be considered in the heat transition?

<u>Models in general</u>

What criteria does a good model have to meet?

  What parameters should a model contain?

Reasons for incorporating certain factors in a tool or model

Apart from the factors considered in the model, can you name other factors that must be considered in the heat transition?

  Why are these not considered in the model?

Do you believe that social factors should play a more prominent role in heat transition models?

Heating systems

In your opinion, what criteria should an alternative heating system, such as district heating or all-electric, meet?

Can you describe your ideal heating system?

Energy poverty

Have you ever heard of energy poverty?

Appendix B
Interview guide stakeholder interviews

Energy prices & low household income
In what way does/will/can the heat transition affect the energy bill of renters?

Energy efficiency
What measures are taken to make the houses in the social housing sector in Overvecht-Noord gas-free?

What adjustments are done to the improve the insulation levels of these houses?

Specific household energy needs
What are vulnerable groups in the transition towards a gas-free Overvecht-Noord?

Recognition justice
In what ways are vulnerable groups taken account of?

Procedural justice
Access to information
In what way do renters in the social housing sector access information concerning the transition towards a gas-free home/Overvecht-Noord?

Participation in decision-making
To what extent are renters involved/can renters be involved in decision-making processes concerning the heat transition?

Legal rights
Are laws or is legislation in place to protect the interests of low income households?
To what extent are these complied with?

Energy poverty
Have you ever heard of energy poverty?

Is energy poverty an issue among your renters?

What activities are put into practice to mitigate energy poverty in the social housing sector?

Appendix C

Description of tools and models used in Chapter 4

HEAT (Alliander DGO)

HEAT is developed by Alliander DGO. Alliander DGO is a subsidiary of the grid operator called Alliander, and has the goal to construct open networks for distribution of renewable and local energy.[32]

HEAT can be used by housing associations, homeowner associations, municipalities, business parks, et cetera (ETRM, n.d.-d). HEAT allows stakeholders to be involved in choosing the best option in the development of new heat infrastructures (ETRM, n.d.-d). The tool was designed to create transparency, trust, support and effective interaction between stakeholders, which should eventually lead to process acceleration (Alliander DGO, n.d.).

HEAT is based on economic and technical data (Alliander DGO, n.d.). The tool gives insight into several concerns, such as CO_2-reduction, costs (e.g. infrastructural costs, costs for housing associations or societal costs) and security of supply (Alliander DGO, n.d.; ETRM, n.d.-d).

Vesta (PBL)

The Vesta model is created by the Netherlands Environmental Assessment Agency (PBL) (ETRM, n.d.-g). PBL is the Dutch national research institute in the domains of environment, nature and spatial planning, and is part of the Ministry of Infrastructure and Water Management.[33]

The model was principally used by the PBL in order to collect knowledge for regional governments and the national government (PBL, n.d.). Since 2017 the model is open-source accessible so that municipalities, energy companies and other organisations can also use it (PBL, n.d.). Vesta is a spatial energy model for the built environment with the aim to explore possibilities to decrease energy use and CO_2-emissions in the period until 2050 (van den Wijngaart *et al.*, 2017). The model can give insights into the technical-economic potential for energy saving, renewable energy and heat grids (ETRM, n.d.-g).

Vesta calculates the effects of measures taken at the building or regional level regarding avoided CO2-emissions, energy use, investment costs and financial benefits of different actors, ranging from energy producers to distributors to owners and users of buildings (ETRM, n.d.-g; PBL, n.d.). Vesta also includes investment costs and infrastructural costs and increasing the capacity of the electricity grid. Also, socio-economic characteristics of households and companies can be accounted for (ETRM, n.d.-g; PBL, n.d.).

[32] https://www.allianderdgo.nl/en/about
[33] http://www.pbl.nl/en/aboutpbl

Warmtetransitiemodel (Over Morgen)

The Warmtetransitiemodel is developed by Over Morgen. Over Morgen is a consultancy which was originally focused on spatial development, and has more recently specialised in the energy transition (Geldhof, interview 31 October 2018). The three main areas of interest in the energy transition are heat, electric mobility and solar energy (Geldhof, interview 31 October 2018). Over Morgen advises governments, housing associations and energy companies about a sustainable living environment (ETRM, n.d.-b).

The Warmtetransitiemodel is used by Over Morgen to help municipalities, provinces, housing associations and grid operators to make the built environment more sustainable (Over Morgen, 2018). The Warmtetransitiemodel underlies the *Warmte Transitie Atlas* (Heat Transition Atlas). The Warmte Transitie Atlas provides insights into the different alternatives to gas for delivering heat (Over Morgen, 2018). The model can be used to calculate the heating alternative with the lowest societal costs and to identify areas that are promising to become gas-free (Over Morgen, 2018).

The Warmtetransitiemodel calculates the investment costs and savings of alternative heating options per household and subsequently for neighbourhoods. Based on the investment costs and savings, a cost-benefit analysis is done to determine the most cost-efficient option for a certain neighbourhood (Over Morgen, 2018). This might not be the cheapest option for all individual households, but the option with the lowest average costs.

Cegoia (CE Delft)

CEGOIA was developed by CE Delft. CE Delft is an environmental research and consultancy organisation that strives to develop solutions to environmental issues that are politically feasible, technically well substantiated, economically feasible and also socially equitable.[34]

CEGOIA can be used by local and regional governments, energy companies and grid operators (CE Delft, n.d.). CEGOIA is used to give insight in the differences between energy options, by calculating the total costs of individual and collective heat provision (Schepers, interview 13 November 2018). The most cost-efficient energy infrastructure is determined per neighbourhood (ETRM, n.d.-a).

Investment costs and infrastructural costs are important factors considered in the CEGOIA model (CE Delft, n.d.). Energy consumption is also included in the calculations (ETRM, n.d.-a). CE Delft is working on including affordability in the model (Schepers, interview 13 November 2018).

[34] https://www.ce.nl/over-ce-delft

Gebiedsmodel (Alliander and D-Cision)

The Gebiedsmodel is developed by Alliander and D-Cision. Alliander, as a grid operator, is responsible for energy distribution.[35] D-Cision is a consultancy which, amongst other things, supports grid operators in grid design and management so as to facilitate the energy transition.[36] The Gebiedsmodel is relevant to policy advisors and energy specialists and is typically used in the exploration of different energy options (ETRM, n.d.-c). The Gebiedsmodel quantifies and visualises the effects of measures taken in the energy transition (ETRM, n.d.-c).

The effects of these measures are calculated for the following domains: the proportion sustainable energy, CO_2-footprint, investment and operating costs, and regional employment (ETRM, n.d.-c).

OPERA (ECN part of TNO)

The Option Portfolio for Emissions Reduction Assessment (OPERA) is a model that was developed by ECN part of TNO.

OPERA can be used by policy makers to create long-term climate strategies and determine the energy systems with the lowest costs given certain constraints imposed by the user (Energy research Centre of the Netherlands [ECN], n.d.; ETRM, n.d.-e).

Constraints that can be imposed include CO_2-emissions, targets for renewables and resource availability (ETRM, n.d.-e). The model includes investment and operating costs per technology and also the efficiency or fuel consumption of technologies (ETRM, n.d.-e). The model not only considers emission levels of CO_2, but also emission levels of other greenhouse gases and air pollutants (de Joode *et al.*, 2016).

TRANSFORM

TRANSFORM is developed by the Austrian Institute of Technology (AIT) and the consultancy of Accenture (Loibl *et al.*, 2014). Accenture was supported by its sub-contractor Macomi in the development of TRANSFORM (Loibl *et al.*, 2014).

TRANSFORM can be used by decision-makers to analyse energy data. On top of that, TRANSFORM gives decision-makers the possibility to simulate plans in terms of CO_2-emissions, renewable energy and costs for different scenarios (ETRM, n.d.-f). TRANSFORM is an interactive decision-support environment (Loibl *et al.*, 2014).

TRANSFORM uses several energy- and climate-related indicators to show whether energy and climate goals can be achieved (ETRM, n.d.-f). Indicators include energy consumption, CO_2-emissions and the amount of renewables (ETRM, n.d.-f). Other factors that are considered in this tool are implementations costs and effects on the city's employment (Loibl *et al.*, 2014).

[35] https://www.alliander.com/nl/over-alliander
[36] http://www.d-cision.nl/index.php?lang=en

Meetlat tool (Greenvis)

The Meetlat tool is developed by Greenvis. Greenvis is an engineering and consultancy company in the field of heating and cooling networks.[37]

The Meetlat tool gives municipalities insight into opportunities for district heating (Greenvis, n.d.). The tool is applied in an early stage in the development of a heat project. Greenvis gives the alternative heating options a score between one and five for each of the following dimensions: economic, technical, political and social dimensions. Then, the administrative body select the alternative with the right balance between these dimensions (de Greef, interview 2 November 2018).

Political and social factors include, for instance, voting behaviour. The presence of neighbourhood sustainability initiatives can also be considered (de Greef, interview 2 November 2018).

Smart Energy Cities model

Smart Energy Cities is a public-private partnership between the ministries of Economic Affairs and Climate Policy (EZK) and BZK, Grid Management the Netherlands, Top Consortium for Knowledge and Innovation (TKI) Urban Energy, and TKI ClickNL.[38] The model is the result of experience and lessons learned in 16 districts in the Netherlands (Smart Energy Cities, n.d.-b).

The Smart Energy Cities model is used to assist municipalities, grid operators, residents and, potentially, housing associations, in accelerating the energy transition (Smart Energy Cities, n.d.-b). The model uses an integrated approach in which a social approach is combined with techno-economic innovations (Smart Energy Cities, n.d.-a, n.d.-b).

Techno-economic factors include, for instance, availability of heat sources, energy infrastructure, information about buildings and financing options (Smart Energy Cities, n.d.-a). Besides these factors, social factors are taken into account, for instance incorporating residents' wishes and needs, involving residents in the process and creating awareness among residents (Smart Energy Cities, n.d.-a).

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[37] http://www.greenvis.nl/nl/
[38] https://www.smartenergycities.nl/over-smart-energy-cities/