ERASMUS UNIVERSITY ROTTERDAM

Erasmus school of Economics

Master Thesis Urban, Port and Transport economics

Energy Poverty in the Energy Transition Policy

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Date final version: 05-01-2023

Abstract

The Fit-for-55 report set a condition for member states to reach a fair, competitive, and green transition. In addition, countries must include energy poverty in the energy transition policies (European Commission, 2021). In response to this report, Mulder et al. (2021) conducted research into the actual rates of energy poverty in the Netherlands in which several risk factors emerged that could indicate both energy injustice and an unequal transition. This research will focus on how these risk factors emerge in existing policies. This study examined the layers within the transition towards a decarbonised housing stock, using the multi-level perspective and transition management model. This revealed that municipalities have an important task and considerable potential to address energy poverty. To examine municipal policies, a textual analysis was conducted using self-prepared dictionaries on the 'Transitie Visie Warmte'. The topics related to a green transition were found to recur in the documents. This research showed that in less than half of the municipalities, the topic of energy poverty is mentioned and more focused on the risk factors related to energy justice than those of an equal transition. There is little focus on those with a financial investment barrier and limited attention in areas where tenants of private landlords are living.

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List of Abbreviations

Abbrevuation	Definition
PAW	Programma Aardgasvrije Wijken
RES	Regionale Energie Strategie
RSW	Regionale Structuur Warmte
TVW	Transitie Visie Warmte
WUP	Wijkuitvoeringsplannen

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1. Introduction

Energy poverty was voted as the Dutch word of the year in 2022 (Onze Taal, 2022). The focus on this word stems from rising energy prices with more people struggling to pay their energy bills. In the report written by the 'Nationale Ombudsman' in 2022, it became clear that energy poverty is not only about the affordability of the energy bill. The residents most affected by rising energy costs are those living in poorly insulated homes whom themselves have little to no influence on the energy transition in their houses (van Zutphen, 2022).

The foundation of the energy transition lies in the Paris Agreement and involves a change from fossil fuel use to green energy use (Bruyninckx, 2016). The agreement is a token of awareness and an action plan to reduce and limit climate change. In 2019, as a follow-up to the Paris Agreement, the Climate Agreement was signed in the Netherlands (Rijksoverheid, 2019). Within this agreement, the energy transition is being tackled in five different sectors, one of which is the energy transition in the built environment. Municipalities have a leading role and should cooperate with housing corporations to decarbonise the housing stock (Mulder et al., 2021). Various actors, such as grid operators, heat companies and governments, need to join forces to achieve the targets of the Climate Agreement (van Berkel et al., 2021).

The interplay between the energy transition and energy poverty, as highlighted in the report of the 'Nationale Ombudsman', was already highlighted in the European Union's Fit-for-55 report. This report was released in 2021 and emphasises the need to comply with the commitments made in Paris. (European Commission, 2021). This report no longer focuses only on the achievement of climate targets but also looks at the allocations within this transition. The objectives indicate a broader purpose: a fair, competitive, and green transition. The European Commission highlights energy poverty in this approach and makes demands on the various member states (Planbureau voor de Leefomgeving, 2021).

Researchers from the independent research organisation TNO, therefore, published a report on energy poverty in the Netherlands (Mulder et al., 2021). The report revealed that 550,000 households are currently experiencing a form of energy poverty, which is approximately 7% of all households. A household is at risk of energy poverty when it has difficulties with paying the energy bills, when the housing quality is too low, or when it is unable to participate in the energy transition. The latter group consists of people that live in a low-energy house, have low financial resources, or cannot decide on investments themselves because they rent a house (Mulder et al., 2021). As a result, people are unable to invest in decarbonising their houses. Also, the investments are often not profitable due to the inferior quality of the house (Tigchelaar et al., 2022).

1.1. Research question

Currently, climate change and energy poverty are interrelated problems in the Netherlands. This is also reflected by the European Fit-for-55 report stating that these issues should be solved simultaneously (European Commission, 2021). The Netherlands should report annually on the statistics in terms of energy poverty, where the report by Mulder et al. (2021) can be perceived as a first step. As a second condition, the Member States must include energy poverty in the energy transition of the residential houses, also referred to as the decarbonisation of the housing stock. This transition can be achieved through two pathways, firstly making homes more efficient and secondly adapting the energy supply to low-carbon sources (Deloitte Netherlands, 2022). This study will map out the approach of the transition towards a decarbonised housing stock and whether it incorporates the problem of energy poverty. The research question therefore reads:

To what extent has energy poverty been taken into account by the governance of the transition to a decarbonised housing stock in the Netherlands?

To answer this main question, several sub-questions have been formulated:

1. *How can the transition towards a decarbonised housing stock be described from the transition management model and which actors fulfil the roles in this classification?*
2. *How do the risk factors of energy poverty relate to housing decarbonisation in the tactical role of the transition in the Netherlands?*
3. *How do the strategic, operational, and reflexive governance roles address energy poverty in the Netherlands?*
4. *To what extent are energy poverty and energy poverty risks reflected in municipalities' policies and does this follow the current state of energy poverty in the Netherlands?*
5. *To what extent is the approach from the other governance roles regarding energy poverty in the transition reflected in municipalities' policies?*

1.2. Set-up research

All sub-questions can be partially answered with the literature review. To be able to answer all the questions comprehensively, a textual analysis will be conducted where the distinct roles within the transition will be researched in more detail, which involves sub-question 1. The transition management model used will be explained in the literature review. The textual analysis will examine energy poverty within municipalities (sub-question 4) and the existing instruments against energy poverty (sub-question 5).

2. Literature review

The literature review aims to map the available information regarding the governance of the transition towards a decarbonised housing stock and its focus on energy poverty. Firstly, the meaning of governance will be discussed, as well as the different fields in which governance is important. This is followed by a discussion of transitions and the governance models that allow transitions to be analysed.

Thirdly, the phenomenon of energy poverty will be discussed and linked to the energy transition through the concepts of energy justice and just transition. Finally, Chapter 4 summarizes the information about the governance of the transition in the Netherlands using a multi-level perspective and the transition management model. This last chapter also describes the approach to reducing energy poverty.

2.1. Governance

To analyse the governance of transitions, it is necessary to understand the meaning of governance and the fields in which this form of research is used.

2.1.1. Definition of governance

There are different ideas within the literature about the exact definition of governance. One of the most cited definitions of governance is described by Rhodes (1997) as: ‘‘the self-organizing inter-organizational networks characterized by interdependence, resource exchange, rules of the game and autonomy from the state’’. Ikenberry & Florini (2003) define governance in a broader sense: “how all how groups of people collectively make choices”.

Within governance literature, three main principles emerge. At first, a governance network is not only about government but about different actors within a governance network. Secondly, these self-organising networks aim for less government control and existing hierarchy. Even though the government may have an overview of the tasks to be accomplished. Thirdly, the networks, therefore, revolve around different actors who each have their interest in a task and are dependent on each other. This is in line with research by Kerbergen & Waarden (2004), who showed the trend from traditional hierarchical governance mechanisms to more modern inclusive arrangements. Governance can therefore be seen as a coordinating mechanism that structures action and interaction between actors with some authority and/or legitimacy.

2.1.2. Governance research

A huge amount of research has been done regarding the conditions in which a governance network emerges, in which networks have been mapped within different dimensions. This resulted in different frameworks and models that scholars believe are the best to use to identify certain preconditions and difficulties to make the networks more effective (Klijn, 2008).

These studies may focus on a particular sector such as the private sector, or on the contrary, the public sector (Klijn, 2008). Several studies have also been done on, for example, healthcare governance (Siddiqi et al., 2009) or IT governance (Almeida et al., 2013).

Governance studies can be categorised into certain geographical scales such as global governance or a smaller scale in regional governance (Hoppe and Miedema, 2020). Research has also been done on the governance of transitions; the governance of a major change in society. Several models can be used to analyse such a major change. To select the right model, it is important to first understand the meaning of transition and identify the specific characteristics of the transition towards a decarbonised housing stock.

2.2. Transitions

The energy transition is an example of a (socio-technical) sustainability transition. This section will first explain what this means. Next, the models for analysis will be explained, the multi-level model and the transition management model. These two models are often used to analyse (socio-technical) sustainability transitions. Finally, the energy transition and the role of decarbonisation of the housing stock in it will be explained. This is important to eventually discuss the issue of energy poverty.

2.2.1. (Socio-technical) sustainability transitions

Loorbach et al. (2008) describe a transition as a transformation on a large scale in society, in which society or important subsystems change fundamentally. The term refers to a long-term nonlinear shift from one equilibrium to another that lasts at least one generation. According to Markard (2018), this process lasts at least 50 years or more and is continuous and gradual.

Transitions can be technological, economic, ecological, socio-cultural, or institutional and can influence each other (Rotmans et al., 2001). Sometimes transitions are used to solve broader problems in society and to reach a sustainable new situation (Avelino et al., 2016). These transitions are known as processes of social change in response to social challenges and are called sustainability transitions

Apart from the fact that sustainability transitions are intended to solve problems in society, other characteristics distinguish them from general transitions.

First of all, sustainability transitions involve more governance and guidance (Smith et al., 2005). This is because they often require many different actors to work together in a coordinated way. This corresponds with Markard (2018) who indicates that public policies often play a significant role and that there is an elevated level of complexity and uncertainty. Secondly, the transition is value-laden; the goals cannot be viewed objectively. Thirdly, sustainability transitions often have winners and losers and are often highly contested. Fourthly, sustainability transitions are often context dependent. Different regions often have different values, political systems, natural resources, and established practices (Markard, 2018).

The latter characteristic has two negative consequences. Firstly, the lock-in of certain systems makes it difficult to change things in these systems (Klitkou et al., 2015). Secondly, it creates path dependency whereby the events that took place before still influence the course of events now (Cairns, 2014). Within the literature, sustainability transitions are often associated with socio-technological changes. This suggests that the transitions require changes in both the technological side and consumer practices, cultural meanings, public policies, markets, models, and infrastructures (Geels, 2019; Elzen et al., 2004).

2.2.2. The multi-level perspective on transitions

Previously, socio-technological transitions were studied using more general theories such as the evolutionary economic theory (Nelson & Winter, 1993). Additionally, theories have been used that focus more on technology, constructive technology assessment (Jacobson et al., 1997) or technology future studies (Porter et al., 2004). To examine sustainability changes, literature on sustainability sciences (Kates & Clark, 2001) or green management and corporate social responsibility (Porter & Kramer, 2006) can be used as examples. In recent years, this shifted to more transition-focused studies. As a result, more models emerged that allowed transitions to be analysed and understood (Bergek et al., 2008; Carlson, 2002).

An example of an emerging model is the multi-level perspective. This model divides a socio-technical system in which a change takes place into three levels. Figure 2.1 shows the different layers and the flows between them. The overarching layer is the macro level, also known as the landscape, which consists of the major autonomous social developments in the field of politics, culture, and world views. The tempo within this layer is low (Ernst et al., 2016).

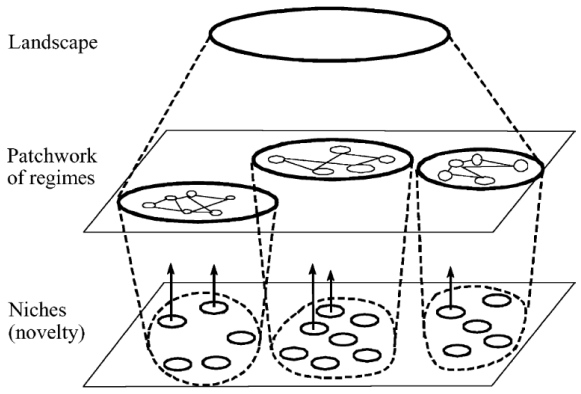

Figure 2.1 The multi-level perspective on transition
Adopted source: Geels (2002)
Note. From "Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study," by F.W. Geels 2002, Research Policy, 31(8–9), 1257–1274. (https://doi.org/10.1016/s0048-7333(02)00062-8)

Below the macro layer is the meso-level: the regimes. This layer consists of a system of rules and interests that are shared by certain groups of actors and concerns the historically grown dominant collective way of thinking. Changes within this stable layer are difficult to implement and there is a focus on preserving the changes to the system (Ernst et al., 2016). Finally, the micro level: the niches. Within this layer, deviations from the existing way of doing things can occur. For example, through new initiatives and technologies.

A sustainable transition can be achieved when changes occur in the regimes. These processes are illustrated in Figure 2.2 When the regime changes, so do the socio-technical systems: including technology, infrastructure, actors, rules, and behaviour (Geels, 2002). In the multi-level approaches, the changes can occur through interaction between the layers. Promising forms of innovation must emerge from the niches to put pressure on the regimes. At the same time, pressure on the regimes comes from the landscape. This causes destabilization within the regimes and can change the existing system and the landscape (Geels, 2002).

Several criticisms of the multi-level approach can be found in the literature. First, Røpke (2016) shows that the distribution systems in society are not highlighted sufficiently. As a result, there is less talk about a socially sustainable transition. This, therefore, means that issues such as poverty are highlighted less in this approach (Jenkins et al., 2018). Second, the multi-level approach deals less with the impact that a transition makes. This is often due to the Schumpeterian economic approach and the desire to understand the transition (Geels, 2019). It is assumed that a transition is intrinsically positive and therefore, transition scholars do not address outcome assessments (Gillard et al., 2016).

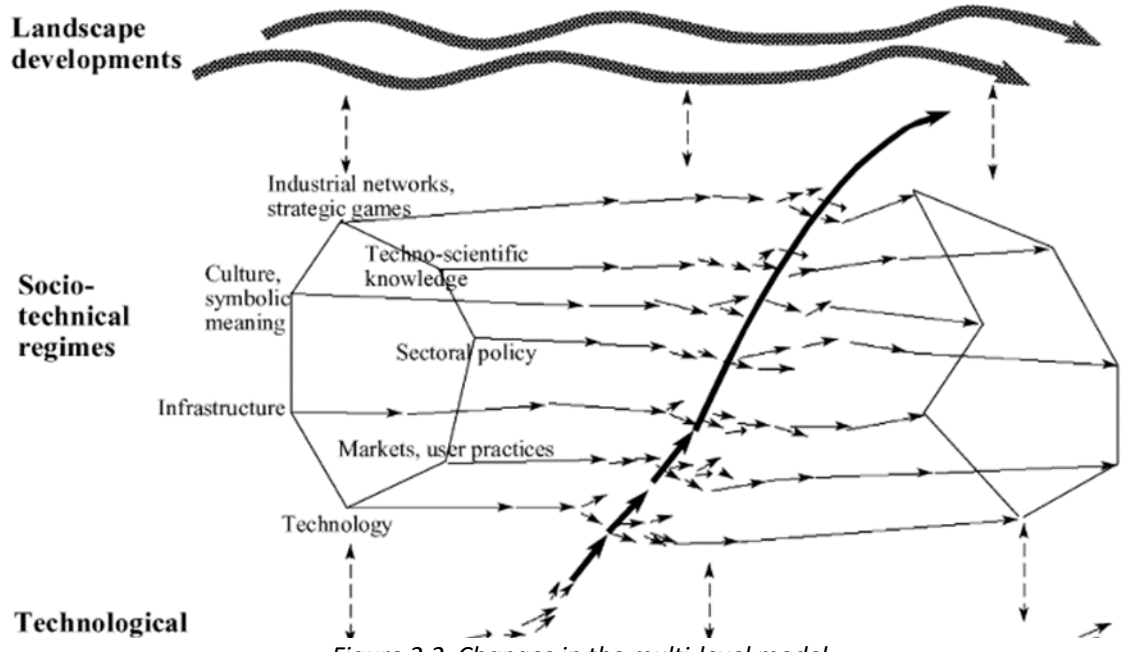

Figure 2.2 Changes in the multi-level model

Note. From "Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study," by F.W. Geels 2002, *Research Policy*, *31(8–9),* 1257–1274. (https://doi.org/10.1016/s0048-7333(02)00062-8)

2.2.3. Governance of transitions

The previous two chapters explained the meaning of a transition and the conditions under which a transition can be successful. Loorbach et al. (2008) have developed a governance model that identifies these conditions and describes the optimal way to set up the organisation around a transition: the transition management model. The transition management model builds on the multi-level perspective seen in the previous section. It assumes a complex system with a lot of uncertainty. The approach is best summarised in five characteristics:

- Long-term thinking to accommodate short-term approaches,
- Thinking in more than one domain and assuming multiple actors at various levels,
- Focus on learning by doing and doing by learning,
- Initiate system innovation together with system improvement,
- Keep many options open in the process (Rotmans et al., 2001).

There are several important concepts in the transition management model. At first, the transition objective needs to be clear but can change during the transition. The transition visions must be appealing and imaginative and can be used to mobilize the social actors. The interim objectives are derived from the long-term objectives and are about the process, learning process and the content of the transition. It is important to evaluate these. The last important note is public support on all levels (Rotmans et al., 2001).

Within this approach, four different governance activities emerge that are relevant to transitions.

First, the strategic activities. These focus on strategic discussions, long-term and collective goals, norm-setting and long-term anticipation. The activities revolve around changing the entire system and achieving consensus about future development. This task takes place within the landscape (Loorbach et al., 2008).

Secondly, the tactical activities. These are interest-driven and relate to the dominant regimes of the system. They revolve around rules, institutions, organisations, infrastructure, and routines. The actors move into different subsectors. These subsystems can be, for example, different sectors or different domains such as technology or policy. The goals often have a period of 5-15 years. These activities take place at the regime level (Loorbach et al., 2008).

According to Loorbach et al. (2008), a problem that often arises is the fact that within a regime, the long-term goal for that regime is often assumed by the landscape. But the actors within a regime already have a long-term vision because of negotiations with the actors within the system, causing them to miss the overall goal. In doing so, the goal for the entire social system is undermined and a long-term integrative policy cannot be implemented. To avoid this, it is important to involve all actors in the processes.

The third governance role is the operational activities. These experiments and actions also often have a short-term vision and are often released for innovation (Loorbach et al., 2008). These activities take place in the niches.

Finally, the reflexive activities, are related to monitoring, assessments, and evaluation of existing policies. These are partly already in existing institutions, but also on the Internet, in the media and in the research world. The reflexive activities are interwoven with the previous three activities (Loorbach, 2010).

To influence the various activities, certain instruments must be designed. Loorbach and Rotmans (2006) have done this by placing the model in a cyclical model which is presented in Figure 2.3.

This model consists of the following elements:

1. Structure the problem and create a long-term sustainability vision. Organize the transition arena which is a network of various important actors in the transition. It is primarily a strategic task.
2. Develop visions of the future and a transition agenda. Derive the necessary transition pathways from this which is primarily a tactical activity.
3. An operational task is to ensure transition experiments and bring the transition networks together.
4. Evaluate and monitor the transition experiments and adjust where necessary. Described as a reflexive task (Loorbach, 2010).

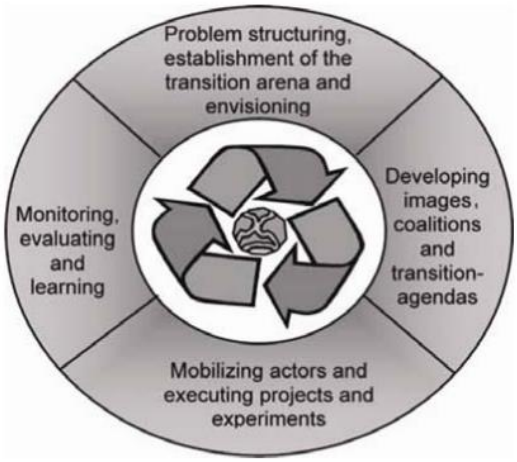

Figure 2.3 Transition Management cycle

Note. From "Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework" by D.Loorbach, 2010*, Governance, 23(1), 161–183. (https://doi.org/10.1111/j.1468-0491.2009.01471.x)*

2.2.4. Decarbonisation of the housing stock

An example of a (socio-technical) sustainability transition is the energy transition. The energy transition involves a change from existing polluting fuels such as coal, oil, and gas to clean energy such as wind, biomass, or solar power. This decarbonisation process involves both a change in energy production and energy consumption sectors (Sievers et al., 2019).

There are several reasons for these changes in the energy sector. Reasons could include trade prices or political goals such as market liberalization and less dependence on other countries because of the scarcity of fossil fuels (Solomon & Krishna, 2011). But as indicated earlier, the basis of this sustainability transition is the goal to reduce energy-related CO2 emissions to combat climate change (Grubler, 2012).

As said, the energy transition can be seen as a socio-technological transition. Innovative technologies emerge to replace the current energy system. On the other side, the social part, new consumer practices, new policies and a new culture emerge in the energy system.

The concept of lock-in, as discussed in Section 2.1, plays an influential role in the energy transition. Fossil fuel energy is an advanced system which has led to being optimised and often the most efficient. As a result, it is difficult for modern technologies to break through (Loorbach & Verbong, 2017). Several other difficulties in the energy transition have been summarised by Rotmans and Verheijden (2021) in three points.

First, the old energy infrastructure needs to be dismantled and new energy infrastructure built. Second, the system needs to move from a centralised system to a decentralised one. Finally, a change from the top-down way of operating to a bottom-up approach is required where new laws and rules are necessary (Rotmans, 2011).

A key event in the energy transition was the Paris Climate Conference, as indicated in the Introduction, which produced the first legally binding Climate Agreement (UNFCCC, 2015). It became clear that climate change required a global approach in which countries themselves interpret the objectives and goals. Within the agreement, the built environment emerged as an important sector, accounting for 38% of total global energy-related CO2 emissions.

In the built environment two emissions are central. First, the embodied emissions, where the gasses are released during the construction and the life cycle of the buildings (EASAC, 2021). Emissions may also be operational, these occur when energy is used in the building, for example for heating houses, delivering hot water and energy for cooking (Parkin et al., 2020).

Operational energy-related CO2 emissions can be reduced through several pathways. Two ways emerge as the most important. First, adjusting the energy efficiency of buildings reduces energy demand (Knobloch et al., 2018). The energy solutions within this pathway can be insulating the building and replacing current heating systems with more efficient ones.

Second, adjusting the current energy supply with renewable energy is important. This represents phasing out fossil fuel use (Langevin et al., 2021).

As mentioned in the Introduction, the Climate Agreement was published, in which they also committed to reducing energy demand and adapting energy supply (Rijksoverheid, 2019). In this covenant, the difference between buildings and houses is an important distinction. Both parts of the built environment have different goals and approaches to bringing down emissions. The goal consists of decarbonising 7 million residential houses and 1 million other buildings, such as schools or offices (Rijksoverheid, 2019).

Within the energy system of the built environment, two systems are currently in use in the Netherlands: the gas system and the electricity system. Gas will start to change in the transition to a system where no fossil gas is used but rather renewable gases such as hydrogen and green gas. Electricity will play a bigger role than it does in the current system. Additionally, a third system will become active, using heat networks. This is the heat energy system.

2.3. Energy poverty

The transition is changing energy systems and the relationships within them. A concept that aligns with these systems is energy poverty. To interpret this concept, the definition, drivers, and consequences of energy poverty will be discussed.

A prerequisite for an equal energy system is energy justice with, as part of it, a just transition. This specific concept is highlighted in the Fit-for-55 report as indicated in the Introduction. This assumes a fair transition. From this perspective, the research institution TNO conducted research on the state of the Netherlands, which is presented in the last section.

2.3.1. The definition of energy poverty

A fuel poverty phenomenon was first reported in the UK by Brenda Boardman (1991), which involved fuel to heat houses. Later, the term energy poverty was introduced to also refer to other forms of energy carriers such as electricity (Bouzarovski & Petrova, 2015).

In the literature, a distinction is made between the definition in developed and less developed countries. In the latter, energy poverty is about having access to forms of energy, without which they remain dependent on traditional biomass for cooking and heating (IEA, 2010). In more developed countries, it is often about affordability (Bouzarovsk & Petrova, 2015).

In the European Union, different definitions and indicators of energy poverty are used. Several European countries have an official definition of energy poverty. For example, France defines energy poverty as a person who encounters in his/her accommodation difficulties in having enough energy supply to satisfy his/her elementary needs. This is due to the inadequacy of resources or housing conditions (ONPE, 2014).

Austria has defined energy poverty as: "A household is considered energy poor if its income is below the at-risk-of-poverty threshold and, at the same time, it has to cover above-average energy costs." (E-control, 2013).

In the Netherlands, there is no official national definition defined. For a long time, it was seen as a general poverty problem and was therefore combated in this way. However, since 2017, more and more research is done and energy poverty is starting to gain more attention (Feenstra et al., 2021).

2.3.2. Drivers of energy poverty

Some drivers of energy poverty have already been discussed in Section 2.3.1, such as having a low income. Yet this is not the only driver, as energy poverty is a multi-dimensional problem. It is therefore difficult to understand how and why households experience this form of poverty (Dubois, 2012). Nevertheless, in the literature, these are often summarized in three main drivers: the households' income, the energy efficiency of the home and the energy prices (Hills, 2011; Straver et al., 2020).

Another often-encountered term is energy vulnerability. This implies the risk factors that contribute to the precariousness of groups of people (Bouzarovski & Petrova, 2015). Several factors can be identified:

- Accesses, the availability of energy carriers that households need,
- Affordability, the ratio between the costs of fuels and the income of the household,
- Ability to invest in new infrastructures,
- The flexibility of moving to an appropriate form of energy,
- The energy efficiency of the homes,
- Practices, the governance of the energy market
- Needs are the match between energy requirements and available energy services (Bouzarovski & Petrova, 2015; Middlemiss & Gillard, 2015).

In the research of Mulder et al. (2021), various drivers of energy poverty emerge. They argue that it is important to look at the social component of energy poverty and found several indicators. One of these is the gender income gap which concerns differences in life expectancy and the sociocultural distribution of tasks between men and women. Disability and chronic illness can also cause people to require extra warmth. The social isolation of a household can make it difficult to pass

on information. Literacy and educational background can limit a person's ability to receive information. The tenure status, is someone an owner or tenant? The occupancy rate, is someone single or living in a large family? Mental health, because of this, someone is less able to deal with energy consumption. A migrant background can also play a role where cultural habits or language issues form a barrier (Mulder et al., 2021).

2.3.3. Consequences of energy poverty

While the previous section highlighted the various causes of energy poverty, there is also research on the effects of this form of poverty. One of the effects that are often observed is the vicious circle of energy poverty and general poverty. General poverty also goes up when energy poverty is experienced (Rademaekers, 2016; Vergeer et al., 2019).

Another major financial consequence is people's saving behaviour on energy due to high energy bills. This indirectly results in health problems (Bridge, 2015; Pye et al., 2016; Bouzarovski et al., 2021). Because of this under-consumption of energy, it is often difficult to identify and map energy poverty (Vergeer et al., 2019).

2.3.4. Energy justice

The various drivers and consequences of energy poverty have shown that energy can increase disparities in society when looking at, for example, the vicious cycle of overall poverty. It is therefore important to look at the distribution of benefits and burdens of the energy market; the energy justice (Bouzarovski et al., 2021). Energy justice means: “Providing all individuals, across all areas, with safe, affordable and sustainable energy" (McCauley et al., 2013). Jenkins et al. (2014), therefore, define this as a safe, affordable, and sustainable energy supply for all.

Energy justice involves the entire energy system and consists of three separate parts: the distributive, procedural and recognition principles. Distributional energy justice is concerned primarily with the equal distribution of benefits and burdens, for example, having access to energy, its price, and the energy efficiency of homes (Walker & Day, 2012).

Procedural justification is concerned with an open, fair, and inclusive decision-making process (Jenkins et al., 2016). Justification by recognition looks at the social factors that influence how the benefits and burdens are distributed. There may be a lack of focus on, for example, the well-being of vulnerable people in the energy system Walker & Day, 2012). Within justification through recognition, then, one often looks at how the distribution runs within the energy transition. People at risk could be older people or households who are unable to take part in the energy transition because of their residential houses (Vergeer et al., 2019).

Part of energy justice is the concept of a just transition, an equal transition. How the just transition concept relates to energy justice is shown in Figure 2.4 The conditions of an equal transition have to do with the justification by recognition principle where attention is paid to those who are not keeping up with the transition and is therefore in line with the energy transition.

The themes and associated risk factors in Figure 2.4 are based on the report of Mulder et al. (2021), the study which emerged earlier. As already discussed, because of the Fit-for-55 report, member states must identify both general energy poverty originating from energy inequality and energy poverty originating from an unequal transition. The states must report on this and include the problems in transition policies.

Mulder et al. (2021) researched the nature, extent, and regional distribution of energy poverty. To measure the drivers of energy poverty, they recognised two themes, energy affordability, related to the risk factors of energy prices and the income of a household. Second, they depicted the theme of housing quality as a prominent issue within energy poverty which is measured by the energy label. An overlap was identified with distributional justice within energy justice research (Jenkins et al.,2016).

In the research of Mulder et al. (2021), the risk factors of an unequal transition were examined. At first, they saw housing as an important theme. This affects both the efficiency of the transition and the overall transition adjustments required. This effect will be discussed further in Chapter 4.2.2.

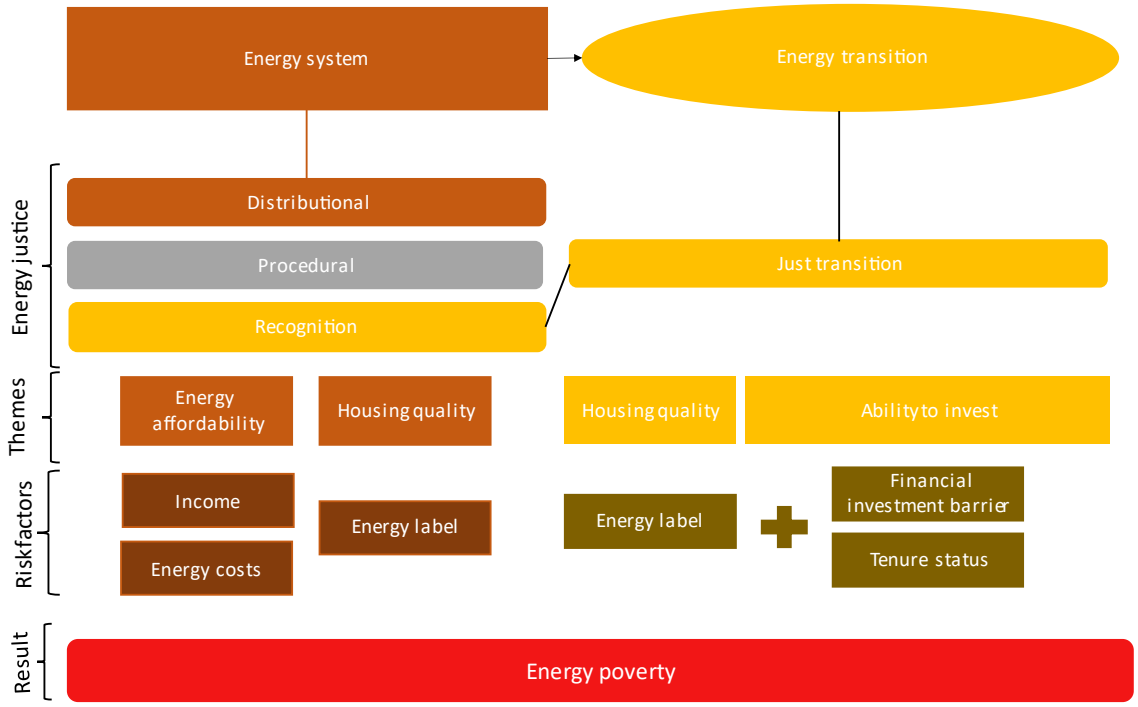

Figure 2.4 Overview of energy justice, theme, risk factors and energy poverty.
Adopted source: Mulder et al. (2021)
Jenkins et al. (2016)

Mulder et al. (2021) went a step further by looking at the people who live both in low-energy houses and have no/little influence on improvement. This ability can lie in two types of components. First, whether someone is experiencing a financial investment barrier, someone does not have the financial means to make certain modifications and whether someone is a renter or a buyer, the tenure status.

In the study, they saw that 48% of households in the Netherlands live in low-energy houses. Over half (26.7%) of them are renters and the remaining group are homeowners with insufficient financial resources (21.3%). In doing so, they used data on energy labels of houses for energy value, information on borrowing capacity and home equity for the financial investment barrier and data on types of ownership to research the tenure status (Mulder et al., 2021).

As said, in the research the regional distribution of energy poverty in the Netherlands is mapped. In their study, they saw that 7% of households face energy poverty. There are large regional differences within this group but also a clear dichotomy, a large concentration in the North and (South) East of the Netherlands and a low level in the Randstad. The large regional differences can also be seen at the district and neighbourhood level with some municipalities having an extremely high average (Mulder et al., 2021)

The researchers mapped all the risk factors as a percentage of the entire municipality. The risk factors related to the transition are shown in Figures 2.5 and 2.6 below. The distribution of people in a low-energy house and insufficient financial resources follows the distribution of overall energy poverty. In the research, tenants in an energetically lesser home are the only group that is an exception, here it follows a very spread distribution across the Netherlands (Mulder et al., 2021).

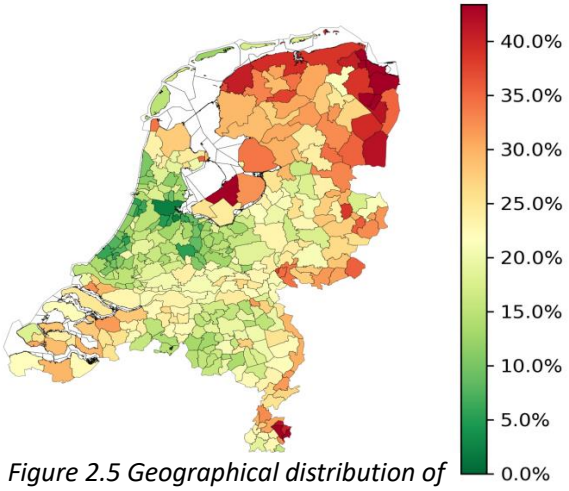

Figure 2.5 Geographical distribution of low energetic houses and low financial resources

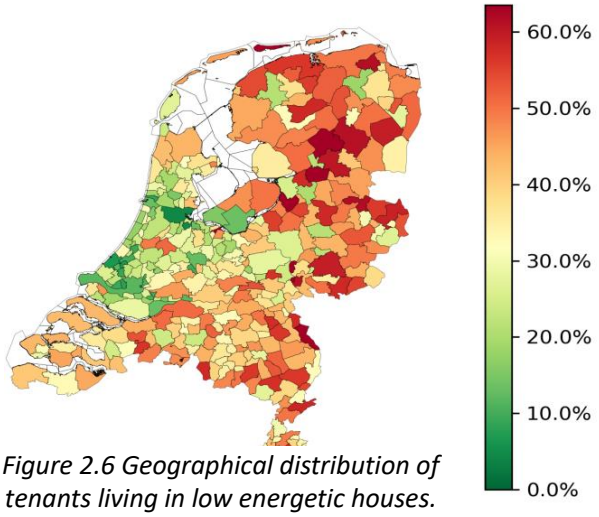

Figure 2.6 Geographical distribution of tenants living in low energetic houses.

Note. Figure 2.5, & 2.6.
From "De feiten over energiearmoede in Nederland Inzicht op nationaal en lokaal niveau" by Mulder et al., 2021 (https://www.tno.nl/nl/newsroom/2021/09/tno-brengt-energiearmoede-gedetailleerd/)

The study also analysed the distribution by urbanity. Energy poverty rates within the group of people who have a low income and an energetically inferior home (energy affordability and housing quality risk factors), emerged to increase with decreasing urbanity. Not being able to keep up with the energy transition due to the tenure status follows this distribution. They explain this by the fact that a lot of investment has been made over the years by urban renewal projects in the Randstad. This has shifted the focus of energetically inferior houses to the North and East (Mulder et al., 2021).

2.4. The transition toward a decarbonised housing stock in The Netherlands

In Section 2.2.4, the characteristics of energy transitions are discussed. Within the decarbonisation of the housing stock, two main transition pathways emerged. First, reducing the demand for energy and changing the supply of energy. This chapter will further explain this transition in the Netherlands using a multi-level perspective and transition management model classification. Finally, the link to the risk factors of energy poverty will be made to understand the impact of the transition on this problem and the policy instruments to address the issue.

2.4.1. Using a multi-level perspective and the transition management model

As emerged in Section 2.2.2 the multi-level model brings out different layers on which change takes place. In the transition management model, these layers are linked to roles that actors occupy within these tasks, which are described in Section 2.2.3. This section combines these two models in explaining the decarbonisation of the housing stock. These models are summarised in Figure 2.7, showing the classification that will be explained further in this section. In the Netherlands, it was agreed to use the classification from the transition management model in the approach to transitions (Ministerie van Volkshuisvesting, Ruimtelijke ordening en Milieubeheer, 2001). Multiple documents emerge within the tasks that are used which are summarised in Table A.1 in Appendix A.

2.4.1.1. Landscape and the strategic role

The overarching layer is the landscape which consists of developments in the field of politics, culture, and worldview. The landscape within the decarbonisation of the housing stocks is the concern about climate change and the realisation of the major influence this sector has. The landscape puts pressure on the regime as shown in Figure 2.7. The strategic role involves setting a long-term goal and thereby changing the entire system. The government fulfils this role by drafting the Climate Agreement (Rijksoverheid, 2019). The long-term goal within the transition of the built environment is decarbonising 7 million homes. In the Climate Agreement, the government identifies the key players, in the transition arena. The municipalities, as part of an energy region, emerge as important players that will have to push through the transition in a neighbourhood-based approach. Housing corporations are also seen as important players that will have to assist the municipalities. Residents are also described as important actors who should be involved in the policy through participation.

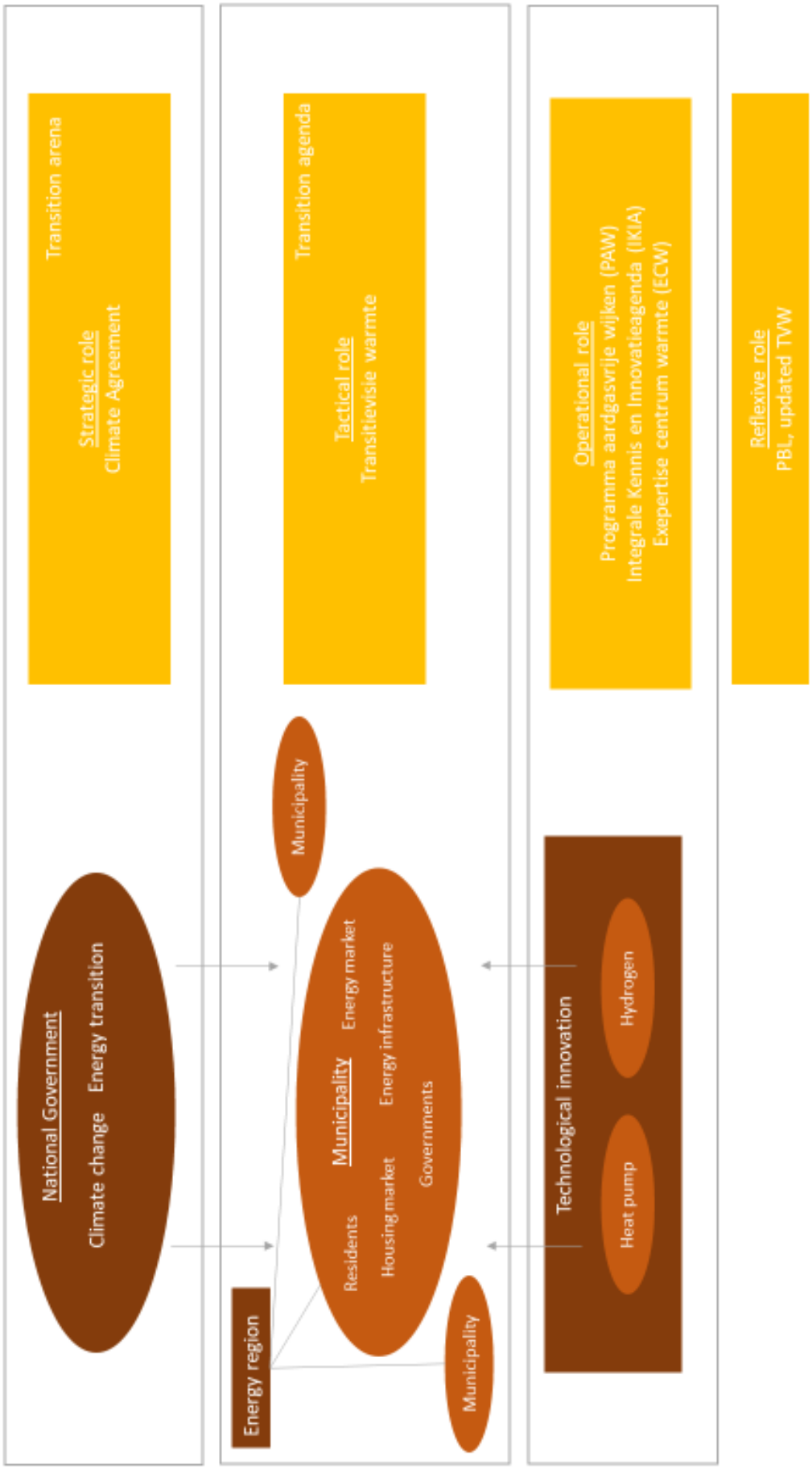

Figure 2.7 Transition using multi-level perspective and transition management model.
Adopted source: Geels (2002) and Loorbach et al., (2008)

2.4.1.2. The regime and tactical role

Regimes play a significant role in a transition. It differs on what scale one looks at the transition which network is seen as the regime. When looking at the energy transition globally, the Netherlands can be seen as a regime. If you look at the transition on a smaller scale and see the municipality as the landscape, the neighbourhoods can act as the regime. In this study, municipalities were chosen to be seen as regimes because of the important task they have been assigned in the Climate Agreement (Rijksoverheid, 2019). This section maps out their role and the key actors within the regime.

2.4.1.2.1. Regime

In the regime layer networks of actors are linked together by rules, interests, existing infrastructure, and culture. It is because of these networks that it is difficult to make changes. Municipalities are divided into energy regions, which thus makes an energy region a patchwork of municipalities. The role of energy regions is to create an overview in terms of energy demand because this often goes beyond the borders of municipalities. They are doing this with the release of the 'Regionale Structuur Warmte' (*RSW*). The energy regions are in turn part of provinces, they have a supporting role (Nationaal Programma Regionale Energiestrategieën, 2021).

In municipalities, residents live in certain neighbourhoods with existing energy infrastructure in the neighbourhood and inside the houses, which is known as the technological side of the transition. The energy infrastructure is linked to energy systems where residents are connected to a certain energy provider. The energy price is set in the energy market (Energie in Nederland, 2021). Around these energy systems and markets, certain laws and regulations are active within which actors must move. Indoors, people have a certain way of receiving and using energy, which is more the social side of the transition (Netbeheer Nederland, 2021). Also, residents are owner-occupiers or tenants of a corporation or landlord. This also makes the rental system an important network within the regime (Rijksoverheid, 2019).

2.4.1.2.2. Tactical role

Pressures from the landscape and niches are going to change these relationships and infrastructure. This change is elaborated in the tactical role, which is fulfilled at the regime level. The tactical role involves translating a long-term vision into a medium-term goal considering the networks of actors. Here, the municipality is responsible for connecting these actors so that the long-term plan can be implemented. This is therefore the reason the role of municipalities can also be partly classified as strategic in terms of bringing together the actors in the transition arena (Rijksoverheid, 2019). The fulfilment of this role is elaborated in a transition agenda which consists of several transition pathways. The municipalities present this in the 'Transitie Visie Wamte' *(TVW)*.

This document provides insight into the following components:

- How many homes and buildings will be insulated and/or made natural gas-free by 2030,
- The most promising transition pathways,
- The option with the lowest national costs (Derksen, 2019).

The final choice per district is worked out in the 'Wijkuitvoeringsplannen' (*WUP*). These must be available eight years before the plans will be implemented in a particular neighbourhood (Derksen, 2019).

2.4.1.2.3. Transition pathways

Several energy solutions emerge in municipalities' *TVW*, and the most important ones are highlighted. These solutions are part of the transition pathways: changing the demand or changing the supply. The possibilities and where these solutions are the most advantageous will be explained, highlighting the potential impact on residents. Within changing the energy supply, three energy systems are central, these are explained in Appendix C.

Transition pathway: energy demand

Within changing energy demand, insulation appears as a solution. This is seen as a 'no-regret' adaptation to the house, lower energy demand is beneficial for the transition and this solution ensures no unnecessary energy infrastructure is built. This involves individual adaptations in current houses, which must go in combination with other transition pathways as insulation is not going to provide renewable energy itself (Vereniging van Nederlandse Gemeenten, 2021)

Transition pathway: energy supply

Within changing energy supply, existing energy systems will change. Within systems, solutions can be either collective or individual. A collective solution is when several households are covered by a particular solution. An individual option is when the solution is used per household. Thereby, solutions can be an endpoint where the energy consists entirely of renewable energy. However, the approach may also use an intermediate solution consisting partly of renewable energy (de Boer et al., 2020).

Energy solutions in the heating system

A new energy system that is emerging is the heat energy system. Central to this option is the construction of heat networks. These form a large part of the transition and are especially suitable in places where there is a high demand for heat in an area (Rijksoverheid, 2019). This is because these networks involve investment and a certain demand for energy to make the networks profitable. In many neighbourhoods, this is the most concrete collective end-solution for the short term, and the expectation is that by 2030 the heat network will be the solution for 30-40% of the neighbourhoods (Van Vlerken, 2021).

Because a heat grid is expensive, this energy solution is applicable in dense buildings. For decision-making on the application of a heat grid, it is advantageous if there is a single owner of buildings that use the heat, such as a housing association. Inside the house, only limited modifications are needed. However, as the gas connection expires, residents will have to switch to electric cooking (de Boer et al., 2020).

Energy solutions in the electricity system

Within the electricity system, two solutions are central. At first, the all-electric solutions, where the entire energy demand is met electrically. The options are individual and are seen as the final solution. Energy solutions include a heat pump, infrared panels, electric radiators, or electric central heating boilers. The all-electric solutions are suitable in neighbourhoods with low building density where a building-by-building solution is needed because a collective solution is not cost-effective. The all-electric solutions are only cost-effective at an energy label of at least B. High investments are required inside the house and residents need to switch to electric cooking (Expertise Centrum Warmte, 2019).

Hybrid solutions are also possible, an example is the hybrid heat pump. This is a combination of a heat pump and the traditional central heating boiler. This option can serve as an intermediate individual solution where natural gas and electricity are currently used and the use of sustainable gas is the final picture (Oei et al., 2021). The solution is suitable for neighbourhoods/areas with low building density, where a collective solution is often expensive and difficult to implement. A hybrid heat pump is already suitable for houses with moderate insulation (Expertise Centrum Warmte, 2020a). Several investments inside the house are necessary, but two connections remain active, making the required investments less than the investments needed for an all-electric solution and not requiring a switch to electric cooking.

Energy solutions in the gas system

Green gas and hydrogen gasses are long-term solutions, these two renewable gasses could be a collective final solution to heat certain areas (Regionaal Energieloket, 2022). Technically, green gas is applicable in all neighbourhoods and will be the cheapest sustainability option for many neighbourhoods. However, this is a very scarce product and requires a lot of electricity. Also, the industry gets priority over heating homes with green gas or hydrogen. This transition path will be deployed in neighbourhoods where another option is not possible such as monumental city centres. Indoors, no modifications are needed for using green gas (Expertise Centrum Warmte, 2021b).

2.4.1.2.4. Actors in the regime and energy solutions

As Figure 2.7 illustrates, there are several networks at the centre of the regime. These are, first, the residents (Rijksoverheid, 2019). They live in houses they either own or rent. As a result, housing associations and landlords are also key players within a regime. The existing authorities are important, including the National Government, the provinces, energy regions, water boards and, of course, the municipality itself. Within regimes, a certain energy infrastructure exists both indoors and outdoors, which the infrastructure a vital component. Finally, the energy markets, are explained in appendix C. Important players here are the grid operators, energy producers, energy providers, heat companies and heat producers. Especially grid operators have a significant role in adjusting the existing energy infrastructure (Energie in Nederland, 2021).

2.4.1.3. Niches and operational role

The changes in regimes, in this case, municipalities, are driven by niches. In the niches, innovative ideas arise through experimentation where existing ideas are tested. In the decarbonisation of houses, these are technological advances regarding, for example, a heat pump or research into hydrogen as energy in homes (European Commission, 2021). These niches, in turn, are driven by the landscape, in this case, climate concerns and the resulting Climate Agreement (Rijksoverheid, 2019). The actors active in the niches can be linked to the operational role where innovation plays a key role. The actors and related documents are explained in Table A.1 in Appendix A.

Primarily, the Climate Agreement focuses on the 'Programma Aardgasvrije Wijken' (*PAW*) programme (Rijksoverheid, 2019). This is a national inter-governmental body in which research on gas-free neighbourhoods is being carried out via living labs, 'Proeftuinen', spread throughout the Netherlands to flesh out the transition. When selecting these labs, the implementation plans, the involvement of residents, the interpretation of the management role by municipalities and the connection with other tasks in the neighbourhood are examined. In the programme, municipalities receive a contribution from the government to quickly make a particular neighbourhood sustainable to be a lesson for the municipalities that follow (Ministerie van Binnenlandse Zaken en Koninkrijkrelaties, 2021).

Another component of the *PAW* is the knowledge and learning programme in which municipalities can participate, set up by the 'Vereniging van Nederlandse Gemeenten' (*VNG)*, the association of municipalities in the Netherlands (Rijksoverheid, 2019). The Climate Agreement also calls for an innovation programme 'Integraal Kennis en Innovatie Agenda' (*IKIA*), which involves cooperation between the business community and knowledge institutes. Another body being created is the 'Expertise Centrum Warmte' (*ECW)*, a knowledge centre about heat, to provide support to municipalities. It is about technical, economic and sustainability aspects (Rijksoverheid, 2019). The 'Leidraad,' a document issued by the *ECW*, indicates for each neighbourhood which heat options have

what impact on the neighbourhood, both in social costs and in costs for end users in the neighbourhood (Rijksoverheid, 2019).

Many researchers within research organisations use their knowledge and research the transition, examples being CE Delft (Deen et al., 2021) and TNO (Dijkstra et al., 2020).

2.4.1.4. Reflexive role

The reflexive role is not assigned to a particular layer in the multi-level system but is located at both the macro, meso and micro levels (Loorbach et al., 2008). The reflexive role involves monitoring and evaluation. Within the *TVW*, this role is partly built-in because this document will be updated every five years evaluating the previous document. So, in 2026, the next document will be released describing what the municipalities will be working on until 2035 (Programma Aardgasvrije Wijken, 2021). In the documents that will be issued now, it is possible to think about what the municipality will work on after 2030. The *TVW* will become part of the municipalities' environmental vision, the long-term vision for the entire physical environment of the territory (Vereniging van Nederlandse Gemeenten, 2018a).

Some bodies undertake monitoring, an example being the governmental institution 'Planbureau voor de Statistiek' (PBL). They researched whether the bottlenecks highlighted in the *PAW* are translated into a change in overall policy at the macro level (van Schie et al., 2022).

2.4.2. Energy poverty risk factors

The previous sections made it clear that there are many actors and policies present within the transition. The transition takes place at the municipal level with a major impact on residents within the regime. As revealed in research by Mulder et al. (2021), quite a number of the residents experience energy poverty, both due to an uneven energy system and an uneven transition. They showed several risk factors that increase the chances of energy poverty in the transition. This chapter will explain the impact of energy solutions on the people at risk of energy poverty. This will be followed by the picture Straver et al. (2020) painted in their research on the instruments and approach against energy poverty in the Netherlands. A condition, as emerged in the Introduction, is energy poverty being included in the policy. This picture will be deepened where the textual analysis will further outline the municipality's approach.

2.4.2.1. Energy poverty and the energy solutions

From the landscape layer, the Climate Agreement pays attention to energy poverty in several ways (Rijksoverheid, 2019). Municipalities are committed to deploying energy solutions. How these options relate to energy poverty risks will be explained in this section.

Transition pathway: energy demand

At first, the solution which adjusts the energy demand is insulation. Insulation can help people living in low-energy houses, label D or lower, bring down energy use. As highlighted earlier, insulation is a 'no regret' solution and there are many gains to be made in these houses. Also, there is an important trade-off with the outcomes of the other energy solutions.

However, people with poor finances do not have the means to invest and experience a barrier. As a result, these people cannot choose this solution (van Berkel et al., 2021). Tenants in a low-energy house do not influence the improvement of the energy value of the house to be able to reduce energy demand.

Transition pathway: energy supply

Energy solutions within the electric system have the advantage that electricity prices are low which makes a switch to this form of energy attractive for people related to the affordability risk factor (van Middelkoop et al., 2018).

Energy solutions in the electricity system

A complete transition to the electricity system is an all-electric solution. Research shows this form is only advantageous in houses with an energy label of A or B and will be cost-effective in 2030. As observed earlier, people experiencing energy poverty live in houses with an energy label of D or lower and so this option is not likely to be cost-effective (Tigchelaar et al., 2022). Thus, this also ensures residents cannot avail the financial benefits of this solution. As with insulation, people with poor finances experience a financial investment barrier for this investment (Tigchelaar et al., 2022). Added to this is the fact that a lot of investment is needed in a house when it switches to all-electric. When households do make the attempt and want to borrow money for this investment, they often do not meet creditworthiness (Schellekens et al., 2019). Tenants also do not influence the elaboration of an all-electric option and depend on the distribution of the costs of the investment.

Another energy solution within the electricity system is hybrid options. These can partly take advantage of lower electricity costs which are advantageous for people with low incomes or high energy costs. This intermediate solution is more quickly effective in low-energy houses than all-electric solutions (Oei et al., 2021). Tenants again do not influence the installation of the hybrid options and depend on the distribution of the costs of the investment. People with a financial investment barrier again do not have the resources for the solutions and thus cannot benefit from the lower electric

costs. The costs in terms of connection are below the all-electric retrofits (Expertise Centrum Warmte, 2020a).

Energy solutions in the heating system

Within the transition to using heat, the price is still linked to the gas price, this makes prices for heat still high. This is disadvantageous for people with people who struggle with affordability. An example of an energy solution, which has come up before, is the heat network. People in low-energy houses still pay a high price while being connected to the gas grid (Autoriteit Consument en Markt, 2022). Tenants also do not influence the connection to a heat network and depend on the distribution of end-user costs (Tigchelaar et al., 2022). People with a poor financial situation in some cases have no means to pay for the investment needed within the home for the heat grid. However, home retrofits are lower than the all-electric and hybrid options retrofits (Expertise Centrum Warmte, 2020b).

Energy solutions in the gas system

Finally, the use of renewable gas in the gas system. In terms of price, much is still unclear in this solution. However, the same will apply here that low efficiency in terms of energy value is disadvantageous. When using green gas, no/little investment is needed in the home (CE Delft, 2021), which is advantageous for people with low financial resources. Tenants again do not influence the use of green gas and depend on the distribution of the investment made (Energie-Nederland, 2020).

2.4.2.2. Energy poverty risk factors in the strategic governance role

The European Union is pushing for energy poverty in the Fit-for-55 report with a focus on a fair transition (European Commission, 2021). In the white paper by Straver et al. (2020), the approach and the different policy instruments to counter energy poverty in the Netherlands are examined. They observed that the National Government uses generic measures and bets on affordability and housing cost neutrality. Residential cost neutrality stands for the fact that the cost of the investment can be recovered through the benefits (van Berkel et al., 2021). This also applies to tenants of social housing, as agreed in the Social Rental Agreement (Ministerie van Binnenlandse Zaken en Koninkrijkrelaties, 2022). As for tenants of private landlords, this is not yet clear. Housing cost neutrality and affordability are tried to be achieved with various subsidies:

- ISDE: Investment subsidy for sustainable energy, homeowners receive a subsidy if they take two or more insulation measures. This subsidy is about 30% of the cost.
- SEEH: Subsidy for sustainability, facilitates homeowners in the short term to make their homes more sustainable already.

In the study by Straver et al. (2020), they noticed that a long-term plan regarding energy poverty is missing. Measures are not specifically targeted at people experiencing energy poverty. Within research done by the 'Nationale Ombudsman', it emerged that the generic measures regarding the affordability of energy bills do not help people structurally but are only a temporary solution (van Zutphen, 2022).

When analysing the Climate Agreement (Rijksoverheid, 2019), the emerging instruments were linked to the risk factors within the problem of energy poverty.

Regarding the risk factor of housing quality in combination with the tenure status, the government is first betting in the Climate Agreement on an isolation standard that landlords must meet by 2050, or sooner if the neighbourhood is designated to go off the gas earlier. This instrument may protect tenants from high energy costs but does not specifically help against this form of energy poverty in terms of investment in the transition (Rijksoverheid, 2019).

Regarding social renting, the 'Startmotor' has been established. Here, housing corporations will cooperate with municipalities to connect social rent houses to heat networks (de Boer et al., 2020).

As for people who have little/no money for investment, a programme for small savings is set up, 'Warmtefonds.' The fund is partly aimed at giving financing options to people who currently find it difficult or impossible to get financing based on the lending standard (Rijksoverheid, 2019).

To complement this, the 'Programma Kleine Energiebesparende middelen' is highlighted whereby homeowners who live in a poorly insulated house do not have much investment space to support (Rijksoverheid, 2019).

2.4.2.3. Energy poverty in the tactical role

Straver et al. (2020) showed in their research that most energy poverty projects are taking place on a municipal scale, with often a positive outcome. This is consistent with research by Berkel et al. (2021), in which they argue that municipalities pay attention to energy poverty. The researchers argue that due to the significant role in the transition and having the general poverty policy as a task, the municipalities can tackle energy poverty.

2.4.3.4 Energy poverty in the operational role

The study by Straver et al. (2020) reveals that within the 'Proeftuinen', the PAW conducts research on various themes, including poverty. The knowledge they gather here is used to advise municipalities that are not part of the 'Proeftuinen'. Here, there is no specific theme focused on energy poverty but is related to general poverty.

They also advise on how municipalities can deal with the subsidies provided by the National Government and the 'Warmtefonds'. Some of them focus specifically on energy poverty (van Schie et

al., 2022). Within the *ECW*, research is done on the economic side of the transition by mapping end-user costs. These costs can be used when making choices regarding costs but are not specifically focused on energy poverty (Expertise Centrum Warmte, 2021a).

2.4.4.5. Energy poverty in the reflexive role

In monitoring, PBL looks at the elaboration of the 'Proeftuinen', for example, paying attention to the issues raised, such as affordability and burden sharing (van Schie et al., 2022).

3. Methodology

The literature review examined the interpretation of the transition towards a decarbonised housing stock in different governance roles using the multi-level model and transition management model. It emerged that at the regime level of the transition, municipalities play a tactical role. They have been given a leading role where using different energy solutions, the transition must be accomplished. In addition, the study revealed how these solutions relate to the issue of energy poverty.

The European Union requires energy poverty to be included in the transition policies. The literature study on energy poverty researched how the policies in the different governance roles reflected energy poverty. In research by Straver et al. (2020) positive projects in municipalities were observed.

The municipalities' transition policies are detailed in the 'Transitievisie Warmte'. To examine the approach to energy poverty in these policies, the documents can serve as input. However, municipalities draft these individually. It was therefore decided to perform a textual analysis of the *TVW* of the municipalities to be able to further interpret the energy transition approach and the energy poverty approach and answer the main research question.

3.1 Research method

By using textual analysis, multiple policy documents can be analysed as the texts are seen as data (Loughran & McDonald, 2015). This research method is more often used within research on policy, energy transition and energy poverty. Within energy transitions, an example is a report by Yu et al. (2020), which researched the differences between energy policies in different countries. The method has also been used often within studies regarding transitions from a multi-level perspective such as the study by Leipprand & Flachsland (2018).

Self-assembled dictionaries of research words will be used to investigate the number of occurrences of certain words in the *TVW* which will be discussed further in this chapter (Loughran & McDonald, 2015).

3.2. Document Selection

Out of the various actors in the energy transition, municipalities were chosen for this study for several reasons. First, because of the important directing and development tasks, they have been given in the transition.

It would also have been a possibility to analyse the *RSW* of the RES regions. However, the objective of the RSW is to coordinate the heat demand between the various municipalities and is therefore more of a technical nature. This does not properly show the trade-offs between the different energy solutions and actors for further interpretation of the energy transition. In terms of energy poverty, this also lacks a relationship between the energy regions and residents (Vereniging van Nederlandse Gemeenten, 2018b).

Another municipal document, the *WUP* documents, could also have been analysed. However, these reports are issued in the final stage within municipalities and are not yet ready for all districts. They lack the trade-offs between the energy solutions and consolidation between actors and are therefore one step too far in the process.

3.3. Municipality selection

This section will discuss how a sample of municipalities to analyse was taken. There are currently 345 municipalities in the Netherlands. By April 2022, over 300 municipalities had completed the *TVW* document, and all of them belong to an energy region (Programma Aardgasvrije Wijken, 2021b).

To make an accurate representation of the different municipalities, a classification by CBS was used. This classification divides the municipalities into eight categories which are defined in Table A.2, Appendix A, defined by the number of inhabitants. The last category contains municipalities with fewer than 5,000 inhabitants and the highest category the municipalities with more than 250,000 inhabitants (Centraal Bureau voor de Statistiek, 2022).

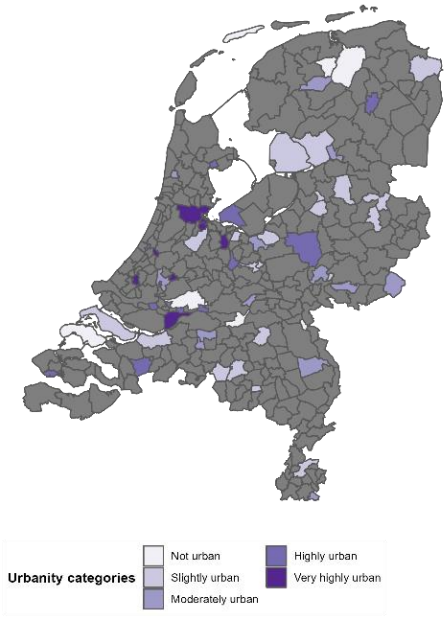

Figure 3.1 Urbanity levels of research municipalities
Adopted source: Centraal Bureau voor de Statistiek, (2021)

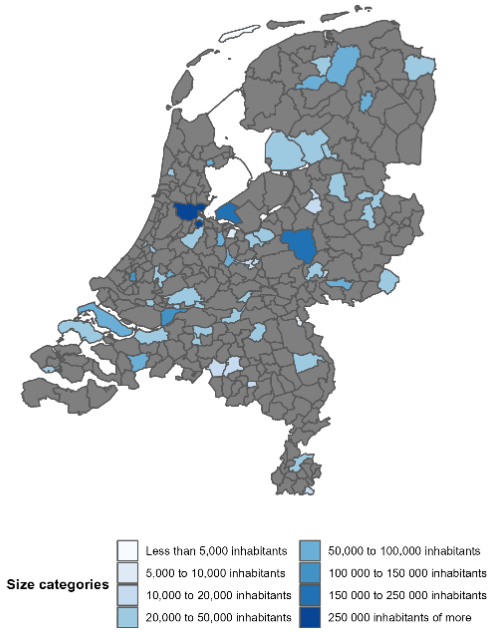

Figure 3.2 Size categories of research municipalities
Adopted source: Centraal Bureau voor de Statistiek, (2021)

This presents most municipalities having between 20,000 and 50,000 inhabitants. As already mentioned, every municipality is part of an energy region. From all the 30 regions two municipalities were chosen, to ultimately get a representative sample of the Netherlands. This approach is based on a study by Hoppe & Miedema (2020). A requirement for each municipality was whether the document was ready and downloadable. Table A.3 (Appendix A) shows the distribution in The Netherlands and the number of municipalities chosen from that category. This resulted in a list, shown in Table A.4 in appendix A, with two municipalities from each energy region and a classification that maintains the distribution of size categories in the Netherlands.

Data from CBS on urbanization is not used for selecting municipalities but will be used later in the analysis. Here, municipalities are classified into five categories by address density (Centraal Bureau voor de Statistiek, 2022). These categories are described in Table A.6, Appendix A.

3.3.1 Information on municipalities with 'Proeftuinen' and high levels of energy poverty

In the research group, ten municipalities participate in the PAW with a district. These are the municipalities of Achtkarspelen, Almere, Amsterdam, Apeldoorn, Assen, Doesburg, Hilversum, Noordoostpolder, Sliedrecht, Vlissingen and Westerkwartier (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2022).

As indicated earlier in their research, TNO saw a group of municipalities that were far above the average rate of energy poverty. For each indicator, they compiled a list of the top 20. Five of the 60 municipalities in this study can be found in these lists. These are the municipalities of Achtkarspelen, Oldambt, Smallingerland, Twenterand and Vaals (Mulder et al., 2021).

3.4. Data collection and preparation

3.4.1. TVW texts

After the list of 60 municipalities was constructed, the municipal documents were downloaded from the municipality websites.

The next step was to load the textual data into RStudio where the documents would be analysed. After loading the raw data, it was cleaned in multiple steps. These steps included:

- Removing whitespaces,
- Changing all letters to lowercase,
- Removing numbers,
- Removing stop words, for this, the package *stopwords* was downloaded which contains a Dutch stop word list,
- Finally, removing punctuality.

After these steps, the texts were tokenized. This was done at both word level and bigram level to be able to test on occurrences of two words. This left two datasets, which were merged into one to be able to analyse them.

3.4.2. Additional data on municipalities

After the dataset was ready for analysis, CBS data on the municipalities as described in Section 5.2, was added to the dataset (Centraal Bureau voor de Statistiek, 2021). This was done using the *CBSdataR* package. First, the entire dataset on the Netherlands was loaded after which filtering was done on the municipalities included in this analysis. Both the urban and size information on the municipalities were added.

To display the data on a map of the Netherlands, the municipal and provincial boundaries based on CBS classifications were loaded into RStudio. These boundaries were obtained from PDOK, a platform of Geodatasets (Centraal Bureau voor de Statistiek & Publieke Dienstverlening Op de Kaart, 2022). The geometric information was linked to the prepared lists of the study municipalities.

3.5. Subquestions and hypotheses

The textual analysis helps answer sub-questions 1,4 and 5. This section will explain for each sub-question what information already exists from the literature review and which are answered within the textual analysis. Based on this, sub-hypotheses were defined.

Sub-question 1

How can the transition towards a decarbonised housing stock be described from the transition management model and which actors fulfil the roles in this classification?

This sub-question has already been partly answered in the literature review. In the analysis, the actors are linked to the distinct roles in the transition management model. This analysis will be extended using textual analysis.

The literature review identified key actors in the transition arena set up by the government within the strategic role. The textual analysis will examine whether these actors also emerge as the most important in the *TVW*. The sub-hypothesis therefore reads:

Hypothesis 1.1: Of the actors mentioned in the TVW's, the most referred actors are housing associations, residents, and municipalities themselves.

The literature review revealed that energy solutions are advantageous in certain places. It was found that one category of solutions has a higher potential than another. It can be examined whether this is reflected within the document. The two hypotheses therefore read:

Hypothesis 1.2: Of the energy solutions mentioned in the TVW'S heat networks and isolation are mentioned the most and renewable gasses are mentioned the least frequently.

Hypothesis 1.3: Heat networks are more frequently mentioned in more urban areas.

Sub-question 4

To what extent are energy poverty and energy poverty risks reflected in municipalities' policies and does this follow the current state of energy poverty in the Netherlands?

The chosen energy solutions within municipalities have a lot of influence on the energy transition. From the research of Mulder et al. (2021), it emerged that municipalities are showing positive signs in terms of energy poverty projects. Concepts associated with this are energy justice and an equal transition. To answer the question, the occurrence of the concept of energy poverty and its related themes will be observed. The hypothesis is:

Hypothesis 4.1: Energy poverty and related themes have been mentioned at least once in every TVW.

The research sample found five municipalities with above-average energy poverty, based on the research of Mulder et al. (2021). It is therefore expected that within the documents of these municipalities, energy poverty is also represented above average. The hypothesis is:

Hypothesis 4.2: The issue of energy poverty is mentioned above average in the municipalities where this problem exists above average.

Subsequently, the risk factors within the themes of energy poverty will be discussed. The themes include energy affordability, housing quality and keeping up with the transition. This also assumes that where the risk factors pose a greater risk, more attention arises in these areas. Here, for the risk factor of tenure status, the housing associations and landlords are also considered since they are especially important for decarbonising these houses.

The hypotheses are:

Hypothesis 4.3: The risk factors have been mentioned at least once in every TVW.

Hypothesis 4.4: The risk factors are mentioned more often in the North and (South) East of the Netherlands plus Zeeland, except for the tenure status risk factor.

Hypothesis 4.5: The risk factors of energy affordability, housing quality and tenure status are mentioned more in less urban areas.

Hypothesis 4.6 The actors in the rental market are mentioned more in less urban areas.

Some of the municipalities have a neighbourhood that participates in the 'Proeftuinen' by the PAW. It is expected that within the municipalities participating, there will be more attention to energy poverty and the risk factors of energy poverty within the transition. The hypothesis becomes:

Hypothesis 4.7: Within the municipalities participating in the 'Proeftuinen', the risk factors are mentioned more.

Sub-question 5

To what extent is the approach from the other governance roles regarding energy poverty reflected in municipalities' policies?

In the literature review, policy instruments that can be used by municipalities to tackle energy poverty emerged. Municipalities are expected to take advantage of this. The policy instruments are in Section 2.4.2.2. linked to the risk factors. This classification was also used in the textual research, examining the generic instruments such as subsidies for all households. Also, the instruments focus on tenure status risk factors and the financial barrier risk factor. The hypothesis reads:

Hypothesis 5.1: Policy instruments from the strategic, operational, and reflexive roles are mentioned in the TVW.

The 'Proeftuinen' municipalities are advised on how to deploy the instruments to combat energy poverty. Therefore, it is expected that in these municipalities the instruments will be addressed above average.

Hypothesis 5.2: *Within the municipalities participating in the 'Proeftuinen', the policy instruments are mentioned above average.*

It is also expected that municipalities with high energy poverty will use the instruments above average.

Hypothesis 5.3 The policy instruments are mentioned above average municipalities where the problem of energy poverty exists above average.

3.5.1. Lists for analysis

To research the hypotheses discussed in the previous chapter, lists of words were compiled and stored in dictionaries (Appendix D). These lists are based on the literature review and can be either single words or two words, in bigram form. Within the topics, separate decisions were made about adding the words which are described below. In each case, the number of words per category was considered to paint an unambiguous and balanced picture.

3.5.1.1. Dictionary list 1: actors

Section 2.2.1.4 highlighted several actors that are important within the regimes. The groups highlighted therein have been adopted. It was decided not to add names of companies because these companies are often locally linked to municipalities, and this could therefore influence the results. A bigram combination was used here to denote the National Government.

3.5.1.2. Dictionary list 2: energy solutions

To visualise choices within the transition, five types of energy solutions were examined which are based on Section 4.1. Several words can indicate the different solutions, such as energy gain or energy efficiency in insulation. It was decided not to add these words to give as balanced a picture as possible of the different energy solutions.

3.5.1.3. Dictionary list 3: energy poverty

The terms energy poverty, energy justice and equivalent transition are taken from Section 2.3.4. Many combinations can be thought of to denote an equivalent transition. Here, a combination of different descriptions was made to still test this phenomenon in the texts.

3.5.1.4. Dictionary list 4: risk factors

The risk factors are taken from the study of Mulder et al. (2021), outlined in Section 2.3.4. The neutral form of the risk factors was chosen, such as the energy label and not the 'bad energy label'. This is because, while analysing the texts, it emerged that many combinations are possible, and it could lead to non-unambiguous results.

3.5.1.5. Dictionary list 5: policy instruments

The list of policy instruments is based on Chapter 2.4.2.2. These have been categorised into the risk factors they are linked to in this chapter.

3.5.2 Document and group size

The hypotheses are compared at the municipal level in certain hypotheses, for instance in hypothesis 4.7. However, the document size of the municipalities differs which may influence the results. Therefore, there is always divided by the number of words in the total text to reflect the proportion of the mentions in the total text. An exception to this is the hypothesis which looks at whether a municipality mentions the topic at least once.

Secondly, municipalities can be considered at an aggregate level, these groups are provinces, urbanity categories, 'Proeftuinen' or high-energy poverty. Here, the first step always took into consideration the total text size when calculating the total per group divided by the group size.

4. Results and analysis

Based on the different sub-questions and hypotheses, the results of the textual analysis will be presented which are categorised under the topics of governance of the transition, energy poverty and its risk factors and the policy instruments. Finally, the main findings will be summarised to conclude.

4.1. Governance of the transition

Sub-question 1: How can the transition towards a decarbonised housing stock be described from the transition management model and which actors fulfil the roles in this classification?

Hypothesis 1.1: Of the actors mentioned in the TVW's, the most referred actors are housing associations, residents, and municipalities themselves.

Figure B.1 (Appendix B) shows the distribution of the four actor groups as emerging in the TVW's, based on total mentions. Within the texts, the largest group are the governments and the two smallest groups the energy market and the rental market. Figure B.2 (Appendix B) shows the distribution among the individual actors within the groups based on total mentions. Indeed, in the residents and governments group, total mentions of residents and municipalities account for 87.1% of the total number of mentions in this group. With 90% of the total number of mentions in the housing market group, housing associations are the most frequently mentioned. The grid operators within the energy market make up 73.8% of the total number of mentions. This is not surprising because of the significant role they have been given in adapting the various energy systems, explained in Appendix C.

Hypothesis 1.2: Of the energy solutions mentioned in the TVW'S heat networks and isolation are mentioned the most and renewable gasses are mentioned the least frequently.

Figure B.3 (Appendix B) reveals the distribution of total mentions by energy solution, based on total mentions. Heat grids and insulation are the most mentioned solutions, and the smallest mentioned category is the hybrid options. This goes against the expectation. However, the differences between renewable gases and hybrid solutions are minor.

Hypothesis 1.3: Heat networks are most frequently mentioned in more urban areas

In Figure B.4 (Appendix B) the distribution of mentioned energy solutions among the urbanity categories is shown. Heat networks are the most frequently mentioned in most urban areas. In Appendix B Figures B.5 until B.9, the energy solutions are shown across the provinces in the Netherlands with the count of mentions per province calculated. Here it can be seen that heat networks are mentioned more in the Randstad and the other energy solutions are mentioned more scattered throughout the Netherlands. The distribution of energy solutions thus follows the expectation.

4.2. Energy poverty and risk factors

Sub-question 4: To what extent are energy poverty and energy poverty risks reflected in municipalities' policies and does this follow the current state of energy poverty in the Netherlands?

Hypothesis 4.1: Energy poverty and related themes have been mentioned at least once in every TVW.

The TWV's were examined by municipality for the occurrence of the various themes. The results of this analysis are presented in Table 4.1. The table reveals that in less than half of the municipalities, the theme of energy poverty is mentioned at least once and the themes of energy justice and an equal transition even less. So, this goes against the above hypothesis.

Table 4.1 *Information on energy poverty mentions by the municipality*

Theme	**Sum municipalities one or more mentions (n)**	**Percentage of total municipalities (%)**	**Total mentions**
Energy poverty	28	47%	123
Energy justice	1	2%	7
Just Transition	4	7%	5

Hypothesis 4.2: The issue of energy poverty is mentioned above average in the municipalities where this problem exists above average.

To examine the distribution of energy poverty mentions, Figure 4.1 shows the percentage of municipalities referring to energy poverty within provinces in the Netherlands. When looking nationally at a high share of energy poverty in certain areas, these are the provinces in the North, (South-) East of the Netherlands plus Zeeland. This results In a list of research provinces which includes Flevoland, Friesland, Groningen, Drenthe, Overijssel, Limburg and Zeeland. This classification is based on the study by Mulder et al. (2021).

Figure 4.1 reveals the provinces Zeeland and Limburg to follow the expected distribution with a high level of municipalities that mention energy poverty. However, the province of Groningen, where there is a lot of energy poverty, shows a low number of municipalities mentioning energy poverty. This shows a mixed picture concerning the distribution of mentions over the Netherlands.

To gain more insight, Figure B.10 (Appendix B) highlights the five municipalities that have above-average levels of energy poverty in the municipality and their share of energy poverty mentioned in the total text. The above-average energy poverty municipalities are based on research from Mulder et al. (2021) and include Achtkarspelen, Oldambt, Smallingerland, Twenterand and Vaals. The Figure reveals that two of the municipalities do not mention energy poverty, while the other three municipalities count above-average mentions. So, like Figure 4.1, this indicates a mixed picture.

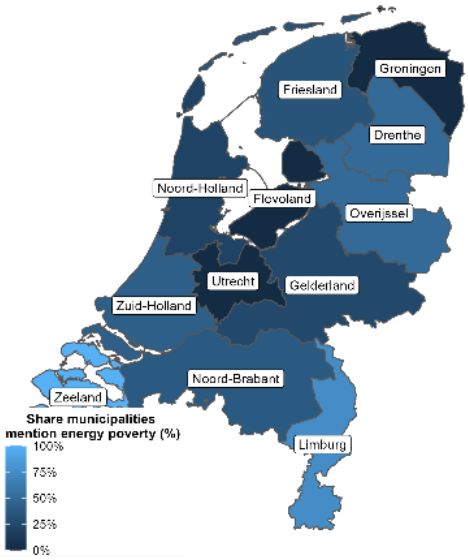

Figure 4.1 Percentage of municipalities with one or more mention within provinces in the Netherlands

Hypothesis 4.3: The risk factors have been mentioned at least once in every TVW.

The texts were analysed by the municipality on the mentions of the risk factors, the results are presented in Table A.7 (Appendix A). The content reveals that the risk factors related to energy affordability and housing quality are mentioned in 90% of the municipalities. This percentage is less for the risk factors related to an equal transition with the financial investment barrier only highlighted in 17% of the municipalities. So, the risk factors are not mentioned in every municipality.

Hypothesis 4.4: The risk factors are more common in the North and (South-) East of The Netherlands and Zeeland, apart from the risk factor of tenure status.

To analyse this, Figures 4.2 to 4.4 show the maps with the mentions of the energy affordability, housing quality and financial investment barrier risk factors by the provinces in the Netherlands. Categories have been created based on the proportion of the risk factor mentioned in the province as a share of the total text.

Figure 4.2 shows the distribution of the energy affordability risk factor. It reveals of the research provinces (the provinces with a higher share of residents with energy poverty), the municipalities in Friesland, Groningen and Limburg mention this risk factor relatively often and the least mentions occur in municipalities in the Randstad, apart from the research province Zeeland.

For the housing quality risk factor, presented in Figure 4.3, the results reveal a less clear outcome and of the research provinces, the risk factor is only mentioned a lot in Friesland.

The risk factor regarding the financial investment barrier, shown in Figure 4.4, is only mentioned a lot in the research provinces Limburg and Drenthe, which follow the expectation. However, the lowest category does seem to be centred in the Northern provinces.

The risk factor of tenure status is more widespread across the Netherlands and thus does not belong to the risk factor located specifically in the North and (South-) East + Zeeland. The results for this risk factor are shown in Figure B.11 (Appendix B) where the count of mentions is particularly low in the Northern provinces.

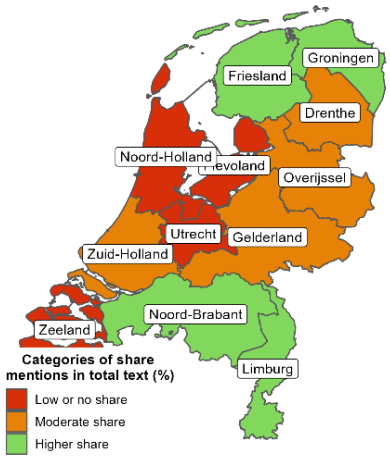

Figure 4.2 The share of energy affordability mentions in total text by province in the Netherlands

Figure 4.3 *The share of housing quality mentions in total text by province in the Netherlands*

Figure 4.4 The share of financial investment barrier mentions in total text by province in the Netherlands

Hypothesis 4.5: The risk factors of energy affordability, housing quality and tenure status are mentioned more in less urban areas.

Hypothesis 4.6 The actors in the rental market are mentioned more in less urban areas.

In Figure 4.5 the distribution of mentions of the risk factors across the urbanity categories is presented. First, it is notable that housing quality is not mentioned in non-urban areas. The results of the tenure status and energy affordability risk factors also reveal an unexpected distribution with fewer mentions in less urban areas. However, this distribution is less clear than the housing quality risk factor.

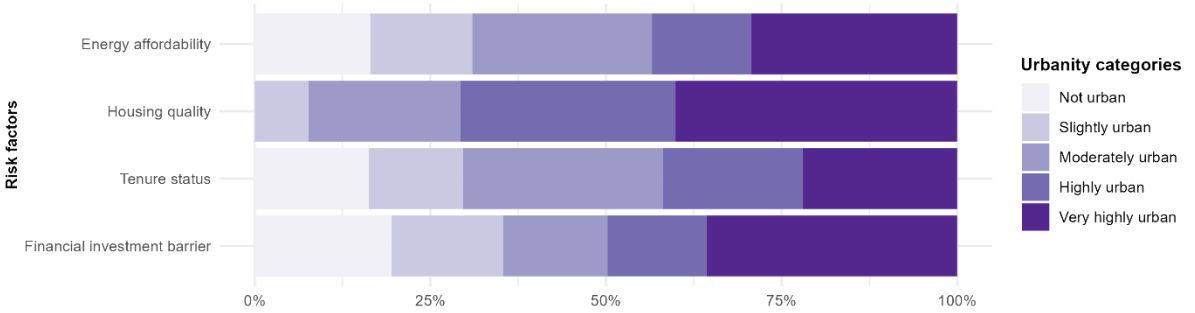

Figure 4.5 The distribution of risk factor mentions in the texts across urbanity categories

To further interpret the tenure status by urbanity, Figure 4.6 shows the distribution of actor mentions across the urbanity categories. Here, private landlords are mentioned little in the least urban areas and housing corporations and show a more spread distribution.

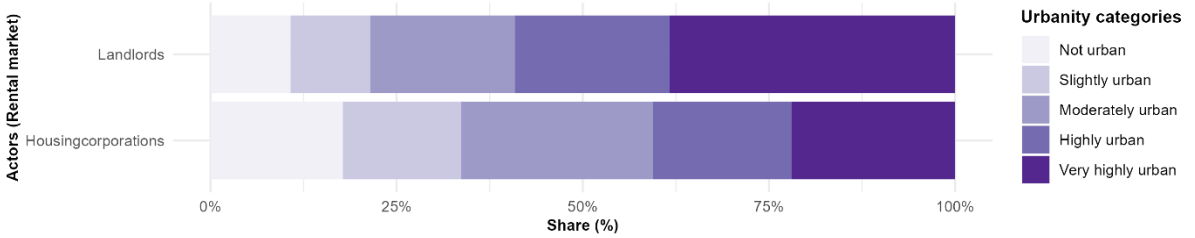

Figure 4.6 The distribution of rental market actors mentions in the texts across urbanity categories

Hypothesis 4.7: Within the municipalities participating in the 'Proeftuinen', the risk factors are mentioned more.

To analyse these municipalities, in Figures B.12 and B.13 (Appendix B), the count of mentions of the 'Proeftuinen' municipalities are highlighted. It is expected that in these municipalities the focus on the themes of energy poverty and associated risk factors is higher than average. Figure B.12 reveals that four municipalities do not mention energy poverty and only 1 out of 11 scores above average.

Figure B.13 shows the mentions of the risk factors as a share of the total text of the 'Proeftuinen' municipalities. Here it can be seen that except for a few municipalities, they do not score above average and in some cases do not mention the risk factors. Both figures thus go against expectations.

4.3. Policy instruments energy poverty

Sub-question 5: To what extent is the approach from the other governance roles regarding energy poverty reflected in municipalities' policies?

Hypothesis 5.1: The policy instruments are mentioned in the TVW.

To research the mentions of the policy instruments, Table A.8 (Appendix A) reveals the number of municipalities that mention the instruments at least once for each overarching theme. The table reveals that for all categories, a minority of municipalities do mention the instruments.

The high share of the financial barrier instrument is notable. This is more than the number of municipalities that put forward the risk factor of having a financial barrier.

Hypothesis 5.2: *Within the municipalities participating in the 'Proeftuinen', the policy instruments are mentioned above average.*

Figure B.14 (Appendix B) shows the share of the total number of mentions of each instrument in the texts of the 'Proeftuinen' municipalities. In a particular case, the policy instruments are mentioned above average, and a substantial proportion of the instruments do not appear at all in the 'Proeftuinen' municipalities. However, the high share of municipalities with one or more financial barrier instruments mentioned is notable. 6 of the 11 municipalities refer to it, which is already a large share of the total number of municipalities with one or more mention.

Hypothesis 5.3 The policy instruments are mentioned above average municipalities where the problem of energy poverty exists above average.

To examine this hypothesis, Figure B.15 (Appendix B) reveals the outcomes of the policy instruments mentioned in the municipalities that have a high share of energy poverty in the municipalities. Here it becomes clear that also in these municipalities the share of the financial barrier instruments is the highest. However, it cannot be assumed that when the problem is the biggest the number of mentions is also above average.

4.4. Textual analysis conclusion

The Fit-for-55 report set a fair, competitive, and green transition as a condition for member states with a specific focus on energy poverty (European Commission, 2021). The findings related to sub-question 1 are in line with expectations regarding the key designated actors and energy solutions, both in terms of distribution across the Netherlands and distribution among energy solutions. It thus shows that the parties and practical solutions needed for a green transition are present in the policy.

The issues of a fair transition and energy poverty are less prominent in the policy documents. Regarding the distribution across the Netherlands, it has been seen that it cannot be said that where the problem of energy poverty occurs more the issue is also addressed in the TVW of the municipalities.

Within the risk factors associated with overall poverty and energy justice, namely energy affordability and housing quality, the analysis showed that the factors are both considered by the municipalities. The results of energy affordability showed that it follows the expected distribution, this could be due to the awareness of the risks related to energy prices and incomes. The municipality already has the task of addressing general poverty. Housing quality is often cited in the documents but not more in the places where this risk is higher.

Within the risk factors associated with a Just and fair Transition, varying results have been observed. Regarding the tenure status, municipalities seem aware of this risk. However, there appeared to be little focus on private landlords in the areas where the risks of its negative impact on households are high. Regarding the financial investment barrier, municipalities have little awareness and do not follow the distribution of more focus where the risk is high.

The analysis of the policy instruments revealed that these are not a central part of the documents, nor are they mentioned more in the municipalities participating in the 'Proeftuinen', apart from the policy instruments that help those with few financial resources for investment.

5. Concluding remarks

5.1. Main conclusion

To what extent has energy poverty been taken into account by the governance of the transition to a decarbonised housing stock in the Netherlands?

To answer the main question, research was conducted into the content of the transition to a decarbonised housing stock. This transition is part of the overall energy transition in the Netherlands which can be labelled as a (socio-technical) sustainability transition. Energy poverty was linked to the change from the existing energy system through the terms energy justice and just transition.

The Fit-for-55 report prioritises a fair, competitive, and green transition. Member states are expected to report on energy poverty and include this issue in their policies towards a new energy system (European Commission, 2021). To examine these policies, two models for analysing the energy transition were applied: The multi-level perspective and the transition management model.

This analysis revealed that the National Government takes a strategic role in the energy transition. Namely, the establishment of a long-term goal: a decarbonised housing stock by 2050. However, a long-term goal regarding energy poverty is lacking, and the focus is on generic interventions. Only a

few measures that target the risk factors of energy poverty specifically can be found in the Climate Agreement.

In terms of green transition, a clear plan at the national and municipal level has emerged; in terms of energy poverty and a fair transition, a lower focus appeared.

Municipalities have a vital role to fulfil in the transition, and their choices have a major impact on those at risk of energy poverty. These choices are set out in the *TVW*. After analysing this document, it was found that within this policy layer, energy poverty and the instruments provided by the National Government are not a prerequisite part of the policy and nor are these included in the decisions made.

Another finding was that municipalities consider energy justice risk factors more than the risk factors of an equal and fair transition. One explanation could be that the risk factors related to energy justice are better recognised. This can also be noticed in the fact that energy poverty is the Dutch word of the year due to higher energy prices.

The people experiencing an unequal transition cannot make their houses sustainable themselves, for example, people experiencing a financial barrier or tenants of private landlords. In research by Mulder et al (2021), it was found that there are certain areas in the Netherlands with a substantial risk of forms of energy poverty. This research found that there is not more attention to this problem in these areas. This may cause this group to grow when prices keep rising, which has a negative impact on the transition outcomes and increases inequalities in society

Within the decarbonisation of the housing stock, pilots are primarily completed by the PAW, set up by the government and composed of different actors. They do not highlight energy poverty as a separate issue, but it is subsumed under overall poverty. The analysis revealed that municipalities do not have a greater focus on energy poverty. However, the PAW does seem to focus on the tools that counter the financial investment barrier.

5.2. Limitations

Within the research, several constraints must be considered. First, concerning the textual analysis. Within this research method, the count of mentions of certain words was examined. However, it was challenging to estimate whether the correct words are present in the dictionaries and whether they are complete. The research assumes that a higher number of mentions means a greater focus on the topic and did not examine the context in which a word appears.

The second limitation is regarding the size of the research group. The research included 60 municipalities in the Netherlands. However, analysing all municipalities 345 could provide a different result. This is in line with the provincial scale used within the analysis. Not all municipalities within a

province were analysed. Within the study, it emerged that the differences between areas can be significant, which means that the research sample may not represent the whole country.

Regarding the data on actual values of energy poverty and related risk factors, the information was based on the geographical location within the Netherlands and the municipalities in the top 20 energy poverty municipalities. By using the actual value per municipality to compare with the count of mentions, a different outcome could emerge in the analysis. Regarding the analysis of approaches to energy poverty within other roles, an attempt was made to outline the approach as best as possible. However, there is a chance that municipalities address energy poverty in other policies, or other governments use different documents explaining energy poverty policies.

5.3. Further research and policy implications

This provides a good starting point for discussion and further research. Regarding the set-up of this research, the documents could be compared with the actual data on energy poverty to create a more balanced picture of the level of energy poverty and the count of mentions. In addition, the 'Wijkuitvoeringsplannen' could be analysed and compared with the actual data on energy poverty in the neighbourhoods. This would make it possible to see whether municipalities at the district level, where differences are often large, are addressing energy poverty sufficiently. Also, in 2026, the update of the TVW could be examined to see the progress in terms of focus on energy poverty. Because of rising energy prices, a significant change may be seen within municipalities when the updated version is analysed.

A different research method such as interviews with employees of the various municipalities could provide insight into the cause behind energy poverty in certain places in the Netherlands and what they lack as tools to counter this. This could also include research into the division made concerning the transition management model. Interviews could be used to research this classification and the division of tasks. According to Loorbach et al. (2008), there is a danger of regimes using their own long-term goal in the policy. Interviews could explore this further and see what the consequences of this are.

There are several policy implications within this research.

The conditions from the European Union regarding a green transition were reflected in policy documents at both national and municipal levels. However, the component of energy poverty and a fair transition appeared to have been left behind. One idea could be for the National Government, like the European Union did with the Fit-for-55 report, to write a follow-up to the Climate Agreement with a clear focus on energy poverty (European Commission, 2021). This could require municipalities to include the issue of energy poverty in all aspects of affordability, housing quality and not keeping up with the energy transition in the next TVW. Because of the current high energy costs the situation is

changed and the focus on energy poverty increased. This was reflected in the Introduction where energy poverty was declared the Dutch word of the year (Onze Taal, 2022). By helping the residents who are unable to make their homes sustainable structurally instead of temporarily, more steps can be taken towards the outcomes of the transition and social differences will not increase in the future.

There should be room to make the approach more specific within municipalities because of the significant differences seen between municipalities in terms of energy poverty. The government could put in a framework with a checklist that municipalities should comply with. Components of the checklist can include:

- Municipalities should be aware of the actual state of the different risk factors in the municipality,
- Municipalities should have a plan on how the different target groups will be reached in terms of tools provided by the government and what options are available in terms of energy solutions,
- Municipalities need to have the living situation of residents clear so that it can be seen which residents cannot decide for themselves.

Here, the PAW must assist municipalities. Just as they do with the implementation of energy solutions. For this, a department within this organization is needed for handling questions regarding the checklist.

In terms of the implementation of the existing instruments, policy implications emerged in the research. The study revealed that the heat grid solution is currently deployed in the Randstad region, where the problem of energy poverty is less pronounced. For the roll-out of these heat networks, there are fewer negative consequences linked to people with energy poverty and there is a great policy tool, namely the 'Startmotor'. Within the areas of energy poverty, namely outside the Randstad, all-electric and hybrid solutions are more common. Within these solutions, on the contrary, many adverse effects have been seen for those with energy poverty. Here, a mismatch can be seen between the solutions and the state of energy poverty that could be better addressed. First, within the less urban areas, a greater focus on the private rental sector with new laws that counteract a rent increase because of the installation of all-electric or hybrid solutions, a law that already exists within social renting. Second, the ‘Proeftuinen’ could focus more on the financial barrier instruments such as the ‘Warmtefonds and ‘Kleine besparende middelen’, The analysis showed that in the municipalities participating in the ‘Proeftuinen’, these instruments are already mentioned above average.

References

Almeida, R., Pareira, R., & Mira da Silva, M. (2013). IT governance mechanisms: A literature review. *International Conference on Exploring Services Science*, 186–199.

Autoriteit Consument en Markt. (2022, March 30). *Uitkomsten analyse warmtetarieven en inkoopkosten energie van warmteleveranciers*. Autoriteit Consument En Markt. Retrieved September 14, 2022, from https://www.acm.nl/sites/default/files/documents/uitkomsten-analyse-warmtetarieven-en-inkoopkosten-energie-van-warmteleveranciers.pdf

Avelino, F., Grin, J., Pel, B., & Jhagroe, S. (2016). The politics of sustainability transitions. *Journal of Environmental Policy and Planning*, *18*(5), 557–567.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy*, *37*(3), 407–429. https://doi.org/10.1016/j.respol.2007.12.003

Boardman, B. (1991). Fuel Poverty: From Cold Homes to Affordable Warmth. *London: Belhaven Press*.

Bouzarovski, S., & Petrova, S. (2015). A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary. *Energy Research &Amp; Social Science*, *10*, 31–40. https://doi.org/10.1016/j.erss.2015.06.007

Bouzarovski, S., Thomson, H., & Cornelis, M. (2021). Confronting Energy Poverty in Europe: A Research and Policy Agenda. *Energies*, *14*(4), 858. https://doi.org/10.3390/en14040858

Bridge, G. (2015). Energy (in)security: world-making in an age of scarcity. *The Geographical Journal*, *181*(4), 328–339. https://doi.org/10.1111/geoj.12114

Bruyninckx, H. (2016, January 22). *Klimaatakkoord: naar een klimaatbestendige, koolstofarme wereld*. EEA. Retrieved April 16, 2022, from https://www.eea.europa.eu/nl/articles/klimaatakkoord-naar-een-klimaatbestendige-koolstofarme-wereld

Cairns, R. C. (2014). Climate geoengineering: issues of path-dependence and socio-technical lock-in. *Wiley Interdisciplinary Reviews: Climate Change*, *5*(5), 649–661. https://doi.org/10.1002/wcc.296

Carlson, B., Jacobsson, S., Homén, M., & Rickne, A. (2002). Innovation systems: analytical and methodological issues. *Research Policy*, *33*, 233–245.

Centraal Bureau voor de Statistiek. (2021). *Gebieden in Nederland 2021* [Dataset]. Centraal Bureau voor Statistiek. https://opendata.cbs.nl/#/CBS/nl/dataset/84929NED/table

Centraal Bureau voor de Statistiek. (2022, February 23). *Gemeentegrootte en stedelijkheid*. Centraal Bureau Voor De Statistiek. https://www.cbs.nl/nl-nl/onze-diensten/methoden/classificaties/overig/gemeentegrootte-en-stedelijkheid

Centraal Bureau voor de Statistiek & Publieke Dienstverlening Op de Kaart. (2022). https://service.pdok.nl/cbs/gebiedsindelingen/2022/wms/v1_0?request=GetCapabilities&service=WMS [Dataset]. In *CBS gebiedsindelingen*. https://service.pdok.nl/cbs/gebiedsindelingen/2022/wms/v1_0?request=GetCapabilities&service=WMS

de Boer, M., Schilling, J., van Berkel, P., & Dehens, J. (2020). Handreiking aansluiten warmtenet. In *Aedes, Vereniging Van Woningcorporaties*. Retrieved September 14, 2022, from https://dkvwg750av2j6.cloudfront.net/m/575e7df5960e5e25/original/Handreiking-Warmtenetten-maart-2020.pdf

De Leidraad. (n.d.). Expertise Centrum Warmte. https://www.expertisecentrumwarmte.nl/themas/de+leidraad/default.aspx

Deen, M., van Capellen, L., & Juijn, D. (2021). *Maatschappelijke Waarde Groengas* (21.210264.139). CE Delft. https://ce.nl/wp-content/uploads/2022/02/CE_Delft_210264_Maatschappelijke_waarde_groengas_DEF.pdf

Deloitte Netherlands. (2022, August 25). *What is decarbonisation?* Retrieved October 5, 2022, from https://www2.deloitte.com/nl/nl/pages/energy-resources-industrials/articles/what-is-decarbonisation.html

Dijkstra, H., Dinkelman, D., Hanegraaf, M., Veldkamp, H., & van Wees, J. D. (2020). *Duurzaamheid van Geothermie in Warmtenetten*. https://www.tno.nl/nl/duurzaam/duurzame-ondergrond/geo-energy-research/geothermie/

Dubois, U. (2012). From targeting to implementation: The role of identification of fuel poor households. *Energy Policy*, *49*, 107–115. https://doi.org/10.1016/j.enpol.2011.11.087

EASAC. (2021, June 2). *Decarbonisation of buildings: for climate, health and jobs*. EASAC - Science Advice for the Benefit of Europe. Retrieved September 24, 2022, from https://easac.eu/publications/details/decarbonisation-of-buildings-for-climate-health-and-jobs/

Eerenbeemt, M. V. D. (2021, September 23). *TNO waarschuwt voor energiearmoede: stijging gasprijs wordt probleem voor veel huishoudens*. De Volkskrant. Retrieved April 19, 2022, from https://www.volkskrant.nl/nieuws-achtergrond/tno-waarschuwt-voor-energiearmoede-stijging-gasprijs-wordt-probleem-voor-veel-huishoudens~b04f4fbb/

Elzen, B., Geels, F. W., & Green, K. (2004). *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*. Edward Elgar Publishing.

Energie in Nederland. (2021, June 29). *Wat zijn de belangrijkste rollen op de gasmarkt en op welke submarkten zijn zij actief*. https://www.energieinnederland.nl/zwe/wetten-en-markten/elektriciteitsmarkt/

Energie-Control. (2013). *Energy Poverty in Austria*. Energie-Control Austria. Vienna, Austria.

Energie-Nederland. (2020). Een Laagdrempelige Energietransitie. In *Stratelligence*. https://www.energie-nederland.nl/app/uploads/2020/04/Laagdrempelige-energietransitie-stratelligence-3-april-1.2-min.pdf

Ernst, L., de Graaf-Van Dinther, R., Peek, G., & Loorbach, D. (2016). Sustainable urban transformation and sustainability transitions; conceptual framework and case study. *Journal of Cleaner Production*, *112*, 2988–2999. https://doi.org/10.1016/j.jclepro.2015.10.136

European Commission. (2021). *"Fit for 55": het EU-klimaatstreefdoel voor 2030 bereiken op weg naar klimaatneutraliteit NL*. European Comission. https://ec.europa.eu/clima/citizens/support_en

Expertise Centrum Warmte. (2019). *Strategie 1: Individuele elektrische warmtepomp*. Retrieved September 12, 2022, from https://expertisecentrumwarmte.nl/themas/de+leidraad/strategiefactsheets/strategie+1+individuele+elektrische+warmtepomp/default.aspx

Expertise Centrum Warmte. (2020a, May 29). *Hybride warmtepomp*. https://www.expertisecentrumwarmte.nl/themas/technische+oplossingen/techniekfactsheets+gebouwmaatregelen/hybride+warmtepomp+nieuw/default.aspx

Expertise Centrum Warmte. (2020b, September). *Warmtenetten*. Retrieved September 14, 2022, from https://expertisecentrumwarmte.nl/themas/technische+oplossingen/techniekfactsheets+energiebronnen/warmtenetten/default.aspx#Betrokkenpartijen

Expertise Centrum Warmte. (2021a, June 1). Expertise Centrum Warmte. https://expertisecentrumwarmte.nl/eindgebruikerskosten/default.aspx

Expertise Centrum Warmte. (2021b, September). *Groengas*. https://www.expertisecentrumwarmte.nl/themas/technische+oplossingen/techniekfactsheets+energiebronnen/groengas/default.aspx

Feenstra, M., Middlemiss, L., Hesselman, M., Straver, K., & Tirado Herrero, S. (2021). Humanising the Energy Transition: Towards a National Policy on Energy Poverty in the Netherlands. *Frontiers in Sustainable Cities*, *3*. https://doi.org/10.3389/frsc.2021.645624

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274. https://doi.org/10.1016/s0048-7333(02)00062-8

Geels, F. W. (2019). Socio-technical transitions to sustainability: a review of criticisms and elaborations of the Multi-Level Perspective. *Current Opinion in Environmental Sustainability*, *39*, 187–201. https://doi.org/10.1016/j.cosust.2019.06.009

Gillard, R., Gouldson, A., Paavola, J., & Van Alstine, J. (2016). Transformational responses to climate change: beyond a systems perspective of social change in mitigation and adaptation. *WIREs Climate Change*, *7*(2), 251–265. https://doi.org/10.1002/wcc.384

Grubler, A. (2012). Energy transitions research: Insights and cautionary tales. *Energy Policy*, *50*, 8–16. https://doi.org/10.1016/j.enpol.2012.02.070

Hills, J. (2011). *Getting the measure of fuel poverty: Final Report of the Fuel Poverty Review*.

Hoppe, T., & Miedema, M. (2020). A Governance Approach to Regional Energy Transition: Meaning, Conceptualization and Practice. *Sustainability*, *12*(3), 915. https://doi.org/10.3390/su12030915

IEA. (2011). *World Energy Outlook 2011*. International Energy Agency, Paris.

Ikenberry, G. J., & Florini, A. (2003). The Coming Democracy: New Rules for Running a New World. *Foreign Affairs*, *82*(5), 169. https://doi.org/10.2307/20033695

Jacobson, C., Rip, A., Misa, T. J., & Schot, J. (1997). Managing Technology in Society: The Approach of Constructive Technology Assessment. *Technology and Culture*, *38*(3), 813. https://doi.org/10.2307/3106907

Jenkins, J., McCauley, D., Heffron, R., & Stephan, H. (2014). Energy Justice, a Whole Systems Approach KIRSTEN. *Queens Political Review*, 74–87.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. *Energy Research &Amp; Social Science*, *11*, 174–182. https://doi.org/10.1016/j.erss.2015.10.004

Jenkins, K., Sovacool, B. K., & McCauley, D. (2018). Humanizing sociotechnical transitions through energy justice: An ethical framework for global transformative change. *Energy Policy*, *117*, 66–74. https://doi.org/10.1016/j.enpol.2018.02.036

Kates, R., & Clark, W. C. (2001). Sustainability Science. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.257359

Kersbergen, K. V., & Waarden, F. V. (2004). "Governance" as a bridge between disciplines: Cross-disciplinary inspiration regarding shifts in governance and problems of governability, accountability and legitimacy. *European Journal of Political Research*, *43*(2), 143–171. https://doi.org/10.1111/j.1475-6765.2004.00149.x

Kirch, M., Den Dekker, L., & Duijff, R. (2020, May). *Warmtenetten ontrafeld*. TKI Urban Energy. Retrieved September 12, 2022, from https://www.topsectorenergie.nl/sites/default/files/uploads/Urban%20energy/publicaties/TKI_WarmtenettenOntrafeld.pdf

Klijn, E. H. (2008). Governance and Governance Networks in Europe. *Public Management Review*, *10*(4), 505–525. https://doi.org/10.1080/14719030802263954

Klitkou, A., Bolwig, S., Hansen, T., & Wessberg, N. (2015). The role of lock-in mechanisms in transition processes: The case of energy for road transport. *Environmental Innovation and Societal Transitions*, *16*, 22–37. https://doi.org/10.1016/j.eist.2015.07.005

Knobloch, F., Pollitt, H., Chewpreecha, U., Daioglou, V., & Mercure, J. F. (2018). Simulating the deep decarbonisation of residential heating for limiting global warming to 1.5 °C. *Energy Efficiency*, *12*(2), 521–550. https://doi.org/10.1007/s12053-018-9710-0

Langevin, J., Harris, C. B., Satre-Meloy, A., Chandra-Putra, H., Speake, A., Present, E., Adhikari, R., Wilson, E. J., & Satchwell, A. J. (2021). US building energy efficiency and flexibility as an electric grid resource. *Joule*, *5*(8), 2102–2128. https://doi.org/10.1016/j.joule.2021.06.002

Leipprand, A., & Flachsland, C. (2018). Regime destabilization in energy transitions: The German debate on the future of coal. *Energy Research &Amp; Social Science*, *40*, 190–204. https://doi.org/10.1016/j.erss.2018.02.004

Loorbach, D. (2010). Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance*, *23*(1), 161–183. https://doi.org/10.1111/j.1468-0491.2009.01471.x

Loorbach, D., Brugge, R. V. D., & Taanman, M. (2008). Governance in the energy transition: Practice of transition management in the Netherlands. *International Journal of Environmental Technology and Management*, *9*(2/3), 294. https://doi.org/10.1504/ijetm.2008.019039

Loorbach, D., & Rotmans, J. (2006). Managing Transitions for Sustainable Development. *Understanding Industrial Transformation*, 187–206.

Loughran, T., & McDonald, B. (2015). The Use of Word Lists in Textual Analysis. *Journal of Behavioral Finance*, *16*(1), 1–11. https://doi.org/10.1080/15427560.2015.1000335

Markard, J. (2018). The next phase of the energy transition and its implications for research and policy. *Nature Energy*, *3*(8), 628–633. https://doi.org/10.1038/s41560-018-0171-7

McCauley, D., Heffron, R., Stephan, H., & Jenkins, K. (2013). Advancing energy justice: the triumvirate of tenets. *Energy Law Review*, 107–110.

Middlemiss, L., & Gillard, R. (2015). Fuel poverty from the bottom-up: Characterising household energy vulnerability through the lived experience of the fuel poor. *Energy Research &Amp; Social Science*, *6*, 146–154. https://doi.org/10.1016/j.erss.2015.02.001

Ministerie van Binnenlandse Zaken en Koninkrijkrelaties. (2021). *Samen leren door te doen: Programmaplan 2021-2024 Programma Aardgasvrije Wijken*. https://open.overheid.nl/repository/ronl-274ddea4-c88f-4694-89b5-48b2a8d2a779/1/pdf/programmaplan-paw-2021-2024.pdf

Ministerie van Binnenlandse Zaken en Koninkrijkrelaties. (2022). Nationale prestatieafspraken woningcorporaties. In *Rijksoverheid*. Rijksoverheid. Retrieved September 14, 2022, from https://open.overheid.nl/repository/ronl-9b3877ddc82aaffa7ece0fa2ac7ce975a3f13154/1/pdf/kamerbrief-bij-nationale-prestatieafspraken-woningcorporaties.pdf

Ministerie van Algemene Zaken. (2022, February 25). *Kan ik zelf een energieleverancier kiezen bij blokverwarming of stadsverwarming?* Rijksoverheid.nl. Retrieved September 14, 2022, from https://www.rijksoverheid.nl/onderwerpen/energie-thuis/vraag-en-antwoord/kan-ik-een-energieleverancier-kiezen-bij-blokverwarming-of-

stadsverwarming#:%7E:text=Als%20u%20stadsverwarming%20of%20blokverwarming,consumenten%20tegen%20te%20hoge%20prijzen

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2022, October 7). *Deelnemende gemeenten aardgasvrije wijken*. Aardgasvrije Wijken | Rijksoverheid.nl. https://www.rijksoverheid.nl/onderwerpen/aardgasvrije-wijken/deelnemende-gemeenten-aardgasvrij-maken

Ministerie van Volkshuisvesting, Ruimtelijke ordening en Milieubeheer. (2001). *Nationaal milieubeleidsplan: een wereld en een wil*. Retrieved September 14, 2022, from https://www.rivm.nl/bibliotheek/digitaaldepot/VROM2001NMP4.pdf

Mulder, P., Longa, F. D., & Straver, K. (2021). *De feiten over energiearmoede in Nederland Inzicht op nationaal en lokaal niveau* (No. P11678). TNO. https://www.tno.nl/nl/newsroom/2021/09/tno-brengt-energiearmoede-gedetailleerd/

Nationaal Programma Regionale Energiestrategieën. (2021). *Nationaal Programma Regionale Energiestrategieën*. Retrieved September 16, 2022, from https://www.regionale-energiestrategie.nl/documenten/handlerdownloadfiles.ashx?idnv=1313654

Nelson, R., & Winter, S. (1993). In search of useful theory of innovation. *Research Policy*, *22*(2), 108. https://doi.org/10.1016/0048-7333(93)90053-k

Netbeheer Nederland. (2021). Transitievisie Warmte In samenwerking met de netbeheerder. In *Netbeheer Nederland*. Retrieved November 9, 2022, from https://www.netbeheernederland.nl/_contentediting/files/files/20210630%20-%20Transitievisiewarmte_%20In%20samenwerking%20met%20de%20netbeheerder.pdf

Oei, A., Akkermans, F., Kreulen, K., & Thijsen, M. (2021). De waarde van de hybride warmtepomp voor de warmtetransitie. In *Een Technisch-economische Verkenning Van Maatschappelijk Efficiënte Verduurzamingskeuzes*. Ecorys.

ONPE. (2014). *Rapport de synthèse. Définitions, indicateurs, premiers résultats et recommandations*. Observatoire National de la Précarité Energétique.

Onze Taal. (2022). *Woord van het jaar 2022*0. https://onzetaal.nl/schatkamer/lezen/woorden/woorden-van-het-jaar/woord-van-het-jaar-2022

Parkin, A., Herrera, M., & Coley, D. A. (2020). Net-zero buildings: when carbon and energy metrics diverge. *Buildings and Cities*, *1*(1), 86–99. https://doi.org/10.5334/bc.27

Planbureau voor de Leefomgeving. (2021). *NEDERLAND FIT FOR 55? Mogelijke gevolgen van het voorgestelde EU-klimaatbeleid*. https://www.pbl.nl/sites/default/files/downloads/pbl-2021-nederland-fit-for-55_4697.pdf

Porter, A. L., Ashton, W. B., Clar, G., & Coates, J. F. (2004). Technology futures analysis: Toward integration of the field and new methods. *Technological Forecasting and Social Change*, *71*(3), 287–303. https://doi.org/10.1016/j.techfore.2003.11.004

Porter, M. E., & Kramer, M. R. (2006). Strategy and society: the link between competitive advantage and corporate social responsibility. *Harvard Business Review*, *84*, 78–92. https://doi.org/10.1108/sd.2007.05623ead.006

Programma Aardgasvrije Wijken. (2021a). *Inhoudelijke kenmerken*. Retrieved November 21, 2022, from https://www.aardgasvrijewijken.nl/themas/regieenorganisatie/transitievisie+warmte2/wat+is+een+transitievisie+warmte/inhoudelijke+kenmerken/default.aspx

Programma Aardgasvrije Wijken. (2021b, April 21). *Transitievisies warmte halen afgesproken doel Klimaatakkoord*. https://aardgasvrijewijken.nl/themas/regieenorganisatie/nieuws+regie+en+organisatie/2204111.aspx

Pye, S., Dobbins, A., Baffert, C., Brajković, J., Deane, P., & De Miglio, R. (2016). Addressing Energy Poverty and Vulnerable Consumers in the Energy Sector Across the EU. *L'Europe En Formation*, *n° 378*(4), 64–89. https://doi.org/10.3917/eufor.378.0064

Rademaekers, K., Yearwood, J., Ferreira, A., Pye, S., Hamilton, I., Agnolucci, P., Grover, D., Karásek, J., & Anisimova, N. (2016). *Selecting Indicators to Measure Energy Poverty*. Trinomics.

Regionaal Energieloket. (2022, January 26). *Is verwarmen met waterstof of groen gas de toekomst?* Retrieved September 12, 2022, from https://kennisbank.regionaalenergieloket.nl/aardgasvrij/groen-gas-en-waterstof/

Rhodes, R. A. W. (1996). The New Governance: Governing without Government. *Political Studies*, *44*(4), 652–667. https://doi.org/10.1111/j.1467-9248.1996.tb01747.x

Rijksoverheid. (2019). Klimaatakkoord. In *Rijksoverheid*. Retrieved September 14, 2022, from https://www.klimaatakkoord.nl/

Røpke, I. (2016). Complementary system perspectives in ecological macroeconomics — The example of transition investments during the crisis. *Ecological Economics*, *121*, 237–245. https://doi.org/10.1016/j.ecolecon.2015.03.018

Rotmans, J., Kemp, R., & van Asselt, M. (2001). More evolution than revolution: transition management in public policy. *Foresight*, *3*(1), 15–31. https://doi.org/10.1108/14636680110803003

Rotmans, J., & Verheijden, M. (2021). *Omarm de chaos*. De Geus.

Schellekens, J., Oei, A., & Haffner, R. (2019). *De financiële gevolgen van de warmtetransitie Een onderzoek naar de investeringsuitdaging, effecten op energie betaalbaarheid en het potentieel van (nieuwe) financieringsvormen*. Ecorys, Rotterdam.

Siddiqi, S., Masud, T. I., Nishtar, S., Peters, D. H., Sabri, B., Bile, K. M., & Jama, M. A. (2009). Framework for assessing governance of the health system in developing countries: Gateway to good governance. *Health Policy*, *90*(1), 13–25. https://doi.org/10.1016/j.healthpol.2008.08.005

Sievers, L., Breitschopf, B., Pfaff, M., & Schaffer, A. (2019). Macroeconomic impact of the German energy transition and its distribution by sectors and regions. *Ecological Economics*, *160*, 191–204. https://doi.org/10.1016/j.ecolecon.2019.02.017

Smith, A., Stirling, A., & Berkhout, F. (2005). The governance of sustainable socio-technical transitions. *Research Policy*, *34*(10), 1491–1510. https://doi.org/10.1016/j.respol.2005.07.005

Solomon, B. D., & Krishna, K. (2011). The coming sustainable energy transition: History, strategies, and outlook. *Energy Policy*, *39*(11), 7422–7431. https://doi.org/10.1016/j.enpol.2011.09.009

Straver, K., Mulder, P., Hesselman, M., Tirado Herrero, S., Middlemiss, L., & Feenstra, M. (2020). Energy Poverty and the Energy Transition.: ENERGIEARMOEDE BETERMETEN, MONITOREN EN BESTRIJDEN. In [Whitepaper]. TNO. https://www.tno.nl/publish/pages/3746/tno-2020-energiearmoede.pdf

Tigchelaar, C., Rovers, V., Zwamborn, A., & Cox, E. (2022). Duiding van de eindgebruikerskosten voor het aardgasvrij maken van Nederlandse woningen. In *TNO*. Retrieved September 14, 2022, from https://energy.nl/wp-content/uploads/tno-2022-p12146-duiding-eindgebruikerskosten-3.pdf

UNFCCC. (2015). *The Paris Agreement*. United Nations Framework Convention on Climate Change.

van Berkel, P., Kruit, K., & Dehens, J. (2021). *Energiearmoede in de warmtetransitie: Onderzoek naar beleidsinstrumenten*. CE Delft. Retrieved September 14, 2022, from https://ce.nl/wp-content/uploads/2021/12/CE_Delft_200304_Energiearmoede_in_de_warmtetransitie_DEF.pdf

van Middelkoop, M., van Polen, S., Holtkamp, R., & Bonnerman, F. (2018). *Meten met twee maten: Een studie naar de betaalbaarheid van de energierekening van huishoudens*. Planbureau voor de Leefomgeving. https://www.pbl.nl/publicaties/betaalbaarheid-energierekening-in-breder-perspectief

van Schie, M., van der Kooij, P., Kunseler, E., Scholte, S., & van der Staak, M. (2022). *Tussen uitvoering en beleid in de warmtetransitie: Over de omgang met knelpunten in de gemeentelijke uitvoering van het Programma Aardgasvrije Wijken*. Planbureau voor de Leefomgeving. https://www.pbl.nl/sites/default/files/downloads/pbl-2022-tussen-uitvoering-en-beleid-in-de-warmtetransitie-4921.pdf

van Vlerken, J. (2021, April 20). *Rol provincies in warmtetransitie*. Stichting Warmtenetwerk. Retrieved September 12, 2022, from https://warmtenetwerk.nl/nieuws/item/rol-provincies-in-warmtetransitie/

van Zutphen, R. (2022). *Ongelijke toegang tot de energietransitie*. De Nationale Onbudsman. Retrieved January 4, 2023, from https://www.nationaleombudsman.nl/system/files/rapport/20220201%20Ongelijke%20toegang%20tot%20de%20energietransitie.pdf

Vattenfall. (2022). *Hoe zit het Nederlandse gasnetwerk in elkaar? | Vattenfall Grootzakelijk*. https://www.vattenfall.nl/grootzakelijk/energiemarkt/nederlandse-gasnetwerk/

Verbong, G., & Loorbach, D. (2017). *Governing the Energy Transition: Reality, Illusion Or Necessity?* Taylor & Francis.

Vereniging van Nederlandse Gemeenten. (2018a). *Factsheet Omgevingsvisie*. https://vng.nl/publicaties/factsheet-omgevingsvisie

Vereniging van Nederlandse Gemeenten. (2018b). *Handreiking Regionale Energie Strategieën*. https://vng.nl/files/vng/handreiking_res_versie_21-12-2018.pdf

Vereniging van Nederlandse Gemeenten. (2021). *Overzicht energietransitie in de gebouwde omgeving*. VNG. Retrieved September 14, 2022, from https://vng.nl/artikelen/overzicht-energietransitie-in-de-gebouwde-omgeving

Vergeer, R., de Bruyn, S., Rooijers, F., & Schep, E. (2019). *Opties voor een rechtvaardig klimaatbeleid*. CE Delft. https://ce.nl/publicaties/opties-voor-een-rechtvaardig-klimaatbeleid/

Walker, G., & Day, R. (2012). Fuel poverty as injustice: Integrating distribution, recognition and procedure in the struggle for affordable warmth. *Energy Policy*, *49*, 69–75. https://doi.org/10.1016/j.enpol.2012.01.044

Yu, L., Xue, B., Stückrad, S., Thomas, H., & Cai, G. (2020). Indicators for energy transition targets in China and Germany: A text analysis. *Ecological Indicators*, *111*, 106012. https://doi.org/10.1016/j.ecolind.2019.106012

Appendix A: Tables

Table A.1 *Summary of governance roles, contributors, documents, and the job.*

Adopted sources: Rijksoverheid, (2019), Vereniging van Nederlandse Gemeenten (2018a) & Vereniging van Nederlandse Gemeenten (2018)

Governance roles	Who?	Contributors	Document/tool	Job?
Strategic	National government	Min. BZK, Min. EZK, Min. IenW, Min LNV	Climate Agreement (Rijksoverheid, 2019)	Climate change mitigation targets, measures, and agreements.
Tactical	RES-region	Partnership of municipalities, provinces, water boards, civil society partners and the National Government	'Regionale Energiestrategie' (RES) 'Regionale Structuur Warmte' (RSW)	Understanding regional heat demand and available regional heat sources. Connecting energy demand in municipalities.
Tactical	Municipality	-	'Transitievisie warmte' (TVW)	The timeframe, scale, and objective of insulating and/or natural gas-free homes.
Tactical	Municipality	-	'Wijkuitvoeringsplannen' (WUP)	Concretisation of the transition vision heat and describes how the municipality wants to implement or direct the district-oriented approach in a specific neighbourhood or district. With a period and what measures are needed for this.
Operational	Nationaal programma Aardgasvrije wijken	Min. BZK, Min. EZK, IPO, Uni van Waterschappen, VNG	Provide living labs to experiment and set up a knowledge and learning programme.	Learn, signal, agenda and solve problems
Opartional	Expertise Centrum Warmte	Steering group: Min. BZK, Min. EZK, IPO, Uni van Waterschappen, VNG. Advice group: Netbeheer Nederland, Energie Nederland, de Nederlandse Vereniging Duurzame Energie, Techniek Nederland, Aedes, TNO, Expertgroep Energietransitierekenmodellen (EG ETRM), het Economisch Instituut voor de Bouw, Bouwend Nederland en Stichting Warmtenetwerk. Implementation has been assigned to the Rijksdienst voor Ondernemend Nederland (RVO)	The 'leidraad'	Provide municipalities technical, economic, legal and sustainability support.

Tabel A.2 *Size categories of municipalities*
Adopted source: Centraal Bureau voor de Statistiek (2022)

Code	Size categories
1	less than 5 000 inhabitants
2	5 000 to 10 000 inhabitants
3	10 000 to 20 000 inhabitants
4	20 000 to 50 000 inhabitants
5	50 000 to 100 000 inhabitants
6	100 000 to 150 000 inhabitants
7	150 000 to 250 000 inhabitants
8	250 000 inhabitants or more

Tabel A.3 *Research municipalities by size categories*
Adopted source: Centraal Bureau voor de Statistiek (2022)

Size Categories	Percentage	Number of municipalities
1	1%	1
2	2%	2
3	17%	10
4	53%	32
5	17%	10
6	4%	2
7	4%	1
8	1%	1
-	100%	60

Table A.4 *Research municipalities with corresponding energy regions*
Adopted source: Centraal Bureau voor de Statistiek (2021)

Municipalities	Category	Municipalities	Category	Energy regions
Doetinchem	5	Winterswijk	4	Achterhoek
Gorinchem	4	Molenlanden	4	Alblasserdam
Woudenberg	3	Eemnes	2	Amersfoort
Doesburg	3	Rheden	4	Arnhem/Nijmegen
Heerde	3	Apeldoorn	7	Cleantech
Dordrecht	6	Sliedrecht	4	Drechtsteden
Assen	5	Meppel	4	Drenthe
Almere	7	Noordoostpolder	4	Flevoland
Nijkerk	4	Scherpenzee;	3	Foodvalley
Terschelling	1	Smallingerland	5	Friesland
Achtkarspelen	4			Friesland
Maasdriel	4	Tiel	4	Fruitdelta Rivierenland
Goeree	5			Goeroe-Overflakkee
Westerkwartier	4	Oldambt	4	Groningen
Waalwijk	4	Hilvarenbeek	3	Hart van Brabant
Dongen	4			Hart van Brabant
Hoeksche	5			Hoeksche Waard
Leiderdorp	4	Oegstgeest	4	Holland Rijnland
Oirschot	3	Waalre	3	Metropoolregio Eindhoven
Zuidplas	4	Gouda	5	Midden-Holland
Mook en Middelaar	2	Venray	4	Noord-en Midden-Limburg

Hoorn	5	Heiloo	4	Noord-Holland Noord
Bernheze	4	Diemen	4	Noord-oost Brabant
Hilversum	5	Amsterdam	8	Noord-Holland Zuid
Putten	4	Hattem	3	Noord-Veluwe
Barendrecht	4	Delft	6	Rotterdam/Den Haag
Wierden	4	Twenterand	4	Twente
De Ronde Venen	4	Zeist	5	U15
Moerdijk	4	Roosendaal	5	West-Brabant
Steenwijkerland	4	Dalfsen	4	West-Overrijsel
Schouwen-Duiveland	4	Vlissingen	4	Zeeland
Beekdaelen	4	Vaals	3	Zuid-Limburg

Tabel A.6 *Urbanity categories of municipalities*
Adopted source: Centraal Bureau voor de Statistiek (2022)

Code	Urbanity categories	Adresses per km2
5	Not urban	Less than 500
4	Slightly urban	500 to 1 000
3	Moderately urban	1 000 to 1 500
2	Highly urban	1 500 to 2 500
1	Very highly urban	2 500 or more

Table A.7 *Information on risk factors mentions by municipality*

Risk factor	Sum municipalities one or more mentions (n)	Percentage of total municipalities (%)	Total mentions
Energy affordability	54	90%	363
Housing quality	54	90%	934
Tenure status	47	78%	230
Financial investment barrier	10	17%	19

Table A.8 *Information on policy instruments mentions by municipality*

Policy instruments	Sum municipalities one or more mentions (n)	Percentage of total municipalities (%)	Total mentions
Generic instruments	7	12%	22
Financial barrier instruments	16	27%	62
Rental instruments (social housing)	8	13%	42
Rental instruments (landlords)	7	12%	36

Appendix B: Figures

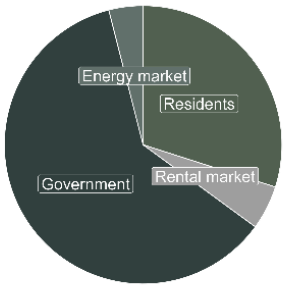

Figure B.1 Distribution of total actor group mentions in the texts across the actor groups

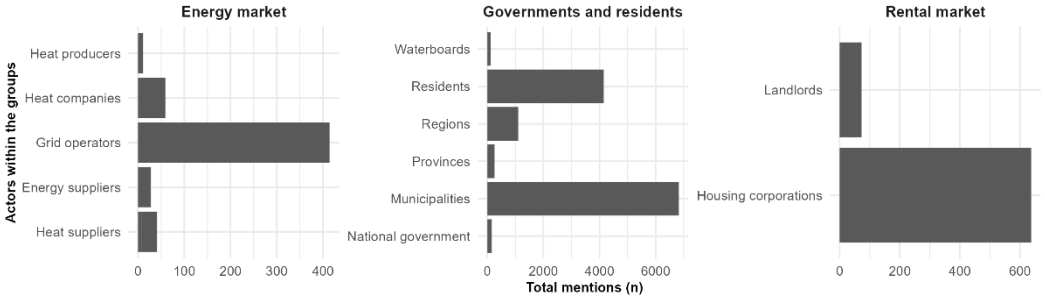

Figure B.2 Count of individual actor groups as mentioned in the texts

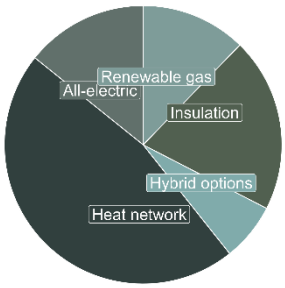

Figure B.3 Distribution of total actor group mentions in the texts across the actor

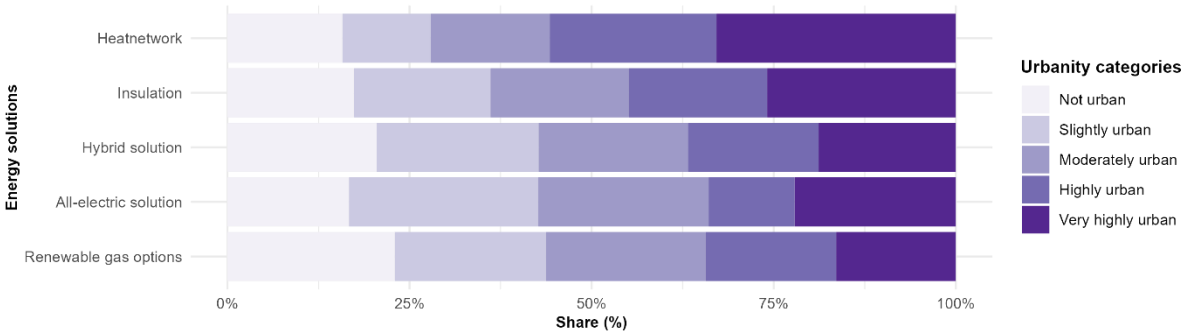

Figure B.4 The distribution of rental market actors mentions in the texts across urbanity categories

Figure B.5 The share of heat networks in total energy solution mentions by province in the Netherlands

Figure B.6 The share of insulation in total energy solution mentions by province in the Netherlands

Figure B.7 The share of all-electric options in total energy solution mentions by province in the Netherlands

Figure B.8 The share of renewable gasses in total energy solution mentions by province in the Netherlands

Figure B.9 The share of hybrid options in total energy solution mentions by province in the Netherlands

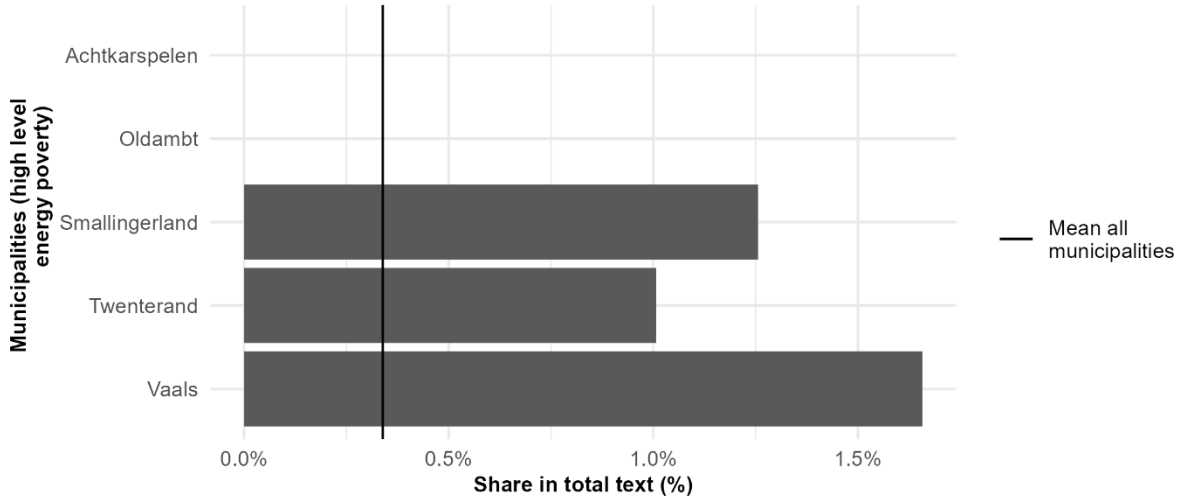

Figure B.10 The share of energy poverty mentions of total text in high-level energy poverty municipalities

Figure B.11 The share of tenure status mentions in total text by province in the Netherlands

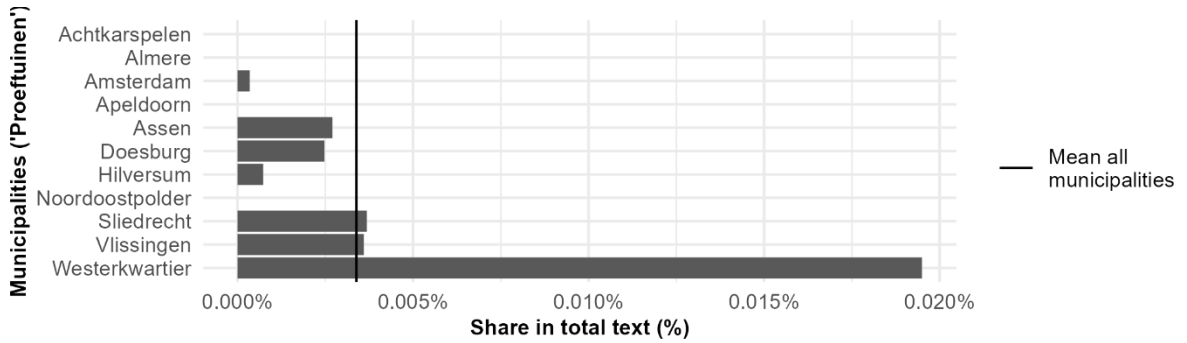

Figure B.12 The share of energy poverty mentions of total text in 'Proeftuinen' municipalities

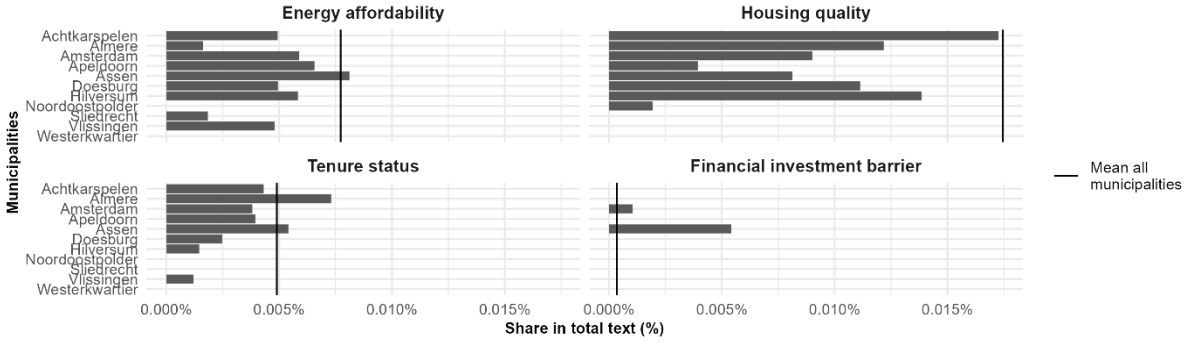

Figure B.13 The share of risk factor mentions of total text in 'Proeftuinen' municipalities

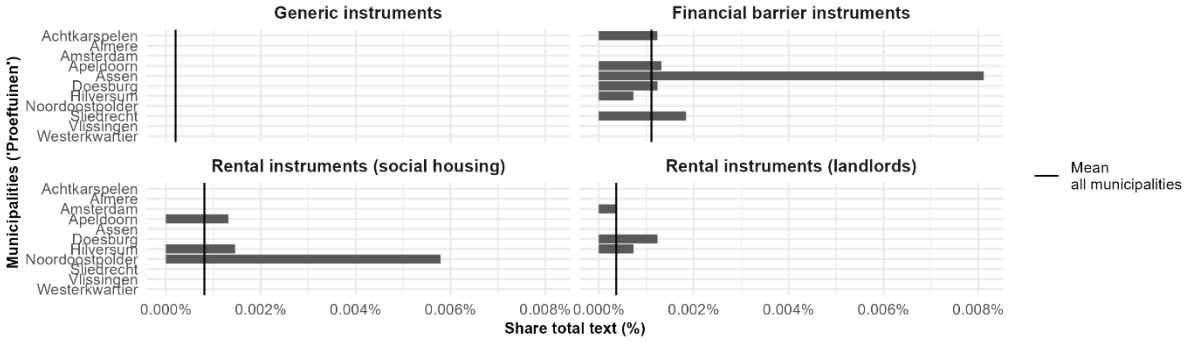

Figure B.14 The share of policy instruments mentions of total text in 'Proeftuinen' municipalities

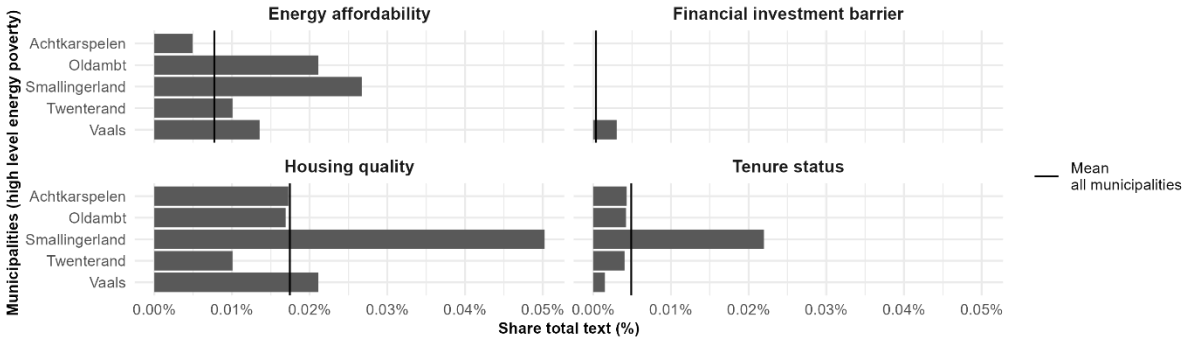

Figure B.15 The share of policy instruments mentions of total text in high-level energy poverty municipalities

Appendix C: Energy markets

Within the overall energy supply three systems are central. Namelijk het elektriciteitssysteem, het gas systeem en het warmte systeem.

In the Netherlands, the electricity market and the gas market are currently mainly active. Here, the producer generates the electricity and gas, the energy supplier buys it from the producer and residents can choose their energy contract (Vattenfall, 2022). The grid operator ensures that the energy can be used and is responsible for managing the infrastructure. The rules and laws regarding the gas market are laid down in the Gas Act (Energie in Nederland, 2021).

Because of the development of heat pumps and all-electric solutions, more electricity demand will arise, which will require the grid to be made heavier and will lead to discussions about the price. De netbeheerder is verantwoordelijk voor het aanpassen van zowel het elektriciteitsnet als het gasnet. The institutional framework of electricity is currently laid down in the Electricity Act. Prices in terms of electricity are now exceptionally low (Energie in Nederland, 2021).

Figure C.1 Set-up of the electricity and gas systems
Adopted source: Energie in Nederland, 2021

Third, a new market is emerging, the heat market, driven by heat networks. In the new heat market, there are the heat producers who supply the heat, and the heat suppliers who sometimes also take on the production, transport, and distribution. These are then also called heat companies. These are new tasks (Kirch, 2020).

The new infrastructure will have to be built. Heat is a more decentralised product as it loses heat over a longer distance. New heat laws will have to be made regarding the price, which is now linked to the gas price, and roles regarding the number of providers. This is because now residents have no choice between heat companies (Ministerie van Algemene Zaken, 2022).

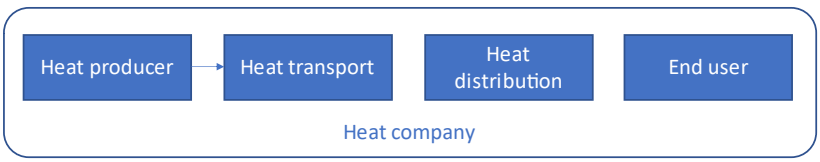

Figure C.2 Set-up of the heat system
Adopted source: Kirch, 2020

Appendix D: Dictionaries

Dictionary list 1: actors

Theme	Category	Words
Residents	Residents	inwoners
Residents	Residents	bewoners
Housingmarket	Housing corporation	woningcorporatie
Housingmarket	Landlord	verhuurder
Governments	Municipality	gemeente
Governments	National government	rijksoverheid
Governments	Provinces	provincia
Governments	Provinces	provincie
Governments	Region	regio
Governments	Waterboards	waterschap
Energy infrastructure	Heatproducer	warmteproducent
Energy infrastructure	Heat company	warmtebedrijv
Energy infrastructure	Heat company	warmtebedrijf
Energy infrastructure	Heat supplier	warmteleverancier
Energy infrastructure	Heat supplier	warmteaanbieder
Energy infrastructure	Energy producer	energieproducent
Energy infrastructure	Energy supplier	energieleverancier
Energy infrastructure	Grid operator	netbeheerder

Theme	Category	Bigram words
actors	Governments	nationale overheid

Dictionary list 2: energy solutions

Theme	Category	Words
Transition path	Insulation	isolatie
Transition path	Heat network	bronnet
Transition path	Heat network	warmtenet
Transition path	All-electric	all electric
Transition path	All-electric	allelectric
Transition path	Green gas and hydrogen	hernieuwbaar
Transition path	Green gas and hydrogen	groengas
Transition path	Green gas and hydrogen	waterstof

Theme	Category	Bigram words
Transition path	All-electric	elektrische warmtepomp
Transition path	Hybride	hybride oplossing
Transition path	Hybride	hybride warmtepomp
Transition path	All-electric	all electric

Dictionary list 3: energy poverty

Theme	Category	Words
Energy poverty	Energiearmoede	energiearmoede
Energy poverty	energierechtvaardigheid	energierechtvaardigheid

Bigram words

Theme	Category	Bigram words
Energy poverty	energiearmoede	energie armoede
Energy poverty	gelijkwaardige transitie	gelijkwaardige transitie
Energy poverty	gelijkwaardige transitie	gelijkwaardige warmtetransitie
Energy poverty	gelijkwaardige transitie	gelijkwaardige energietransitie
Energy poverty	gelijkwaardige transitie	inclusieve transitie
Energy poverty	gelijkwaardige transitie	inclusieve energietransitie
Energy poverty	gelijkwaardige transitie	inclusieve warmtetransitie
Energy poverty	gelijkwaardige transitie	rechtvaardige energietransitie
Energy poverty	gelijkwaardige transitie	rechtvaardige warmtetransitie
Energy poverty	gelijkwaardige transitie	rechtvaardige transitie
Energy poverty	gelijkwaardige transitie	draagkrachtige transitie

Dictionary list 4: risk factors

Add by hand: verhuurder|huurdersvereniging|verhuurdersheffing

Theme	Category	Words
riskfactors	Betaalbaarheid	energiequote
riskfactors	Betaalbaarheid	energieratio
riskfactors	Betaalbaarheid	inkomen
riskfactors	Betaalbaarheid	energierekening
riskfactors	Betaalbaarheid	energiekosten
riskfactors	Betaalbaarheid	energielasten
riskfactors	Huiskwaliteit	isolatieniveau
riskfactors	Huiskwaliteit	energielabel
riskfactors	Huiskwaliteit	energieprestatie
riskfactors	Huur	huurder
riskfactors	financieel	investeringsruimte
riskfactors	financieel	leenruimte
riskfactors	financieel	investeringsmogelijkheden

Bigram words:

Theme	Category	Words
riskfactors	Huur	sociale huurwoning

Dictionary list 5: policy instruments

Theme	Category	Words
measurements	rentalsocial	startmotor
measurements	rentallandlord	isolatiestandaard
measurements	financial	warmtefonds
measurements	financial	energiebespaarhypotheek

Bigram words:

Theme	Category	Bigram words
measurements	generic	investeringssubsidie Duurzame
measurements	generic	subsidie energiebesparing
measurements	rentalandlord	standaard isolatie

measurements	financial	kleine energiebesparende