Towards a future without natural gas for housing corporations

A study about the challenges and potential solutions for housing corporations in their role as “frontrunners” in the Dutch energy transition

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Abstract

The energy transition towards a low carbon future in the climate-change combat is one that does not go unnoticed in the Netherlands. The national government committed in the Paris Climate Agreement to making the country entirely free of natural gas by 2050, and has developed policy accordingly. Housing corporations are an important actor in the energy transition, given that they, apart from their societal commitment, can implement renewable energy renovations on potentially large scale. There is, however, still an action gap between what climate scientists see as necessary for achieving such a transition and what is actually happening on the ground. The goals set by housing corporations to improve energy efficiency by 2021 and become energy neutral by 2050 are hard to achieve at the current pace of action. The implementation of renewable energy technologies is limited, there is a major focus on social economic barriers, and the benefits resulting from energy renovations in buildings are underestimated. This study has investigated the current view of five housing corporations in three Dutch neighbourhoods on the energy transition, by means of narrative inquiries. The results have been analysed using a sectoral system innovation approach, and provide insight into housing corporations' visions on housing availability and affordability versus sustainability, the short-term and long-term practical and financial challenges, and the array of opportunities on the road to a low carbon future. Evaluation has shown that major systemic changes in the sector are required. At the same time, the challenges encountered by the housing corporations also incorporate directions for solutions for advancing the energy transition in more than 2,5 million social homes.

Preface

The journey I made for writing my thesis felt short but intense, with both ups and downs. With a specific interest in future oriented research, I enthusiastically started to explore the possibilities of doing research on a low carbon future. The decision to explore the Dutch energy transition towards a future without natural gas, and specifically the role of housing corporations in this, was not a difficult one, as this topic appears regularly in the news. What was challenging was to match the results of this exploratory research to existing theories. The way I experienced this journey can therefore be compared to what one of the respondents said about the energy transition "it is not a sprint, it is a marathon". Meaning that writing a thesis takes effort, with progresses and setbacks along the way, which will eventually help you achieving your end goal.

This end goal was twofold to me. First, my aim was to hand in a decent master thesis, which could contribute to understanding the current energy transition – a transition inevitably affecting all of us. Second, I hoped to discover some aspects with practical value, to improve actions regarding the energy transition.

Although the results of this thesis are not yet known while writing this preface, I do know that the help and efforts made by a few people have been very supportive. Peter Pelzer, my supervisor from Utrecht University, has helped me with constructive feedback to bring more depth to the research, and to critically evaluate how to use the research results. The Urban Insight team ('Uitjes'): Fieke van Leest, Lisette van der Kolk and Maarten Grotholt from Sweco - my internship company - who gave me freedom in working things out my own way, but always supported me to be more precise about the theories behind the research topic. Last but not least, my father, who always and ever has a critical but very substantiated view on energy related issues, and has been there for me through thick and thin, not only with this thesis but also throughout my whole educational career.

With their help, I was able to overcome the challenges on the road, which is in line with the main message of this research!

Enjoy reading,

Rolien De Jong

Amsterdam, 25 June

Extended summary[1]

Dutch housing corporations are confronted with a major challenge in the energy transition, imposed on them as part of the Dutch government policy of making the country entirely free of natural gas by 2050, as a follow-up to the 2015 Paris Climate Agreement: phasing out natural gas in their housing stock of approximately 2.5 million homes by 2050 to combat climate change. Housing corporations offer unique opportunity to contribute to climate actions, however, there is still a major focus on the challenges rather than on solutions. This research has used the method of narrative inquiries among housing corporations to understand what specific challenges they encounter in the energy transition in the Dutch housing sector, and how these challenges may be effectively addressed. Following Faber & Hoppe (2013), the results have been analysed using the four main building blocks of innovations in sectoral systems: agents and networks, institutional framing, technological regime and market demand. The following insights have been gained.

Focus on no-regret options

The future without natural gas is highly uncertain to corporations, due to the current state of the technological regime and institutional framing. The *technological regime* poses a challenge for corporations as the available energy efficiency and renewable energy measures are expensive, unreliable - because the *market demand* is not fully developed - and not generally applicable. There is no 'one-fits-all' alternative energy technology available on the market yet. Corporations face difficulties in financing such measures, as there is only a limited amount of money and loan available to finance new projects ánd apply energy measures in existing districts, without affecting affordability and availability of houses. Regarding *institutional framing*, affordability and availability are according to the New Housing Act key tasks of corporations and cannot go at the expensive of the energy transition. Corporations therefore apply no-regret measures to prepare for a future without natural gas, hoping that the future will offer sustainable energy technologies with better financial return. A no-regret action is cost-effective in the present, e.g. insulation, but will also be beneficial under a range of future scenarios.

Use renovations as a starting point

The *institutional framing* poses a challenge to corporations in that regulations set by the national government are somewhat contradictory: corporations are required to pay additional taxes, such as corporation tax, tenants' levy, higher tax on natural gas, ánd make major investments in the energy transition, ánd securing affordability and availability of social housing. Even when there is budget available for the transition, investments are often seen as a split incentive, which means that investments will benefit the tenant but will result in an investment loss for corporations, as the investment cannot be covered by increased rents. However, all social homes are renovated every 25 years. Although the primary focus of renovations is on quality improvement, they are also excellent moments for implementing energy measures. Investing in energy renovations at "natural moments" is hence advantageous because budgets are available. In addition, energy renovations generate affordable, qualitative and sustainable homes, a better social image for corporations, and increased

[1] Refer to Appendix 1 for a Dutch summary.
[2] Note worthily, Faber & Hoppe (2013) use the term barrier in their research, which has a slightly negative connation, i.e. a solution is hard to find. This research prefers the term challenge, which has a more positive connation, i.e. a

net worth on paper. Renovations can thus be effective starting points for both energy targets ánd securing the core priorities of corporations.

Show the benefits of the transition to convince tenants

Regarding *agents and networks*, tenants pose a challenge to corporations. Corporations are restricted to start (energy) renovations without permission of 70% of the tenants involved. Convincing tenants of the need for a renovation can be a daunting task when it is framed in terms of energy/sustainability. Sustainability matters are often not a priority to tenants. They worry about increasing rents. It is therefore highly important for corporations to inform their tenants in a persuasive yet correct manner. For example by showing the potential for a reduced energy bill, or the improved quality and aesthetics of successful energy renovations. On top of that, it is important to indicate clearly what energy renovations actually imply, such as improved comfort, appropriate housing and increased liveability in the neighbourhood.

Sync renovation schedules

The *institutional framing* poses a challenge to corporations in that the energy targets, which have been set at the national level, have not yet been converted to regulations on the level of the municipalities, i.e. the level at which corporations operate. Energy renovations, especially when gas is to be phased is, often require major activities in (the underground infrastructures of) the built environment. There is a maze of infrastructures in the underground, involving many agents other than corporations, e.g. municipalities, grid operators, sewerage companies, project developers. These agents are interdependent, and are awaiting clear guidance from the municipality on how to deal with energy changes. The regulatory framework on a municipal level needs to be adjusted and address the new roles and responsibilities of agents clearly. The current situation leads to inactivity and concerns. Important in the new situation would be to juxtapose “natural moments” for renovations of different stakeholders, and align them. Knowledge can be shared; cost- and time-efficiencies can be achieved. Such coalitions can contribute to broad social development, leading to improvements in, among others, liveability, mobility, and housing.

In summary, although systematic changes in the housing sector are required, the challenges encountered by the housing corporations also incorporate directions for solutions for advancing energy-transition efforts in the 2,5 million social homes.

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List of abbreviations and figures

List of abbreviations

UN	United Nations
NOM	Nul Op de Meter (zero on the meter)
WKO	Warmte Koude Opslag (heat/cold storage)
CO_2	Carbon Dioxide
EPBD	Energy Performance in Buildings Directive
EPV	Energy Performance Refurbishment
RES	Regionale Energie Strategie (Regional Energy Strategy)
CORA	Coördinatenstelsel Werken Aan de Weg (renovating public spaces)
EU	European Union
PJ	Peta Joules

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The scientific case for climate change has been made, and solutions for reducing emissions are now readily available. However, there is a significant action gap between what the scientific evidence shows must be done to prevent the worst impacts of climate change, and what we are currently doing.

Bushell et al (2016, p.1)

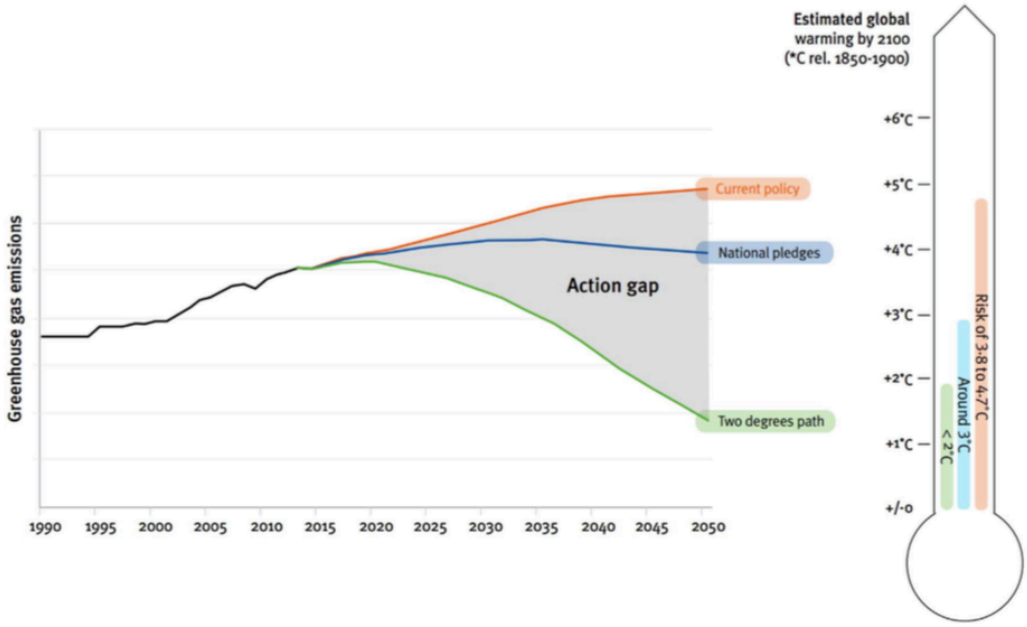


Figure 1. Visual representation of the action gap (Bushell et al, 2016).

Chapter 1. Introduction: housing corporations in the energy transition

1.1 Problem statement and scientific embedding

The 21st UN Conference (Paris, Dec. 2015) resulted in a political agreement to limit greenhouse gas emissions and combat global warming in the future (Hajer & Pelzer, 2018). The Dutch national government committed to this agreement and expressed the ambition for a transition from fossil fuels to renewable energy – known as the energy transition (Rijksoverheid, 2018). Fossil fuels release carbon emissions (CO_2) when being burned and contribute to global warming. There is little certainty on how a future without fossil fuels looks like, yet there is certainty that natural gas will not be part of this future: the Netherlands should be entirely free of natural gas by 2050. Phasing out natural gas, specifically in the housing sector, is currently hot topic (NOS, 2018). The housing sector offers huge potential to reduce CO_2 emissions, as most buildings are currently connected to non-renewable energy such as natural gas (Ferreira & Almeida, 2015). In fact, the Dutch housing sector is locked-into natural gas for the supply of heat and electricity (Miedema et al, 2018). Approximately 7 out of 7.7 million dwellings are connected to the gas network. Eric Wiebes, former Minister for Economic Affairs, introduced a Heat Vision to ensure gas reduction in the housing sector through various measures (Rijksoverheid, 2018). All newly constructed buildings shall be gas-free; existing neighbourhoods have to switch to alternatives through a gradual transition of 30,000 to 50,000 homes per year until 2022. After 2022 it will be accelerated to 200,000 homes a year. Housing corporations are appointed to take the lead (Klimaatakkoord, 2018).

Out all stakeholders that are involved in the energy transition, housing corporations are at the core of this research. Housing corporations have a mission of general interest in providing affordable housing for a public of low-income tenants (Braga & Palvarini, 2013). Faber & Hoppe (2013) identified all stakeholders involved in energy innovations within the housing sector, and labelled housing corporations as primary agents. Besides, Dutch politics have designated housing corporations as frontrunners that could and should boost the energy transition in the housing sector (Klimaatakkoord, 2018). Housing corporations are expected to be a leading example in the energy transition (Filippidou et al, 2017). They provide a unique opportunity to progress the transition: they own approximately 2.5 million homes, which add up to 30% of the total housing market (Ministerie van BZK, 2018). The Netherlands has the highest percentage of social housing in Europe. Because of this magnitude, they generally execute large-scale renovation and new housing projects (McManus et al, 2010). They can reduce financial costs to tenants when investing in energy targets within such projects (Mei & Rowley, 2011). However, the goals set by housing corporations to improve energy efficiency by 2021 and become energy neutral by 2050 will be hard to achieve if the current pace of action is to be continued (Filippidou et al, 2017). The implementation of sustainable energy technologies is low (IEA, 2010); there is a major focus on social economic barriers within the energy transition and the benefits resulting from energy renovations in buildings are underestimated (Ferreira & Almeida, 2015). Besides this, there is currently no instrument to force housing corporations to phase out natural gas in their housing stock; it is based on voluntariness (Klimaatakkoord, 2018). An analysis of how corporations experience and could advance their role in the energy transition seems relevant.

There is much scientific debate on how to understand transitions (Malerba, 2002; Geels & Schot, 2007; Geels, 2010), the roles of agents in transitions (Smith et al, 2005; Geels, 2010; Hermwille, 2016), and how to advance transitions (Zhao et al, 2016; Faber & Hoppe, 2013). Among many other points of discussion, there is much criticism stating that theoretical approaches on transitions are too broad and vague to apply for empirical research, e.g. multi-level perspective (Berkhout et al, 2004; Geels, 2011); there is uncertainty regarding the influence of various agents in steering transitions (Smith et al, 2005; Geels, 2010); and there is no consensus on how to identify technological or societal barriers that hamper transitions (Unruh, 2002). This research does not aim to clarify this debate, find common ground and contribute to a unifying theory. It rather elaborates on an approach that has been proven useful in the context of the energy transition in the Dutch housing sector: a sectoral system innovation approach (Faber & Hoppe, 2013).

Faber & Hoppe (2013) used a *sectoral system innovation (SSI)* approach to analyse the main building blocks of the energy transition in the Dutch housing sector and to identify the barriers and mismatches that hamper implementation of energy innovations within the sector as a whole. They redefined four building blocks: agents and networks, institutional framing, technological regime and market demand. The question that remained unaddressed in their study is how these barriers may be effectively addressed to advance the energy transition. A deeper understanding and a more coherent overview of the barriers ánd potential solutions, specifically for housing corporations that are seen as the driving force behind the energy transition in the housing sector, lacks. In this research, a SSI approach *sensu* Faber & Hoppe (2013) will be used to analyse the experiences of housing corporations regarding the challenges[2] and potential solutions in the energy transition.

A growing body of scholarship demonstrates that *futures research and methods* have the potential to find ways on dealing with future system changes (Miller et al, 2015). Futures research and methods can, generally speaking, gain insights into future (un)certainties and by that help organizations to think of alternative ways forward. Narratives are seen as particularly useful in dealing with future energy changes. Narratives are meaningful stories to understand what is happening around us (Leach et al, 2010). They can be used as an approach or as a method. A narrative approach is a way to guide individuals or groups in formulating stories about the challenges they confront [1], the potential ways of addressing those challenges [2] and what these imply for the community as a whole [3] (Paschen & Ison, 2014). Narratives as a method, known as narrative inquiry, can be used to understand how changes in our environment are being experienced, as they provide an avenue for people to explain what is important to them and why it matters (Soutar & Mitchell, 2018; Miller et al, 2015). In this research, the focus is on narrative inquiries to research how housing corporations experience the energy transition. The components of a narrative approach *sensu* Paschen & Ison (2014) are used to guide the narrative inquiries, to make explicit the challenges and potential solutions that housing corporations see for themselves in the transition.

Until this far, little research has been done on how narrative inquiries can be used to understand the Dutch energy transition, and how the outputs can be linked to the different blocks of SSI to find out what specific challenges housing corporations encounter, but more importantly, what options are seen as relevant to progress in terms of the energy transition in 2.5 million social homes.

[2] Note worthily, Faber & Hoppe (2013) use the term barrier in their research, which has a slightly negative connation, i.e. a solution is hard to find. This research prefers the term challenge, which has a more positive connation, i.e. a problem is going to be resolved.

1.2 Research objective and questions

This research examines the experiences of housing corporations in the energy transition in the Dutch housing sector, to identify the challenges and possible ways of addressing these challenges, by means of the concept SSI and the method narrative inquiries. Housing corporations that are already progressing in terms of natural gas-free ambitions are examined, as they are the ones that can provide insight into what the energy transition for housing corporations entails in practice. A selection of corporations has been made which are currently active with energy renovations in three Dutch urban neighbourhoods: Van der Pek (Amsterdam), Palenstein (Zoetermeer) and Benedenbuurt (Wageningen). The following research questions will serve as a guide:

How can a sectoral system innovation approach provide insight into challenges, and contribute to the search for solutions, for housing corporations in the current energy transition in the Dutch housing sector?

I. How can a sectoral system innovation approach provide insight into challenges, and to the search for solutions, in the energy transition in the Dutch housing sector?
II. What does the energy transition in the Dutch housing sector involve?
III. How can the role of housing corporations in the energy transition in the Dutch housing sector be understood?
IV. What are the challenges for housing corporations in the energy transition in the Dutch housing sector?
V. What steps are and can be taken to advance the energy transition in the social housing stock?

1.3 Relevance of the research

Societal relevance

As our climate is changing due to great amounts of (greenhouse) gases being emitted into the atmosphere, having different - and mostly adverse - impacts in different parts of the world, there is broad consensus that it is becoming important, if not required, to take action (Bushell et al, 2017, Allen et al, 2018). Numerous climate agreements and goals have been made, yet, they can only be effective if they are implemented, which is currently not the case. Housing corporations play an important role in closing the gap, especially when it comes to the energy transition in the Dutch housing sector (Klimaatakkoord, 2018). However, there is still a major focus on barriers (Ferreira & Almeida, 2015) and the pace of action is too slow (Filippidou et al, 2017). A better understanding of what currently hampers action and what seen as important for advancing the transition is required. It is of social relevance to understand how housing corporations, as they own 2,5 Dutch social homes and carry the responsibility to provide housing to a large public of low-income tenants, can become more engaged and willing to support the current energy transition.

Scientific relevance

Thinking of how the future might change and could look like is slippery terrain for social science (Hajer & Versteeg, 2018). Social scientists are used to understand the present based on what happened in the past. Beckert (2016), however, emphasized that it is no less important to realize that ideas on the future predict what happens in the present. A narrative inquiry is a method to understand how current changes in and future plans for our environment are being experienced, as

they provide an avenue for people to explain what is important to them and why it matters (Soutar & Mitchell, 2018; Miller et al, 2015). The contributions of narrative inquiries to identifying challenges and finding ways to move forward in the energy transition has, however, received little attention in academia. This is striking, narrative inquiries have been proposed as "perhaps the best window into how we think" and can contribute in finding ways to progress to a certain future (Hart, 2002, p. 142; Hewitson, 2014). This research therefore tries to get a grip on what the output of narrative inquiries tells about the specific building blocks of SSI, which can clarify where specific improvements are required or can be made to advance housing corporations' role as frontrunners.

1.4 Research outline

This research is build up as follows. In this chapter (1), the research problem, aim and questions regarding the crucial role of housing corporations in the energy transition have been lined out, in both a practical and scientific manner. Chapter 2 includes the theoretical basis on transitions and agents, which contributes to understanding the role of housing corporations, and the barriers they encounter, in the energy transition. This provides an answer to the first sub-question. Chapter 3 includes the methodological basis of this study, which elaborates on the qualitative nature of this research, and the usage of narrative inquiries. Chapter 4 and 5 seek to answer the second and third (descriptive) sub-questions, to clarify the context and the role of housing corporations in the energy transition. Chapter 6 and 7 evaluate the primary data to answer the last two (exploratory) sub-questions addressing the challenges and potential solutions for housing corporations. Chapter 8 includes a conclusion on the findings of the research. Chapter 9 critically reflects on the theory, methodology and results of the research. See figure 2 for a visual overview.

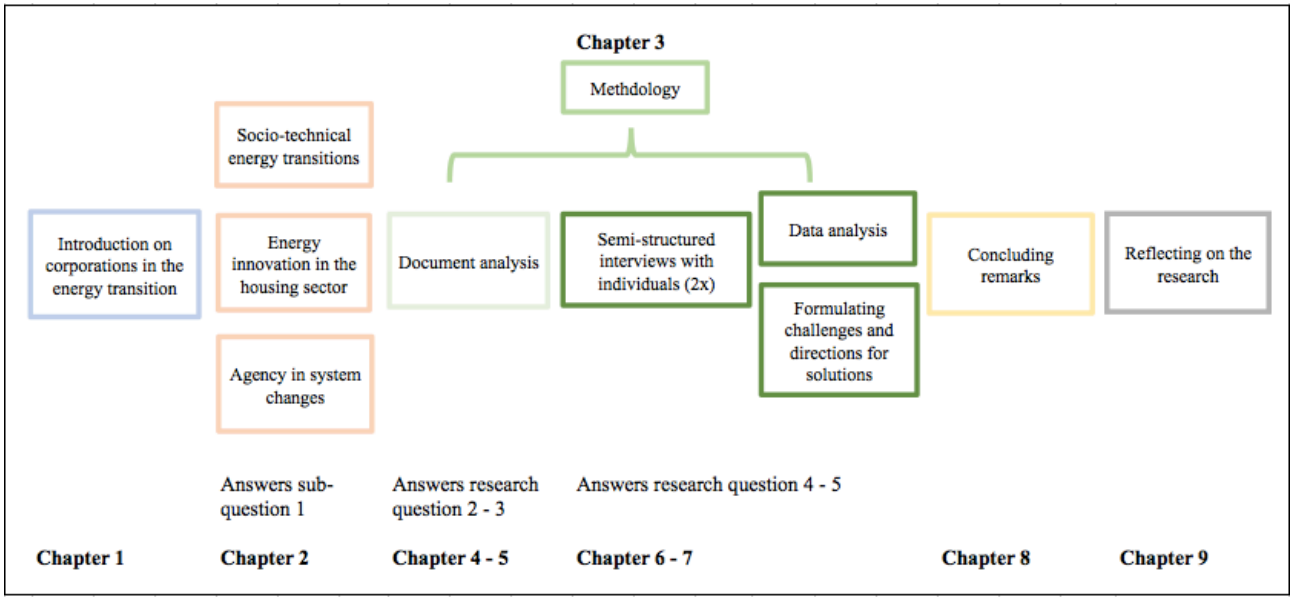


Figure 2. Visual overview of the outline of this research.

Chapter 2. Theoretical framework: challenges in innovation

This chapter describes theories that offer the framework for the research: understanding the aspects involved in changing the energy system in the Dutch housing sector, identifying the challenges experienced by the housing corporations in the energy transition, and offering directions for addressing these challenges. The *multi-level perspective* (MLP) theory is used to illustrate the phases in which systems move towards a transition, which is useful for assessing the general **evolution** of transitions, such as the energy transition. The *sectoral system innovation* (SSI) approach is used to describe the main building blocks of energy innovations in the Dutch housing sector, and thus helps to identify structural **barriers**, and thereby **possible directions for solutions,** on the road to the energy transition. The *strong structuration theory* clarifies how agents, e.g. housing corporations, navigate and experience their **practices** within broader system changes.

2.1 The evolution of transitions using 'multi-level perspective'

Worldwide issues related to environmental change and degradation, such as global warming, trigger the urge for a more sustainable society (Fuenfschilling & Truffer, 2014). The changing dynamics between institutions, individuals and technological innovations dealing with these issues, can trigger transformations, known as transitions. Transitions are perceived as gradual, continuous processes of change that transform the structural character of a society (or sub-system of society) (Rotmans et al, 2001).

Scientists have tried to capture transitions in theories (Markard et al, 2012). The *socio-technical systems perspective* has been introduced to describe transitions that involve social as well as technical changes (Fuenfschilling & Truffer, 2014). This perspective has often been used to describe shifts in energy systems (Smil, 2010). Historical shifts in energy systems have been the transition from wood to coal in the 19th century, and that from coal to oil in the 20th century, which resulted in fundamental changes, such as industrialisation, urbanisation and consumerism. The current energy transition from fossil fuels to sustainable energy sources will also entail significant technological, social and political changes (Jiusto, 2009; Hermwille, 2016). The *multi-level perspective* (MLP) theory is one of the central models for analysing such socio-technical transitions (Verbong & Geels, 2007). Although transitions evolve along a variety of paths, recent research using the MLP theory has shown that transitions come about through the interplay of three levels and four phases (Fig. 3; Geels, 2018):

- In the *first phase*, new and alternative developments in technology, policy and/or lifestyle emerge in ***niches*** (Wieczorek, 2018). Niches are a societal level in which there is room for actors to test such alternative developments Mourik & Raven, 2006). There is a low degree of institutionalization in niches, as these alternatives are not yet protected or supported by the dominant system. The lower level in figure 3 entails niche-innovations.
- In the *second phase*, the alternatives are used in small niche markets, which result in a community of actors that try to improve the alternatives (Geels, 2005). Rules, designs, user preferences, and more, are stabilized through this learning process.
- In the *third phase*, the alternative(s) will break through in ***the regime*** (Geels, 2005). There are internal drivers for such breakthroughs (price optimization), and external drivers (pressures from the landscape) and 'windows of opportunities' (problems in the regime).

- The socio-technical regime includes the organizations, governance structures and corresponding lifestyles and beliefs that exist within the dominant socio-technical system (Osunmuyiwa et al, 2018; Verbong & Geels, 2007). The regime forms the deep structures that regulate the stability in a system. In other words, the regime constitutes the rules and routines defining the dominant 'way of doing things' in society (Wieczorek, 2018). The middle level in figure 3 constitutes the regime.
- The ***landscape level*** includes the broader societal structures, such as demographic changes, political ideologies or economic growth (Wieczorek, 2018). The landscape level can either stabilize or put pressure on regimes (Verbong & Geels, 2007). The upper level in figure 3 is called the socio-technical landscape.

- In the *fourth and final phase*, the alternative(s) become(s) part of the regime (Geels, 2005). This often happens gradually: the creation of a new sociotechnical regime takes time and actors tend to stick to the old regime dimensions due to vested interests.

In short, a successful *transition* develops in four phases, resulting from the dynamics between three levels: a new regime will occur when both innovations in niches and external pressures from the landscape level reinforce towards a new state, see figure 3 (Geels, 2018). Such transitions can be defined as '*changes from one socio-technical regime to another*' (Geels & Schot, 2007), which in simpler words means a new way of ordering life.

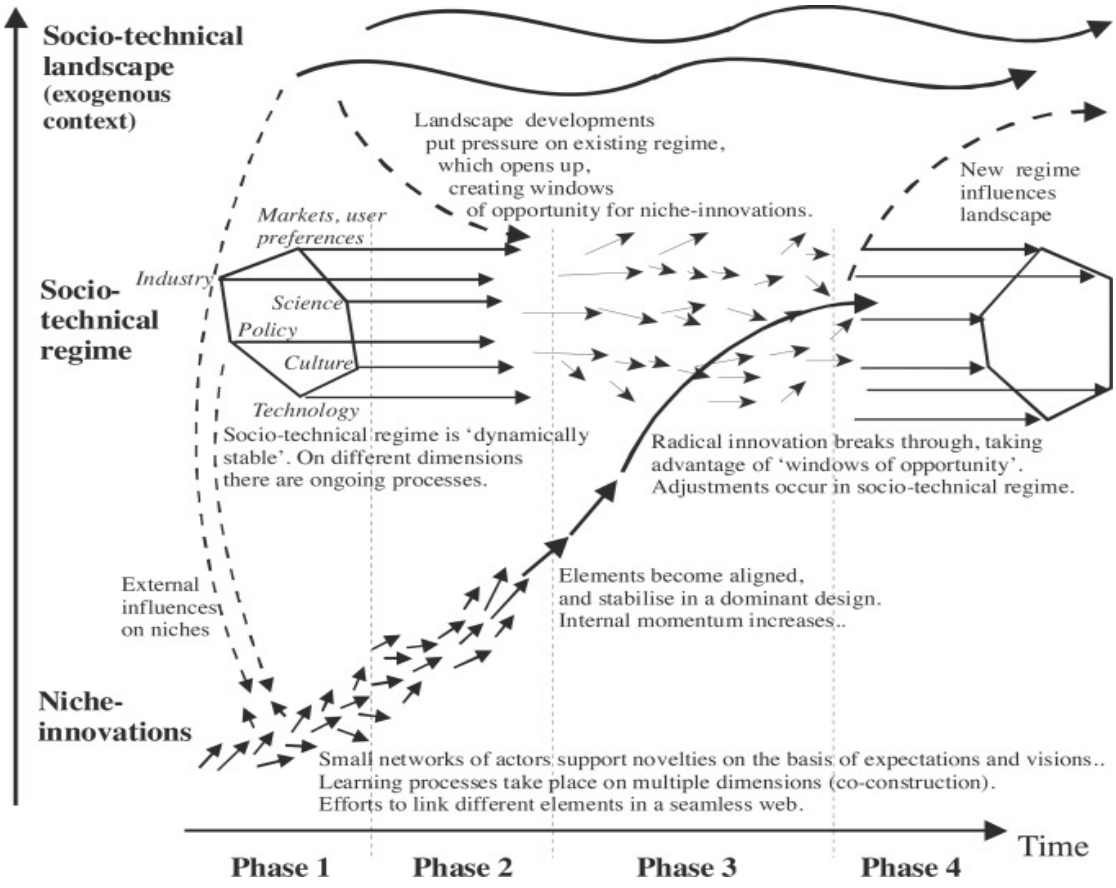


Figure 3. The MLP theory: transitions come about when external pressures together with innovations create a new regime (Geels, 2018).

2.2 Energy innovations in the housing sector using 'sectoral system innovation'

The MLP theory has been strongly criticized for its limited description of the functioning and characteristics of the levels in a socio-technical system (Smith et al, 2005). The descriptions remain general and difficult to apply in empirical research (Fuenfschilling & Truffer, 2014). The concept of *innovation systems* offers a systemic, more explicit, perspective on the interactions between institutions, technologies, agents and markets that steer transitions (Malerba, 2002). Innovation systems can be defined on various levels, for example on national, regional or sectoral. Faber & Hoppe (2013) used a *sectoral system innovation (SSI)* approach to analyse and precisely define the main building blocks of energy innovations in the Dutch housing sector. A SSI approach can be described as a group of agents that is responsible for the production and sale of certain products (Malerba, 2002). There are four building blocks or dimensions within SSI (Faber & Hoppe, 2013; refer to Appendix 2 for details):

1. ***Agents and networks*** are the main conductors of sectoral changes (Faber & Hoppe, 2013). Agents include individuals as well as organisations, with certain characteristics in terms of motivations and responsibilities. They interact through (formal and informal) processes of communication, cooperation and competition.
    - The primary agents perform core innovative activities and experiments within a sector.
    - Secondary agents provide support in knowledge development, finances and regulations within a sector.
2. ***Institutional framing*** include various formal and non-formal rules, such as laws and values, which shape actions of and interactions between agents (Faber & Hoppe, 2013).
    - Formal regulations refer to the 'allowed' ways of doing things, often captured by (governmental) policies. They constitute:
        - A sectoral context, which includes all elements of 'agents and networks';
        - A regulatory design, which refers to the basic purpose of policies;
        - Stringency, which is the strictness of policies;
        - And flexibility; which is about the allowance of changes in application.
    - Informal regulations are the values, responsibilities and common beliefs agents can refer to when acting.
3. ***Technological regime*** is the dimension in which technologies, artefacts and practices come together, and has five important features (Malerba & Orsenigo, 1997).
    - A knowledge base, which is the amount and characteristics of knowledge available;
    - Learning conditions, which is about the freedom of learning by doing and collectively learning with and of other agents;
    - Technological opportunity, which is about the easiness – given the amount of resources available- for new technologies to be introduced;
    - Appropriateness, which means that the new technological innovation is profitable;
    - Cumulativeness, which implies that the new technology is a logic sequel of the previous one.
4. ***Market demand*** is the variety of requirements and preferences that consumers and producers have in energy innovations (Faber & Hoppe, 2013). A large diversity of requirements and preferences refers to a heterogenic market demand. The innovations are developed in niche markets that vary in structure, size and segmentation.

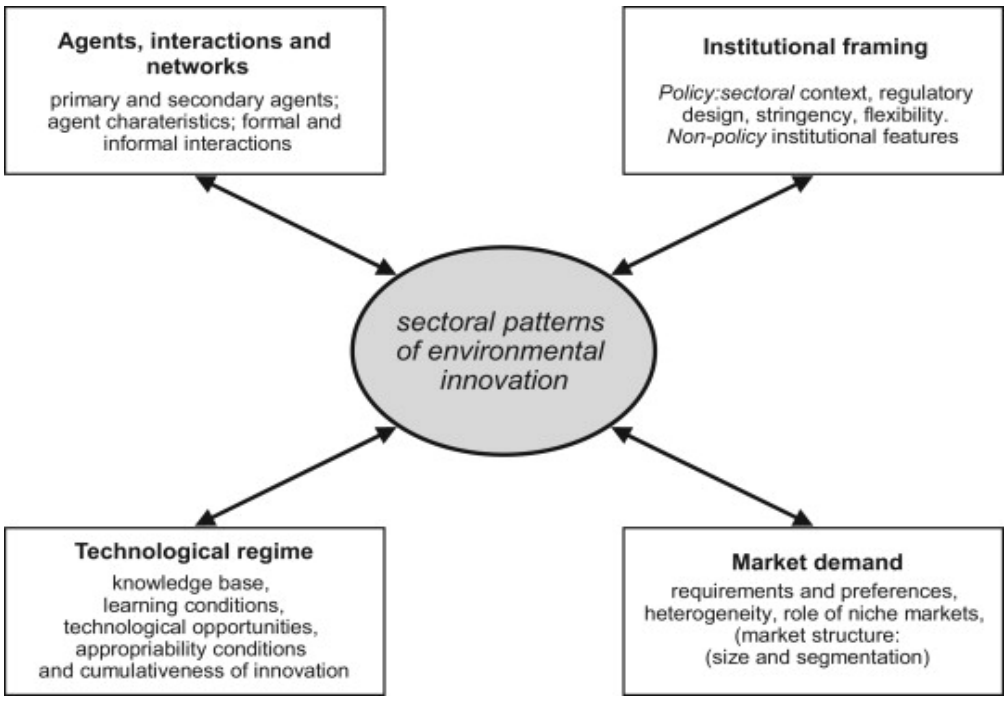


Figure 4. Various elements of sectoral system innovation (Faber & Hoppe, 2013).

The four building blocks are interdependent, and need to co-evolve towards a certain innovation (Fig. 4). An innovation often requires breaking through a lock-in, i.e. a situation in which technologies, actors, markets and/or institutional regulations are locked into a certain system, such as a fossil fuel-based energy system (Unruh, 2002). Radical innovations, such as the introduction of renewable energy technologies, often encounter challenges in breaking through, as they have to compete with the dominant regime (Monstadt, 2009). A barrier in one of the building blocks implies a mismatch: the various parts of a system do not and cannot evolve in a coherent way (Malerba, 2002). The social, economic or political orders are, for example, not adjusted to a new technological regime, which requires a longer phase of searching and experimenting to find a 'match' and to innovate (Freeman and Perez, 1988). Following Faber & Hoppe (2013) a SSI approach can be used to identify the barriers, mismatches and thereby directions for solutions for patterns of innovation in the energy transition in the Dutch housing sector.

2.3 Agency in transitions using 'strong structuration theory'

It is key to take a look at the process of structuration to understand how agents, such as housing corporations, deal with and act within a changing environment (Hermwille, 2016). Giddens' *Structuration theory* describes and explains the relationship between agency and structures, by means of structuration. Agency is about practices of agents, both individuals and organizations. Structures are about the broader context of rules, norms and resources. Structuration refers to the interaction between agents' practices, e.g. using a certain energy technology, and to their role in the (re)production of the social structures, e.g. the discourse of a certain energy system. In other words, the organization of a society determines how an agent wants to and should behave, and, in turn, this behaviour affects how a society is functioning. This implies that a change in behaviour occurs when, for example, the rules within a society change, and the other way around. This is called the duality of structure, and is seen as one of the central mechanisms for change in society, see figure 5.

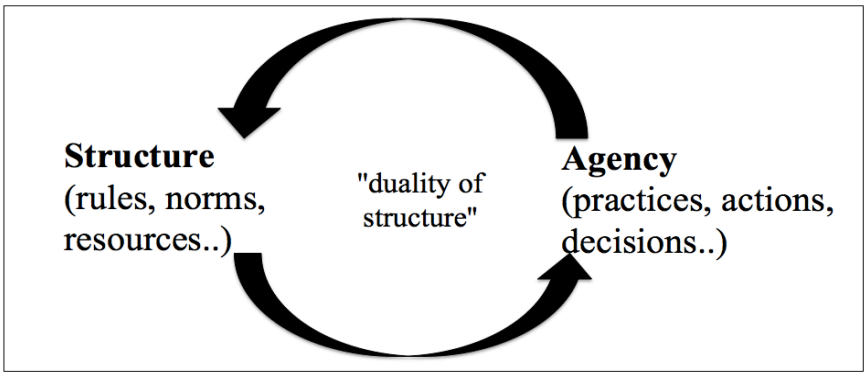


Figure 5. Duality of structure.

Giddens' theory focuses on the broader societal structures through which agents navigate their practices, e.g. rules, norms and resources. The theory has received critique for its limited attention for individual characteristics, such as beliefs, attitudes and knowledge that agents use when acting, known as their internal structures. Building on Giddens' work, Stones (2005) developed the *strong structuration theory,* in which he differentiates between external and internal structures of agents:

1. *External structures* are separate from the agent and delimitate conditions, and include laws, formal policies, informal regulations, and organisations.
2. *Internal structures* are divided into two classes: *general-dispositional structures* (including habits, norms, values, and worldviews of agents) and *conjunctural structures* (relating to agents' knowledge and understanding of their context). The two internal structures are analytically distinct, yet, in practice they may overlap.

External Structures	**Internal structures** Conjuncturally-specific	**Internal structures** General-dispositional
• External conditions • Practices and regulations • Physical and/or technical aspects	• Contextual knowledge • Perception of external structures • Expectations about behaviour of others	• Capabilities • Worldviews • Norms; values • Classifications

Figure 6. Overview of the structures that influence agency (modified after Hermwille, 2016).

The conjunctural structures of agents often act as a catalyst between the external structures and the general-dispositional structures. This means that the knowledge, perceptions and expectations agents have of external structures, e.g. policies, and of general-dispositional structures, e.g. values in society, determine how they act or refrain from action. The conjunctural structures of an agent can be analysed through narratives according to Hermwille (2016). Narratives are the key vehicles by which knowledge, perceptions and expectations are transported. They are meaningful stories to understand how the structures around us are experienced (Leach et al, 2010). Narratives do not only transport meaning about how agents themselves perceive external and general-dispositional structures, but also how the other agents perceive the same structures (Hermwille, 2016). Narratives thus reveal how actors experience the structures around them, which determine how they act.

2.4 Conceptual framework

While SSI and the MLP theory are transition models that capture the overall process, Stones' strong structuration theory provides an understanding of how agents behave within a changing system. Agents refer to external and general-dispositional structures when navigating their practices, and use their internal conjunctural structures in doing so.

Housing corporations are the agent, *sensu* Stones, analysed in this study. The four building blocks of SSI *sensu* Faber & Hoppe (2013) form the external and general-dispositional structures on which housing corporations base their practices within the energy transition. Within this context, the present study specifically deals with the barriers - or more positively: challenges - that housing corporations encounter in the energy transition, and how these relate to the structures of SSI. It provides insight into the challenges and mismatches, and reveals where systemic adjustments need to be made and thus potential directions for solutions for housing corporations lie. This forms an answer to the first sub-question. The MLP theory is of limited practical use in the execution of this type of research; the results of this study will be discussed in terms of the MLP theory in the reflection, section 9.1.

Figure 7 shows a graphical representation of the conceptual framework of this study.

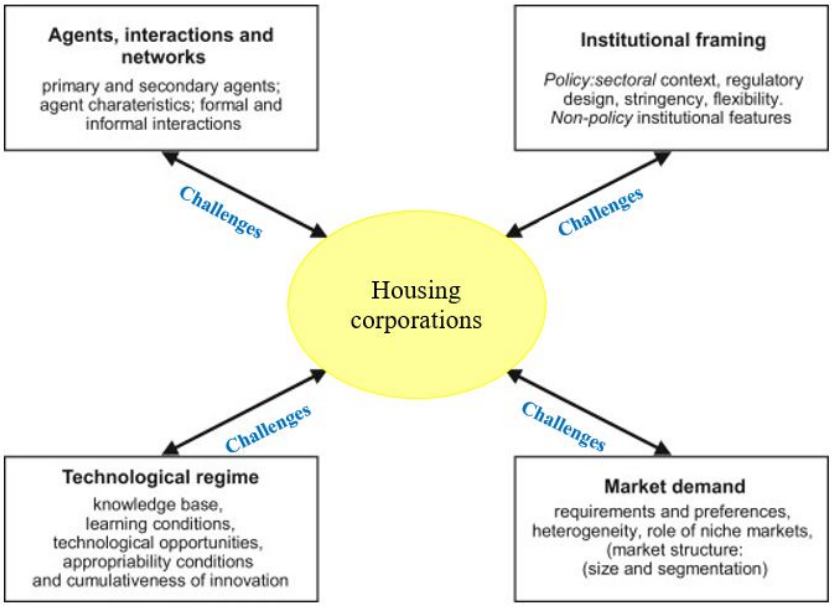


Figure 7. Conceptual framework of the role of housing corporations in SSI.

Chapter 3. Research methodology: qualitative research

This research explores the experiences of housing corporations in the current energy transition, by means of a *qualitative research strategy*. A *comparative case study* is used as a research design to compare and analyse the corporations active in Van der Pek (Amsterdam), Palenstein (Zoetermeer), Benedenbuurt (Wageningen). Qualitative *documents*, and two rounds of *semi-structured interviews* are used to collect the necessary data, and link the results to theory. This chapter further elaborates on the methodological choices made, and is divided into four sections: research philosophy, case studies, data collection and processing, and research limitations.

3.1 Research philosophy

Doing social research comes along with a certain philosophy on how the sources of knowledge and the nature of knowledge are perceived. The epistemological nature – i.e. what is regarded as acceptable knowledge - of this research is interpretivist, meaning that both researcher and respondents may experience and interpret the world in different ways (Bryman, 2012a). There is not one singular or objective way to understand the world. The ontological nature – how is reality constructed - of this research is constructionist, meaning that the world is constructed through multiple understandings of reality (Bryman, 2012a). Reality is a product of how people experience and interact with it.

The research philosophy of this research thus acknowledges the existence of multiple experiences on reality. This implies that housing corporations could have different experiences regarding their role in the energy transition. A qualitative research strategy is suitable to analyse the (potentially) different experiences of corporations. Qualitative research aims at gaining a deep understanding of a specific organization, event or group of participants, in this case housing corporations, and encourages people to expand on their responses (Bryman, 2012a).

The nature of the relationship between theory and social research is, in this study, predominantly deductive. A deductive research implies that existing theory or theories will guide the research (Bryman, 2012a). Deductive research often comes along with testing theoretical hypothesis. In this study, however, there are no explicit hypothesis formulated based on theory. The theories, mentioned in chapter 2, are rather used as a lens to explore the potential directions in which challenges and potential solutions for housing corporations in the energy transition can be found.

3.1 Case studies – the corporations active in three neighbourhoods

This research makes use of case studies, which is valuable when research is focused on a ‘how’ or ‘why’ question that seeks to explain or explore a situation through an in-depth description (Yin, 2009). Case studies can use a variety of sources, which ensures that the issue is not analysed through one lens only. This research uses a comparative case study. Comparative case studies analyse differences and similarities across two or more cases that have a common focus or goal, to understand how and why certain activities work or fail in a specific context (Goodrick, 2014). This research aiming on providing an in-depth description of corporations’ experiences in different urban contexts therefore requires such a strategy.

The unit of analysis, the major entity that is being analysed (Bryman, 2012b), is housing corporations. To narrow down the scope of this research, only the corporations that are active in a few specific neighbourhoods are examined. These neighbourhoods are selected from a Dutch national experiment on natural gas-free neighbourhoods, 'Programma Aardgasvrije Wijken' (Rijksoverheid, 2018). Kasja Ollongren, Minister of Internal Affairs and Kingdom Relations, initiated this experiment in which 27 Dutch municipalities, and selected neighbourhoods, received a substantial amount of money (120 million euros in total) to foster the transition towards a gas-free built environment, and to experiment with new energy technologies and stakeholder-partnerships. To find out which of these neighbourhoods would be interesting to explore the experiences of corporations, they have been examined and compared based on: the characteristics of the neighbourhood (year of construction, percentage of single-family versus multi-family homes), the population (amount of people, age pyramid, origins), the geographical situation (urban versus rural area) and the types of ownership (percentage of buildings owned by housing corporations versus private homeowners). The following three neighbourhoods had a few similarities, which are seen as relevant in the context of this paper (see Appendix 3 for more information):

- Van der Pek, and specifically the part called Gentiaan, is the first neighbourhood in Amsterdam to become natural gas free. The municipality of Amsterdam has the ambition to reduce CO_2 emissions with 55% in 2030 and with 95% in 2050, requiring massive changes in the energy supply system in the built environment (City of Amsterdam, 2018). Moreover, it has the ambition to fully phase out natural gas in residential buildings, for heat purposes, by 2040. The Van der Pek neighbourhood is the first area in Amsterdam to experiment with alternatives for natural gas (City of Amsterdam, w.y.). The **housing corporation Ymere** owns most of the (rental) properties and expressed the ambition to connect all homes to a heating district (HierVerwarmt, w.y.a). The large-scale renovations by Waternet (water management) and Liander (grid operator) that were planned anyway were a decisive factor for Ymere to start renovations. Ymere has made the first block of 38 homes gas-free.
- Palenstein is located in Zoetermeer. The municipality of Zoetermeer, grid operator Stedin and **housing corporations De Goede Woning, Vestia and Vidomes** have appointed Palenstein as the first district to become natural gas free (City of Zoetermeer, w.y.). Palenstein was once the first housing district in Zoetermeer, and is now – after more than 50 years - ready for large-scale renovations. Such renovations offer opportunities for making the housing stock in the neighbourhood more sustainable. The three housing corporations (owning 70% of all homes in Palenstein) decided to commit to a gas-free environment.
- In Benedenbuurt residents have been working with the municipality of Wageningen and the **housing corporation 'De Woonstichting'** to find ways to making this neighbourhood no longer dependent on natural gas (Wageningen Woont Duurzaam, 2018). The immediate reason behind these efforts is that the municipality wants to replace the sewerage and pavement in Benedenbuurt from 2019 onwards, because of its age. The gas network is also out-dated. A heating district, or other alternative, can prevent a new natural gas network from being installed. The different parties involved in the housing sector in Benedenbuurt are examining the possible alternatives to natural gas.

The five housing corporations are chosen based on their active role in three neighbourhoods that are similar in progressiveness on the energy transition, location in an urban area and dominance of housing corporations, see Appendix 3. Figure 8 shows the geographical location of the cases.

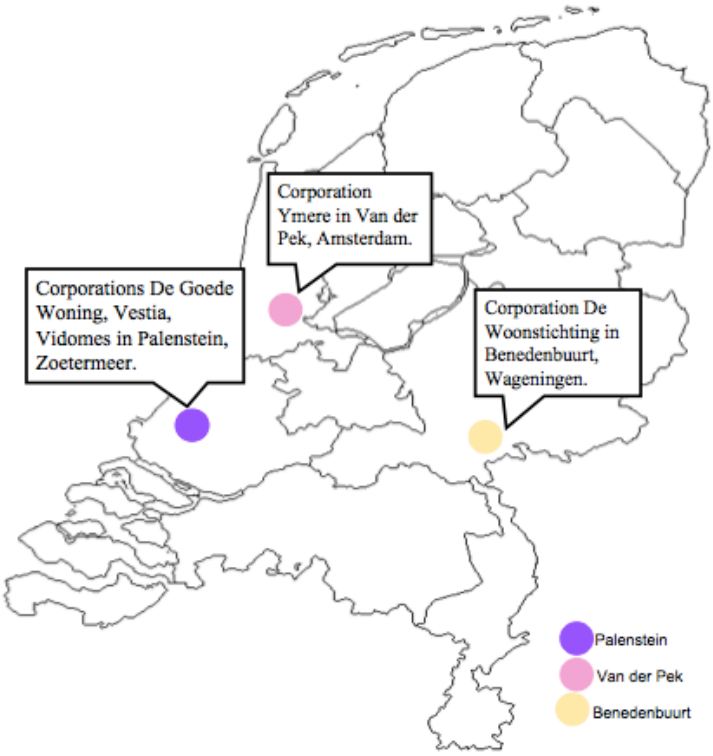


Figure 8. Locations of the five housing corporations in three Dutch neighbourhoods.

3.2 Collecting and processing data - narrative inquiries and analysis

Data collection – narrative inquiries

In this research data is collected by means of several types of sources: (scientific) literature, (online) documents and interviews. The literature described in chapter 2 provides theories that underpin the aim of this research and answer the first sub-question. The second and (partially) third sub-question - chapter 4 and 5 - are answered using a document analysis. The document analysis for the second sub-question is guided by the building blocks of SSI; the document analysis for the third sub-question revolves around the role of housing corporations in the energy transition. Primarily academic papers, but also policy documents, news articles and websites are used as sources.

A limitation of a document analysis is that it lacks a more personal perspective on the topic of this study. Therefore, semi-structured interviews are conducted, to answer the exploratory sub-questions of this research: (partially) the third, and fourth and fifth sub-question. Semi-structured interviews, which is interviewing with an interview guide, allow flexibility in asking questions but keep the focus on the relevant questions (Dunn, 2010). Unstructured interviews may have the risk of digressing; structured interviews may provide little insight in personal experiences. These considerations determined the choice for semi-structured interviews.

The so-called narrative inquiry is used as an interview technique. Narrative inquiry is a technique to explore individual experiences, often by giving respondents the freedom to tell stories about a certain subject (Paschen & Ison, 2014). These stories are called narratives, and thus refer to the conjunctural specific internal structures of agents, mentioned in section 2.3. The components of a narrative approach *sensu* Paschen & Ison (2014), see the blue box, are used to guide the narrative inquiries, to make explicit the views, challenges and potential solutions that housing corporations

see for themselves in the energy transition. In this context, narrative inquiries reveal how changes are understood or interpreted: whether it is perceived a challenge or opportunity (Wolf & Moser, 2011). They also provide understanding of what sort of measures are necessary to progress towards a certain future, and why (Hewitson, 2014). Hart (2002, p. 142) calls narrative inquiries "perhaps the best window into how we think". Questions are often kept open, so participants can interpret them freely.

A narrative approach addresses:

1. Current challenges;
2. Potential ways of addressing those challenges;
3. Implications for the community as a whole.

Narrative inquiries are used for the first round of interviews. The questions in figure 9 are used as a guide. The purpose of the first row of questions is to gain an understanding of what the transition implies and means to the respondent. The second row of questions explores the respondents' perception on how the transition could be addressed more effectively. The last row dives into what these aspects imply for the community. The questions are not yet related to the SSI dimensions, as that would steer their experiences towards a certain direction.

Themes	Questions
1. The experiences in the energy transition	• What is the corporations' vision on the energy transition? • What does the transition to a low carbon future mean for your organization, in neighbourhood X? • What are the main challenges that emerge from such a future? • What are the main opportunities that emerge from this future?
2. Dealing with the energy transition	• Do you think that the energy transition is effectively addressed? • How else could we effectively approach such a future, talking from the corporations' perspective?
3. Implications for the corporations	• How could the energy transition reinforce contribute to the core qualities/values of corporations? • What would you consider a hopeful (gas free) future? • Could such a future stimulate corporations to start acting?

Figure 9. Interview guide for narrative inquiries: themes and (adjustable) questions.

Individual respondents have been interviewed by means of narrative inquiry. For each case, multiple respondents were approached (based on online references). They were selected based on theoretical sampling criteria: a respondent should be 'active' in the energy transition in the specific neighbourhood. This means that (1) the respondent attends meetings related to the transition, and/or (2) the respondent has a central role, for example through a position in a key project. For this study, it is assumed that an active respondent is well informed of what the transition implies for their corporation, and can be seen as representative. In the case of Benedenbuurt only one respondent was interviewed, she ensured to represent her near colleagues too.

Neighbourhood	Corporation	Respondent	Position	Interview
Palenstein	De Goede Woning	R1*	Board member	18th of April
	Vidomes	R2	Board member	2nd of May
		R3*	Project manager Palenstein	2nd of May
	Vestia	R4*	Advisor sustainable housing	18th of April
		R5*	Project manager Palenstein	25th of April
Van der Pek	Ymere	R6*	Region manager Amsterdam-Noord	8th of April
		R7	Strategic advisor Amsterdam	11th of April
		R8*	Project developer Amsterdam	16th of April
Benedenbuurt	De Woningstichting	R9*	Housing counselor Zoetermeer	10th of April

Figure 10. Overview of the respondents.

Data processing – narrative analysis

After gathering data through narrative inquiry (first round of interviews), narrative analysis is used to identify how housing corporations experience the energy transition. 'Narrating' is, according to Cortazzi (2001) an interactive process of tracing the experiences of respondents; narrative analysis is a means of examining the experiences and meanings of the respondents. Narrative analysis explores how a story is told and what the main message is (the plot or storyline) by re-reading and re-listening the interview (Lejano et al, 2013). To analyse the data more in depth as well as gaining a proper overview, codes are created around themes (not around individual stakeholders) and clustered into categories that aid in answering the research questions. Quotes from the interviewees are used to both back-up the found narrative themes as well as to leave the stories coherent and authentic (Bremer et al, 2017).

Data collection and processing 2.0

The results of the narrative inquiries are presented to respondents in a second round of interviews. Through an evaluation of the output of the narrative inquiries (see previous paragraph) visions, challenges and potential solutions for housing corporations are identified and linked to the SSI dimensions. The respondents with a "*" in figure 10 were willing to participate in the second round. The respondents are asked to respond to an overview of the results, including multiple hypotheses (see Appendix 4 in Dutch). The output of the interviews are, again, analysed and evaluated. Through this, it is possible to verify and falsify certain assumptions regarding SSI, which allows drawing conclusions with more certainty. This leads to a highly iterative process of evaluating and adjusting (Bryman, 2012a), see figure 11.

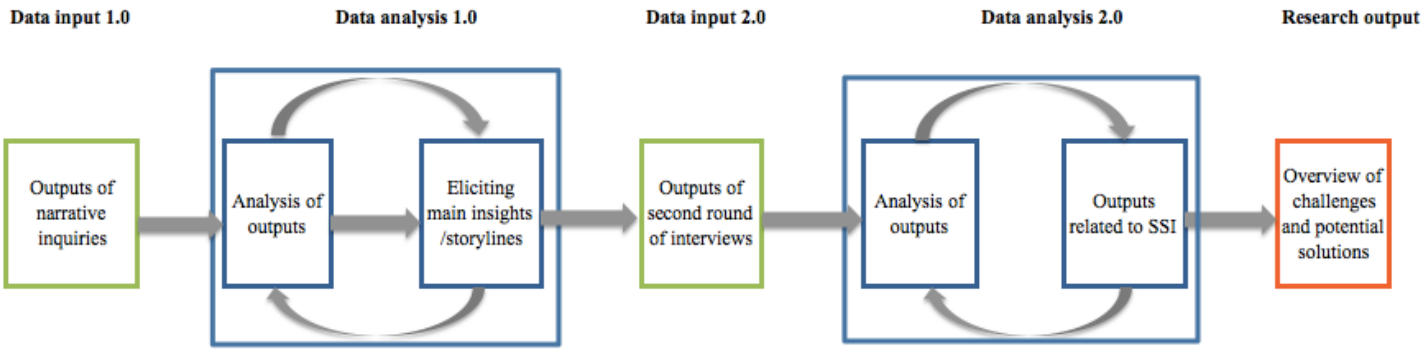


Figure 11. The iterative process of this research.

3.3 Research implications

The methodological choices made in this research come along with certain implications. These are:

- That there is a chance of misinterpreting the research results. An interpretivist research assumes that there are multiple accounts of social reality (Bryman, 2012a). Narrative inquiries as a research method focus on how people interpret the world from their specific role in society (Paschen & Ison, 2014). Goals and targets that may be communicated through these interviews are at risk of being politically or ideologically coloured. One of the ethical challenges of this research is therefore be to remain a neutral outsider, a researcher who simply explores what is being told about the energy transition. To avoid doubts in this area, research methods and steps are exhaustively reported: the document analysis is tailored to the relevant sub-questions, the interview guides are written down and the interviews are recorded, transcribed and coded to ensure transparency. Also, triangulation is used, which is about using more than one method or source of data in the study of social phenomena (Bryman, 2012a). This research combines documents (both policy and academic literature), interviews and check-up interviews, to provide a deep and well-understood understanding of what people tell, mean and want for the future.
- That there is tension between the context-dependency and representativeness of the results. Although generalizations are not necessarily desired when using case studies, the cases used for this research can be seen as somehow representative (Yin, 2009), as they represent a broader group of corporations that all have the same challenge for the future: phasing out natural gas. Also, the corporations examined in this research are not only active in the three neighbourhoods; they are active in a variety of areas throughout the Netherlands, see Appendix 3. However, the corporations that are chosen for this research are progressive regarding the energy transition; they have certain characteristics (corporation are willing to change or renovations that are required anyway) that may make it easier to change. This research is therefore set up as exploratory, as it explores the views of a certain group of corporations, instead of being focused on drawing conclusion for the whole population.

A more general limitation of this research is that the perspective of only one stakeholder is taken into account. Although corporations are seen as leading actors in the energy transition in the housing sector, their perspective and actions will not ensure a full transition. There are many other influential agents involved (see next chapter). This study is therefore just a first step in identifying where progress in the energy transition in the Dutch housing sector can be made.

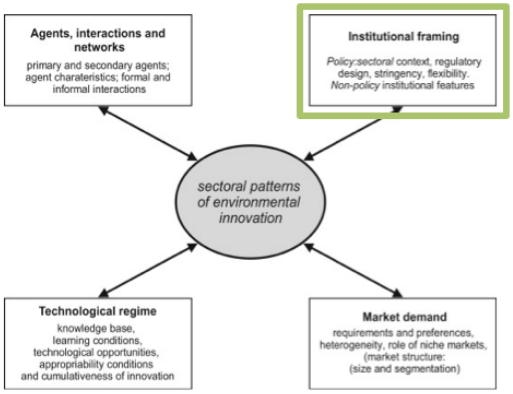
Chapter 4. The current energy transition in the Dutch housing sector

This chapter seeks to understand what the current energy transition in the Netherlands involves, by briefly touching on the building blocks of SSI (Fig. 4). In doing so, it tries to answer the question: What does the energy transition in the Dutch housing sector involve? As it includes a broad question, multiple references are made to appendices for an elaborate description. Also, it is acknowledged that this chapter does not capture all aspects of SSI, as some aspects are either not yet known (i.e. exact descriptions of the current market demand) or too extensive to discuss here (i.e. informal regulations that exist within the sector). The dimensions of the energy transition form a fluid, dynamic whole, which cannot be fully captured on paper. This chapter rather provides a general outline of the context, which contributes to answering the main research question.

4.1 The building blocks

A large-scale renovation took place in the 1960s to connect the Dutch built environment to natural gas, replacing coal (Verbong & Geels, 2007). Within a decade 80% of the Dutch households were connected to the national gas grid. This led to a large national dependency on low caloric natural gas and to a lock-in of the Dutch housing sector. Currently 93% homes are connected to natural gas for heating purposes, see Appendix 5 for more information (Schoots & Hammingh, 2015). To escape this lock-in, regulations, agents, technologies and demands are, according to the literature and documents analysed, slightly moving towards a new (renewable) energy system.

Institutional framing – formal regulations

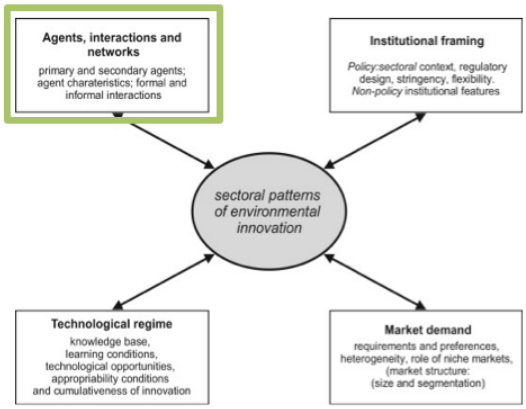


It has become clear that the large-scale gas combustion in the Netherlands led and still leads to significant emissions of CO_2 (van Leeuwen et al, 2017). Natural gas is a fossil fuel, which means that CO_2 is released when it is burned and that the supply is not infinite. Every year, approximately 38 megaton of CO_2 emissions can be attributed to the Dutch built environment, which is about 19% of national total greenhouse gas emissions (MNC, 2010). Current environmental policies therefore aim to improve energy efficiency and phase out the use of fossil fuels in, among other things, the housing sector. Such formal regulations are particularly important in steering the energy transition (Faber & Hoppe, 2013).

The Dutch national government has already been working for years on the transition to a low carbon future. This has resulted in an Energy Agreement in 2013, a Heat Vision document in 2015, a commitment to the Paris Agreement in 2015, and a Dutch Climate Act in 2018 (Klimaatakkoord, 2018), see Appendix 6 for descriptions. Whereas it started with a vision and policies to stimulate renewable energy use, it has now become a legally-binding ambition to reduce CO_2 emissions, documented in the Climate Act: greenhouse gas emissions should be reduced by 2030 with 49% compared to 1990 and with 95% by 2050, and the entire electricity production must be sustainable in 2050. Specific regulations and targets are currently being set for, among others, the built environment. For example the Energy Performance in Buildings Directive (EPBD) standard, which is a European policy focused on the energy performance of the built environment, related to CO_2 emissions (European Parliament, 2012). The EPBD includes energy performance certificates for

buildings, with A+++ being the best to G being the worst certificate. There are also other scales on which formal regulations are being set. Authorities at the regional level, such as provinces, decide on the energy sources and technologies exploited; authorities at the local level determine when and where measures are being implemented. It is dependent on the context how formal regulations are being worked out. Informal regulations, which undoubtedly play a role, will not be addressed in this chapter, as these are not precisely known. What can be mentioned is that there is a general believe that emissions need to be reduced, but that investing in energy innovations is financially unattractive at this moment; the benefits will only occur in the long term (Faber & Hoppe, 2013).

Agents and networks



Faber & Hoppe (2013) identified all agents involved in energy innovations in the Dutch housing sector, see figure 12. They made a distinction between primary and secondary agents. The primary agents perform core innovative activities and experiments. In the energy transition in the housing sector, these are the firms that develop and build homes, the suppliers and installers of technologies, the main users including households and housing corporations, and the municipalities. The municipalities, for example, enact building sites and permits, and facilitate construction and renovation projects, often documented in covenants with housing corporations/ project developers. The focus of this research is on housing corporations, as they are designated as frontrunners in the energy transition in the housing sector by the Dutch national government. An elaborate description of housing corporations can be found in the next chapter. Secondary agents support in knowledge development, finances and regulations. Within the housing sector these are the governments, banks, research institutions and consultancies. National and European regulative conditions are particularly important in the energy transition (see above paragraph or Appendix 6 for more information). Primary and secondary agents interact through formal and informal relations. A more precise description of all agents and networks has been left out in this chapter, as it is highly dependent per project which agents will be involved, what their specific roles are and how they relate to other agents.

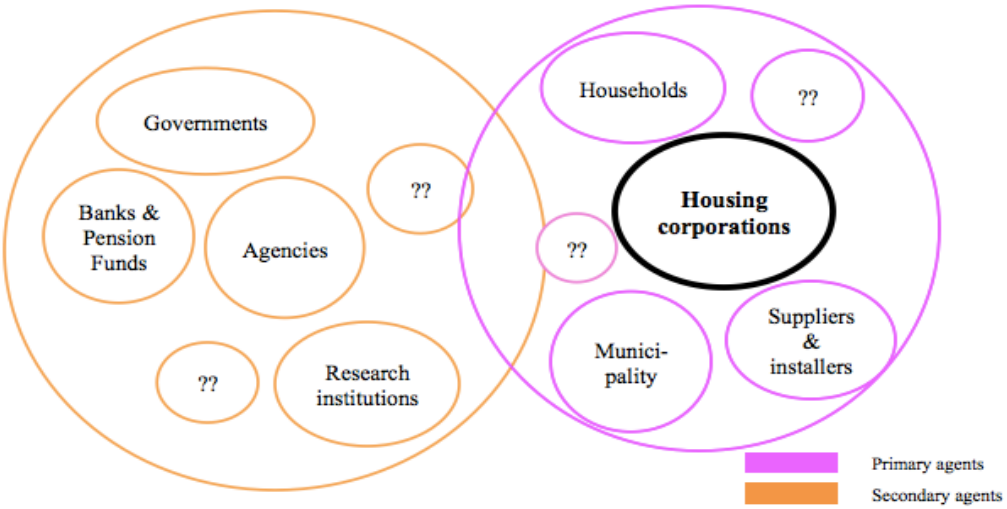
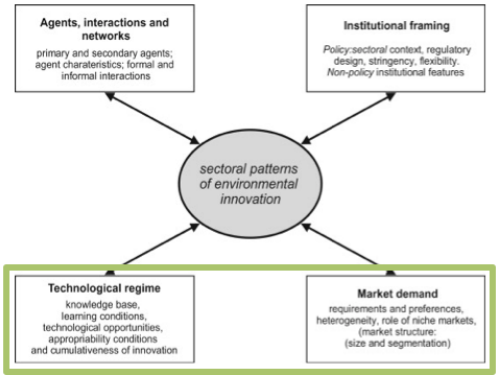


Figure 12. Actors involved in the energy transition in the Dutch housing sector.

Technological regime & market demand



Although the first steps towards the energy transition, which is ultimately a future without natural gas, have been made, it is uncertain what such a future precisely entails (RVO, 2017). It is in fact in the name 'a future *without'*, but what will replace it? Currently, the average demand of a Dutch household is about 1500m^3 natural gas for heating, warm water supply and cooking per year (CBS, 2016). This comes down to 11 billion cubic meters of gas consumed by households, which is about half of the current production of gas from the Groningen field on a yearly basis. This leads, as mentioned, to significant CO_2 emissions. There are various technologies available that could significantly reduce CO_2 emissions from buildings (IEA, 2010). The housing sector is, however, regarded as a captive customer due to the high financial investments needed for applying such alternative technologies and the low rates of return in the short term (Miedema et al, 2018). It is expected that many of these technologies will become economically more attractive in the near future (Smekens et al., 2011). These technologies can be defined as 'innovative energy systems': renewable energy and energy efficiency technologies that substantially differ from conventional technologies (Hoppe, 2012). This research is limited to innovative energy systems for heat and electricity in Dutch homes, excluding offices and other utility buildings. The most important are collective networks (heat districts), individual solutions (all electric) and green gas (Rijksoverheid, 2015a). Appendix 7 provides more information on these. A concrete overview of the market demands on innovative energy system has not been found. What is known is that there is a lack of knowledge regarding the technologies and their application, which hampers learning processes in the energy transition in the housing sector (Faber & Hoppe, 2013). Also, there is little attention for energy issues, as most agents are focused on investing in new housing.

4.2 Conclusion – a search for comprehending the energy transition

The energy transition in the Dutch housing sector has been set in motion: agreements have been signed, policies are developing, agents have been identified and technologies are being worked. The transition includes major building blocks and with that major changes in our whole society. It has neither been desirable nor possible to map out the precise details of these broad aspects in this chapter. What this chapter did show is that the transition has been set in motion through top down formal arrangements, and that all the other aspects in SSI are still under development, unknown or uncertain. This research focuses on the role of housing corporations to narrow down the scope of this research, and as the entry point for analysing this broad phenomenon and to become more concrete about the challenges involved. The next chapter elaborates on the role of housing corporations.

Chapter 5. The role of housing corporations in the energy transition

This chapter looks in more detail at the role of housing corporations in the energy transition, by taking a brief look at their historical and current responsibilities, and how they experience their current role themselves. In doing so, it tries to answer the second research question: How can the role of housing corporations in the energy transition be understood?

5.1 The ever-changing role of housing corporations

The Dutch national government has assigned the implementation of the current energy transition in the built environment, and thereby the housing sector, to municipalities (RVO, 2017). The local level suits best for determining the alternatives for meeting the energy demand, as energy infrastructure, storage and sources are often organized locally (Klimaatakkoord, 2018). All municipalities have to deliver a (Heat) Transition Vision by 2021, including a planning for making neighbourhoods gas free in an inclusive and affordable way. The neighbourhoods in which housing corporations have a large share of ownership are seen as an effective starting point for the transition. Corporations provide a unique opportunity to progress the energy transition: they own approximately 2.5 million homes, which add up to 30% of the total housing market (Ministerie van BZK, 2018), and (are argued to) have financial reserves to invest in energy targets (Schilder et al, 2016). Corporations are therefore seen as the actors that should and could boost the energy transition.

Dutch housing corporations were public and semi-public institutions, financed by the national government until 1995 (Koffijberg, 2005). In 1995 they were privatized, making them financially independent. The Dutch national government tried to influence corporations with financial schemes, strictly monitored by economic and social performance indicators. The energy efficiency levels of houses were not part of these indicators for a long time (Walker & Van der Zon, 2000). But since 2008, energy savings have become more dominant within the social housing sector (Aedes, 2013). The sector adopted the EPBD standard (European Parliament, 2012). The EPBD for Dutch housing corporations is described in the Energy Saving Covenant for the Rental Sector (2012). The Covenant is a voluntary agreement between Aedes – the umbrella organisation of housing corporations – the national tenants union and the Dutch national government. The current aim is to achieve an average EPBD of 1.25, corresponding to an energy label B, by the end of 2020 (Ministerie van BZK, 2014), and to become energy neutral by 2050 (Aedes, 2018).

To prevent that housing corporations focus too much on side issues, such as risk taking activities to increase revenues, the tasks of the corporations have been restricted in 2015 and laid down in a revised Housing Act (Rijksoverheid, 2015b). With the Act the governments want to ensure that corporations focus on their core task, which is affordable and quality housing for low-income groups. Through this, corporations may, but not (yet) have to, invest in renewable energy renovations that will result in a label higher than B. Besides, even to reach an average of label B by 2021, the pace of renovations need to go up (Fillipidou et al, 2017). This means that corporations need to be willing to invest in innovative energy systems. Municipalities are able to exercise influence and encourage corporations to invest in energy issues through subsidies and legal permits (Hoppe, 2012). Nonetheless, the municipality remains dependent on the willingness of corporations to cooperate. Through this, corporations have an influential say in decision-making and decide whether or not and how much to invest in energy targets. Consequence is that there is a gap

between municipal ambitions and practical realizations (Hoppe, 2009). The role that the government has reserved for corporations as frontrunners in the energy transition is thus somewhat paradoxical: corporations should focus on their core tasks while at the same time be willing to function as a starting point for the energy transition. A question that remains is: how do corporations see their own role in the energy transition? The next section will dive into this.

5.2 Balancing affordability, availability and sustainability

To understand how housing corporations experience their role in the energy transition, nine narrative inquiries and seven check-up interviews have been done to verify or falsify the findings. Through this, it has become clear what corporations see as their responsibilities and priorities regarding the energy transition.

Affordability, availability and sustainability

The housing corporations sector has committed to have an *average* of energy label B by the end of 2021, and to be energy neutral by 2050 (Aedes, 2018). Some corporations have formulated additional ambitions, for example: De Goede Woningstichting in Palenstein has the ambition to have an average of label A by 2035 (Interview, R1, 2019a). Not all housing corporations have, however, formulated a concrete vision on how to make their stocks more sustainable and to phase out natural gas, as the energy transition is still in its infancy (Interview, R9, 2019a). Yet, a few common components have been identified.

According to all interviews, affordability, availability and sustainability are the core values; the main components of every housing corporation. The first two are seen as the most important components, as corporations carry the responsibility to offer affordable, qualitative housing to lower income groups (Boelhouwer & Priemus, 2014). In the last few years, sustainability has become a third component, see figure 13. Sustainability involves CO_2 reduction through measures that vary between corporations: some focus on energy renovations in dwellings only (Interview, R4, 2019a), others take the use of materials (circularity) or their own office buildings also into account (Interviews with R6, 2019a; R1, 2019a). Energy renovations involve either insulation or a full renovation (Interview, R6, 2019a). Insulation is applied to better retain the heat in houses and reduce energy consumption. According to all interviews, this is the first measure housing corporations apply if possible. Full energy renovations involve a technological upgrade, which allows the switch from natural gas to alternatives (see Appendix 7). Corporations can apply different combinations of insulation and full renovation measures to reach an average of energy label B by 2021. But, these measures will only yield its results when tenants will adjust their behaviour to the new energy systems (Interviews with R9, 2019; R6, 2019a).

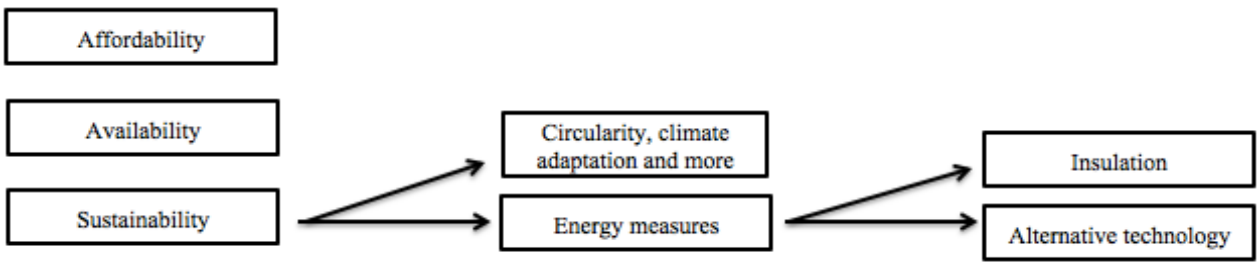


Figure 13. Overview of the visions of housing corporations, specifically on sustainability.

Although the component sustainability is often not a priority or goal in itself, with every renovation carried out by corporations, it is seen as important to investigate how this can be done in the most sustainable way, without affecting the affordability and availability (Interviews with R4, 2010; R7, 2019; R5, 2019a; R2, 2019). Nevertheless, the balance between the three components is dependent on financial possibilities of corporations (Interviews with R4, 2019a; R1, 2019a; R5, 2019a), political choices (Interviews with R8, 2019a; R4, 2019a) and the state of the economy (Boelhouwer & Priemus, 2014).

5.3 Conclusion – sustainability if convenient

Housing corporations have incorporated sustainability into their vision for the future. Sustainability is a broad concept, which includes energy measures. Corporations can apply different combinations of insulation and full renovation measures to reach an average of energy label B by 2021. Whether this target, or more ambitious targets, can be met, is highly dependent on numerous situational factors. And even when these factors favour energy measures, it is dependent on the willingness of corporations to invest in such, as their main focus is affordability and availability of houses. The role of corporations in the energy transition is thus a contested one, as they are expected to be progressive but in reality (can) only apply energy measures if it is convenient.

Chapter 6. Challenges for housing corporations in the energy transition

This chapter sheds light on the challenges that housing corporations experience in the energy transition in the Dutch housing sector. It tries to answer the question: What are the challenges for housing corporations in the energy transition in the Dutch housing sector? The challenges are identified using narrative inquiries and check-up interviews, supported with secondary data, and linked to the building blocks of SSI to understand which dimension(s) require(s) adjustments and/or where mismatches can be found.

6.1 Challenges encountered by housing corporations

There is a major focus on challenges related to the energy transition in the housing sector, in both literature (see for example Faber & Hoppe, 2013; Hoppe, 2012; Van Lidth & Midden, 2014; Fillipidou et al, 2018), and in media (see for example Van der Walle, 2017; Vermeeren, 2018; Huisman, 2018). This section provides insight into challenges encountered by housing corporations, identified by means of narrative inquiries. See figure 14 for an overview.

Financing Affordability, Availability and Sustainability

Housing corporations face difficulties in balancing affordability, availability and sustainability, as there is only a limited amount of money, and loan, available (Interviews with R6, 2019a; R2, 2019). Especially in urban areas where the demands for new houses as well as more sustainable houses are high (i.e. Randstad), corporations experience conflictions in demands (Faber & Hoppe, 2013). Corporations tend to invest in the increasing housing demand, rather than in quality demands such energy efficiency issues. This is, among others, due to the somewhat contradictory policies that the national government has imposed on them. Firstly, corporations need to focus on affordability and availability according to the new Housing Act (of 2015), they are in fact prohibited to invest in "other tasks" than affordability and availability, documented in, among others, Article 47 and 48 of the Act (Interview, R6, 2019b). At the same time, the government designated corporations as the driving force behind the energy transition. Secondly, corporations are expected to ensure affordability, availability ánd sustainability, while the Dutch national government imposed several new tax policies on corporations in the last few years (corporation tax, tenants' levy, higher tax on natural gas), which are highly expensive (Interviews with R5, 2019a; R1, 2019b). Thirdly, corporations have to be energy neutral by 2050, while they are also legally restricted to start energy renovations without permission of 70% of all tenants. Corporations are, according to R1 (2019b) "attacked from all sides". Financing the energy transition is therefore seen as a long-term project (Interviews with R7, 2019; Schaapkhok, 2019a), especially now that many energy alternatives are not yet economically appealing (Interviews with R4, 2019a; R5, 2019a).

We have to do a lot of investments now in new buildings ánd sustainability (R6, 2019a, translated).

The New Housing Act and the political statements made, contradict each other (R8, 2019b, translated).

We are active in too many neighbourhoods to phase out natural gas all at once (R2, 2019, translated).

There is no optimal energy alternative to gas (yet)

Almost all respondents mentioned that the future without natural gas is highly uncertain. There is no 'one-fits-all' alternative energy source or technology available on the market yet. The possibilities to phase out natural gas are highly dependent on the availability of sources in he surrounding area, for example geothermal energy or industrial residual heat, and on the decisions made in the Regional Energy Strategies (RES, see Appendix 6) (Interview, R2, 2019). Also, the status and characteristics of houses have a role in determining the options to phase out gas. For example, corporation Ymere owns a number of monumental buildings, in which it is legally controversial to apply alternative energy measures (Interview, R6, 2019a). Or, corporation Vestia owns many flats, which are more difficult to connect to alternative energy sources than single-family homes (Interview, R5, 2019a). But even when contextual factors allow alternative energy measures to be applied, it does not always make sense to do so, as some houses will lose their value in the near future due to their location in a shrinking area (Interview, R7, 2019). Another aspect that makes the future uncertain is the lack of competitive alternative technologies. Technologies develop rapidly, but no optimal business case has been found (Interview, R6, 2019b). The system based on natural gas is financed nationally, whereas the alternatives will have to be paid by the ones that will use it. This makes alternatives more expensive than our conventional eneryg system. But the alternatives are also noisy and not reliable, do not supply as much energy as natural gas, and still depend on subsidiaries.

Renovating monumental sites is an interesting challenge for the future (R6, 2019a, translated).

We can say 'this technology is the future' but that can change within two years (R3, 2019a, translated).

Tenants need to be willing to change too

Tenants, with 70% or more, need to approve a project plan to start a renovation (Hoppe and Lulofs, 2008; Interview with, R6, 2019a). This is complex, especially when it comes to energy renovations, considering that tenants mostly do not have sustainability as a priority (Interviews with R9, 2019a; R7, 2019; R5, 2019a). In fact, a recent study showed that the majority of tenants have little interest in the energy performance of their homes (Vringer et al, 2016). They mostly worry about increasing rents. Convincing tenants to approve energy measures that may result in an increased rent is challenging (Visscher et al, 2016). This is not only challenging because of the costs, but also due to possible language barriers that complicate communication, and because the implications of energy measures cannot be guaranteed (Interviews with R5, 2019a; R7, 2019). The implications of energy measures for the energy bill of tenants are, for example, based on averages. Whether the energy bill of a tenant will change after measures have been taken highly depends on the behaviour of tenant (Interview, R3, 2019a). Further, energy measures, especially when it involves an alternative to natural gas, have implications for tenants' freedom of choice. A heat district, for example, implies that tenants are forced to consume energy from one certain supplier (Interview, R1, 2019b). Such implications can hamper support of tenants (Interview, R4, 2019a).

Most of our tenants are not very concerned with sustainability (R6, 2019a, translated).

Some tenants say: tell me what to change; I will do it, provided that it won't imply any costs (R9, 2019a, translated).

Housing corporations have been given a task that tenants can obstruct (R1, 2019b, translated).

Lacking an integral approach

Housing corporations find it challenging to cooperate with other agents involved in the energy transition in the housing sector. Agents all have their own schedules, ambitions and financial possibilities regarding energy renovations (Interview, R7, 2019). In the past, agents, including corporations, started a renovation whenever it was in their own interest. Nowadays, actors are interdependent, especially when it comes to changing infrastructures in (the underground of) the built environment (Interview, R2, 2019). There is a maze of infrastructures in the underground, involving many agents other than corporations, e.g. municipalities, grid operators, sewerage companies, project developers (Interview, R6, 2019a). If one agent decides to renovate or replace infrastructures, it will inevitable affect/damage other agents' infrastructures. Agents are currently awaiting clear guidance from the municipality on how to deal with such situations. There is no regulatory framework on a municipal level for managing changes in the built environment in the context of the energy transition. Stakeholders are dependent on each other's willingness to invest money. Willingness is not always present, especially when investments imply a divestment for certain stakeholders, which occurs when renovations are made before the value of the object that is being renovated has expired (Interview, R2, 2019). Further, the one that initiates a renovation plan is the one paying for most of the changes, documented in CORA[3], which obstructs stakeholders in taking action (Interview, R8, 2019a).

Infrastructure under the ground is like spaghetti (R6, 2019a, translated).

Communicating with stakeholders in Gentiaan was time-consuming; we did not have that time (R6, 2019a, translated).

Split incentive

Housing corporations experience a split incentive in the energy transition, i.e. homeowners have no incentive for making energy investments from which their tenants will have the main benefits, and tenants have no incentive to invest in the homeowners' property (Faber & Hoppe, 2013). Corporations must raise the rents to be able to recover (some) investments costs of energy measures (Interviews with R6, 2019a; R4, 2019a). But, changing the energy supply of dwellings is often part of maintenance; rents cannot be raised if renovations fall under the guise of maintenance (Interview, R8, 2019b). And even when it is possible to raise rents, the investments are usually too high and can never be fully covered by increased rent, which means that corporations need to invest without full return (Interview, R1, 2019b). Some investment costs can be covered through the Energy Performance Refurbishment (EPV): a national law through which corporations can ask a refurbishment (maximum 130 euros a month) from tenants after energy renovations. The EPV can, however, only be applied if the renovations fulfil strict criteria, which often imply major investments (Interview, R5, 2019b). The large amounts of investments that need to be made by corporations are thus at odds with the limited options to earn this money back.

It costs us way too much money (R4, 2019a, translated).

We spend way more much than we earn, you cannot keep this up for long (R1, 2019a, translated).

[3] CORA stands for *Coördinatenstelsel Werken Aan de Weg*, and is a policy through which organizations that work in public spaces can coordinate their plans (Interview, R8, 2019b).

Challenges encountered by housing corporations
• Financing affordability, availability and sustainability
• There is no optimal alternative to gas (yet)
• Tenants need to be willing to change too
• Lacking an integral approach
• Split incentive

Figure 14. Overview of the challenges encountered by housing corporations.

6.2 Challenges linked to the building blocks of SSI

The challenges housing corporations encounter in the energy transition have been identified by means of narrative inquiry, which allowed respondents to tell about their experiences without much explicit steering. The second round of interviews aimed at linking those challenges to the building blocks of SSI in an explicit manner; see Appendix 4 for the interview guide. This section provides insight into these results, and is summarised on figure 15. Noteworthy is that the four building blocks differentiated in theory overlap in practice (Malerba, 2002).

Institutional framing

The institutional framing surrounding the energy transition in the housing sector comes along with various challenges for housing corporations. National energy targets and corresponding policies have been set to foster the energy transition and to reduce CO_2 emissions, but what these precisely entail for corporations is uncertain (Interviews with R2, 2019; R6, 2019b). National regulations have not yet been converted to regulations on the level of the municipalities, i.e. the level at which corporations operate. Corporations are highly dependent on the decisions made in the RES, and in turn, in the municipal heat plans (Interview, R2, 2019). These are currently still under construction, making corporations dependent on the willingness of other agents to invest (Interview, R1, 2019b). This hampers corporations in taking action (Interview, R6, 2019b). Besides this, the national government has imposed several, somewhat contradictory, measures on corporations in the last decade: corporations need to focus on and secure affordability and availability of houses (through the Revised Housing Act); corporations need to pay more taxes (through the tenants' levy, the increased company taxes and taxes on natural gas); ánd corporations need to be frontrunners in the energy transition. In addition, corporations need to be energy neutral by 2050 while being legally restricted to start energy renovations without permission of 70% of the tenants involved and to recover the major investments through increased rents. The corporations see investing in the energy transition as an additional financial burden, due to the many other measures that have been imposed on them (Interview, R1, 2019b). The informal regulations, on the other hand, are more supportive. There is a common believe that corporations carry a responsibility for striving to a low carbon future. To offer affordable housing of good quality to lower income groups is, however, seen as the main task (Interview with R6, 2019a; R7, 2019; R2, 2019, R9, 2019a). All in all, playing an effective role in the energy transition in the housing sector is made very difficult for housing corporations by the uncertainties and contradictories in the institutional framing. In terms of SSI, the institutional framing is a challenge for corporations.

Agents and networks

The energy transition in the housing sector requires from housing corporations to cooperate with other agents. There are many other agents, both primary and secondary, involved in energy measures, especially when natural gas is (to be) phased out (Interview, R2, 2019). Collaboration is required, but a municipal framework for such collaborations is lacking. The sector is fragmented as collaborations are often based on once off projects (Faber & Hoppe, 2013). The municipalities do not take a leading role, neither in directing nor financing, and it is uncertain who will and can take responsibility for what task (Interview, R6, 2019b). In addition, energy renovations are often a major divestment for housing corporations and other agents, as the value of their infrastructure has not yet expired. And even when investments are made, questions of ownership pop up: who owns, benefits and is responsible (Interview, R1, 2019b). Changing the energy system in dwellings owned by housing corporations is therefore currently a complex, time-consuming and expensive task. And even when all actors are willing to invest, more than 70% of all tenants will need to approve the plan, which is a challenge on its own. Other agents involved can thus obstruct the task that corporations have received from the national government. In a nutshell, there are challenges in terms of responsibilities, communication and cooperation between housing corporations and other agents, and the formal frameworks that should guide these aspects.

Technological regime

The *technological regime* poses a challenge for housing corporations as the available energy efficiency and renewable energy measures are expensive, unreliable - because the *market demand* is not fully developed - and not generally applicable (Interview, R8, 2019b). There is no 'one-fits-all' alternative energy technology available on the market yet. The corporations analysed own large parts of the building stock in Dutch urban areas with a large variety of houses and apartment buildings and in a variety of urban settings, for which there is not a single and common energy alternative to gas. This requires a different approach in every area (Interview, R3, 2019a). Corporations are currently experimenting with several alternatives to learn how they work and what the pros and cons are. The knowledge base is still under development. In addition, the easiness for the technologies to be introduced and possibility to extract profits from them is not optimal either (Interview, R1, 2019b). Implementing alternatives takes time, money and does not yield much profit at the moment. Through this, alternatives are not yet a logic sequel of the technologies and infrastructures based on natural gas. The current state of the technological regime is therefore a challenge for corporations that are expected to invest in such alternatives on a large scale.

Market demand

The market demand is related to the current state of the technological regime. There are alternatives available and in development, but they are not yet optimal. The main preferences are based on reliability, i.e. the supply of energy is secured, and affordability, i.e. the cheapest option to lower CO_2 emissions and to eventually phase out natural gas (Interview, R8, 2019b). The availability of such options is, however, limited. According to R6 (2019b) this has, partly, to do with a split incentive: the ones that make the investment do not directly feel the benefits. This retains the demand for alternatives. Given that legally binding ambitions for the energy transition have been set by the government, housing corporations hope that market demands will develop favourably (and technologies will become cheaper) over time (Interview with R6, 2019a; R5, 2019a).

Building blocks of SSI	Pose a challenge to corporations
Institutional framing	• A **lack of a municipal coordination** make it challenging for corporations to start acting • Policies are contradictory, making it challenging for corporations to invest in **affordability, availability ánd sustainability**
Agents and networks	• A **lack of municipal coordination**, and a clear division of roles, make it challenging for corporations to cooperate with other agents • More than **70% of all tenants need to approve** the plan, which is a challenge on its own
Technological framing	• The possible alternative energy sources and measures depend on contextual factors, and are still **highly uncertain** and expensive, making it challenging for corporations to invest in
Market demand	• The availability of reliable and affordable alternative energy technologies is limited. Investing in such options results in a **split incentive**, making it challenging for corporations to do so

Figure 15. Overview of the challenges for corporations related to the building blocks of SSI.

6.3 Conclusion – systemic changes are required

Multiple challenges have been identified that hamper housing corporations of being frontrunner the energy transition in the Dutch housing sector (fig. 15). There are contradictions in the institutional framing, as corporations are expected to undertake action on the transition while being dependent on others' decisions and being obliged to pay more taxes but secure affordability and availability. There is a lack of clarity on how to (net)work with other agents, and it is unclear who will pay for what costs. The technological regime and related market demands are also not yet favouring the role of corporations in the transition yet: technologies are expensive and require specific contextual circumstances to be applied in a certain neighbourhood. These statements imply a *mismatch*: the various parts of the system do not evolve coherently. Politicians have set the transition in motion and pushed corporations forward, whereas the majority of the parts of the sector do not "support" such changes. Consequently, there is not to speak of a break through of our lock-into natural gas yet. Systemic changes are required for corporations to fulfil their imposed tasks. But systemic changes are highly dependent on the numerous levels and internal and external structures (see sections 2.1); there is no simple driver in transitions. The next chapter therefore dives into the steps that can already be taken by housing corporations to improve their energy-transition efforts.

Chapter 7. Advancing energy-transition efforts of housing corporations

The role of housing corporations in the energy transition in the Dutch housing sector comes along with multiple challenges, that relate to broader systematic mismatches, as shown in the previous chapter. Systematic changes, however, do not happen overnight and require big steps that are beyond the scope of this study. This chapter explores the steps that corporations can already take to advance their energy-transition efforts, as a first gesture towards sectoral solutions, and provides an answer to the following question: What steps are and can be taken to advance the current energy transition in the social housing stock?

7.1 Steps towards the energy transition

The energy transition in the housing sector is still a major search for housing corporations, according to almost all interviews. The transition is still in an initial phase, and much remains to be learned (Interviews with R9, 2019a; R2, 2019a). A few components have been identified as steps that could advance energy-transition efforts made by corporations.

Focus on no-regret options

The future without natural gas is highly uncertain to corporations, due to the uncompetitiveness of alternative energy technologies (*technological regime* and *market demand*) and the contradictories of policies (*institutional framing)*, as mentioned in section 6.2. Housing corporation therefore apply no-regret measures to prepare for a future without natural gas, as they cannot invest their money in energy targets only, and are hoping that the future will offer sustainable energy technologies with a better financial return (Interviews with R6, 2019a; R1, 2019a; R2, 2019). A no-regret action is cost-effective in the present, but will also be beneficial under a range of future scenarios. A step-by-step investment, which leaves room open for new options in the future, is currently seen as the best way forward. As R7 (2019) stated: “the energy transition is not sprint, but a marathon”. No-regret options ensure that corporations keep moving forward, without having to make all the investments at once (Interviews with R3, 2019a; R2, 2019). Corporation Ymere insulates homes to such an extent that it improves the energy label up to label B, but that it does allow for other alternative sources of energy to be installed later on (Interview, R7, 2019). Ymere believes that new technological innovations will allow more sustainable energy sources to be used in the future, and does not want to exclude these options by insulating homes to the fullest (Interview, R6, 2019a). This saves major investments in energy measures at the moment. Another example of a no-regret measure is that during a large-scale renovation, the necessary infrastructure is already installed for a possible heat network in the future (Interview, R7, 2019). Minor no-regret steps, such as the instalment of an induction plate, can be taken whenever it is convenient, for example during a ‘mutation’, which is the period of a home having no tenant because it is changing ownership (Interview, R2, 2019).

A no regret measure is one that we hope we will not regret in 15/20 years. Whether this will be the best measure is uncertain, but we act step by step (R6, 2019a, translated).

Becoming more sustainable is a marathon, not a sprint (R7, 2019, translated).

I hope we will reach the 2050 goals thanks to new techniques (R6, 2019a, translated).

Use renovations as a starting point

Housing corporations face conflictious demands in financing affordability, availability and sustainability due to conflictious implications of the *institutional framing*, as shown in section 6.2. Even when there is budget available for the transition, investments are often seen as a split incentive - investments will benefit the tenant but will result in an investment loss for corporations – which withhold agents to increase their *market demands*. However, all social homes require renovations once in a while. Most homes require small renovations every 25 years and large scale renovations every 50 years (Interview, R7, 2019). Ymere, for example, assessed that approximately 5000 of their houses will need to be renovated in the coming years (Interview, R8, 2019a). These renovations are carried out when the quality of the housing stock is due for improvement, at so-called "natural moments", e.g. when houses require maintenance and/or have low energy performance. The investments required at those natural moments are budgeted in a maintenance plan, *Meerjaren Onderhoudsbegroting* in Dutch (Interview, R1, 2019b). Although the primary focus of renovations is on quality improvement and "maintaining the assets", they are also excellent moments for implementing energy measures (Interview, R7, 2019).

Through renovations you can bring your housing stock up to present-day-standards. Sustainability standards can be included in these renovations at once (R6, 2019a, translated).

Renovations are rather linked to maintenance than to sustainability (R6, 2019a, translated).

The motivation is renovation (R8, 2019a, translated).

Investing in energy renovations at natural moments is thus advantageous because budgets are available. In addition, an evaluation of the interviews shows that energy renovations can contribute to affordable, qualitative and sustainable homes, which, all together, positively affect the worth of social homes (on paper). Through this, it is clear that energy renovations do not only imply energy improvements, but also contribute to wider social and economic benefits. The descriptions below provide insight into some benefits; for an extensive description refer to Appendix 9.

- *Affordability*. Investing in energy renovations provides an opportunity for corporations to maintain an affordable energy bill for their tenants (Interview, R5, 2019a). Social homes often correspond with low energy performance, which affects the monthly energy bill of families that occupy such dwelling. Investing in energy renovations can reduce energy loss and consumption, which may result in a lower monthly energy bill for tenants.

  A lower energy bill after energy renovations is an incentive (R9, 2019a, translated).

- *Qualitative housing.* Energy renovations offer the opportunity to maintain and foster a modern qualitative housing stock (Interview, R7, 2019). As mentioned, social homes often correspond with low energy performance, which implies that the quality of the buildings needs to be improved. Energy renovations therefore improve the general quality and comfort of social homes. Further, energy renovations – especially when gas is phased out – involve a safer and healthier living environment (removal of gas reduces the chance on explosions/fire and damaging gases to be released). Such houses are, obviously, more worth on paper than houses without energy improvements (Interview, R6, 2019a). This benefit offers a counterbalance to the 'split incentives' argument.

- *Sustainability*. Energy renovations, obviously, offer opportunities in terms of sustainability. It reduces CO_2 emissions and dependence on natural gas (Interview, R8, 2019a). The energy transition offers opportunity for housing corporations to take societal responsibility and set the right example to their tenants.

  We have signed agreements to reduce CO_2 emissions, as we would like to change the way we currently consume our planet's resources (R6, 2019a, translated).

  We strive for CO_2 reductions, not necessarily a specific energy label (R7, 2019, translated).

Show the benefits of the transition to convince tenants

The role of tenants, within the *agents and networks*, poses a challenge to corporations, as they need to agree with 70% or more on a renovation project, as shown in section 6.2. Convincing tenants of the needs for a renovation can be a daunting task when it may involve an increase in rent. It is therefore important for corporations to inform tenants in a persuasive, clear yet correct manner, prior to the project (Interview, R3, 2019b). A focus on the benefits of the energy transition for tenants – shown in the previous paragraph - could help in convincing tenants to accept renovation plans. For example, by showing different scenarios on how the energy bill can be reduced (Aedes, 2018). It can also be useful to show the results of energy measures in practice. Corporation De Goede Woning in Palenstein convinced tenants of their planned energy renovations by starting with a few houses, through which they could show the end results (Interview, R1, 2019a). These results, showing an improvement in the buildings' aesthetics, resulted in a 100% score of approval in the remaining houses. Another approach to get tenants along is to take care of ancillary matters, which involves small physical details or habits people are attached to, such as: sunshades installed to their old façade (Interview, R1, 2019a). This implies extra costs though.

It has been useful that tenants could see the successful end results of the energy renovations (R1, 2019a, translated).

Try to take minor wishes of tenants into account when planning energy measures; this will increase their willingness to approve the measures (R3, 2019b, translated).

Changing frames of energy renovations may also help in convincing tenants (Interview, R1, 2019a). Corporation De Goede Woning has reframed the three main responsibilities into appropriate housing, comfortable housing and liveability in the neighbourhood. Appropriate housing is about availability (including newly build houses) and affordability. The second is comfort, which is about sustainability but also basic quality standards for homes. The third is liveability in the neighbourhood, which can be stimulated when applying the first two. Through such frames, it becomes easier to explain why certain renovations will have to be made. But, informing tenants about the benefits of energy renovations is only relevant when there is certainty about the changes involved; it is about finding the right timing (Interview, R3, 2019a).

Sync renovation schedules

The *institutional framing* poses a challenge to corporations in that the energy targets, which have been set at the national level, have not yet been converted to regulations on the level of the municipalities, i.e. the level at which corporations operate. This obstructs corporations in taking action, and makes them dependent on the willingness of other agents to participate in coalitions to

jointly invest in energy targets/renovations. The regulatory framework on a municipal level needs to be adjusted and address the new roles and responsibilities of agents, in the context of the energy transition in the housing sector, clearly. In the neighbourhood Palenstein, agents are already experimenting with coalitions that jointly invest in (energy) renovations (Interview, R2, 2019). Palenstein has long been the most deprived neighbourhood of Zoetermeer (Interview, R1, 2019a). In 2004 the municipality of Zoetermeer decided to restructure the area, which included renovating old buildings and building new houses and new shopping centre. It was a few years later that the idea arose to phase out natural gas in Palenstein, to make it an "example neighbourhood" (Interview, R2, 2019). This integral approach of revitalising a neighbourhood in a sustainable way has been costly, but successful. Agents now know where and when to find each other, and can share knowledge and costs, for example by sharing the costs for hiring a counselling firm (Interview, R5, 2019a). Also, for agents such as grid operators it is more interesting to connect new infrastructure to multiple corporations/building blocks rather than to one. It would be effective in the future to sync renovation schedules – i.e. the natural moments for investing - of different stakeholders in a certain neighbourhood, and if needed, trying to align them (Interview, R2, 2019). The municipal Heat Transition Visions for 2021 will be important in safeguarding the interests of agents such as corporations and their desired planning for renovation (Interviews with R7, 2019). It becomes important to come to common ground on the type of collaboration and the moment(s) of participation (Sanders-Kaiser, 2019; Interview, R3, 2019a). Renovations can, then, contribute to broad social development, as investments to improve liveability, mobility and housing can be made together. Residents can be engaged on all developments in the neighbourhood.

The game changer of the energy transition is that stakeholders cannot manage solutions or renovations on their own anymore, but that decisions regarding the alternative, timing and investments need to be made together (R2, 2019, translated).

It would be useful if all stakeholders keep track of their renovation plans, and share these with each other (R6, 2019a, translated).

Plans for energy renovations here in Wageningen started with municipal plans to replace the sewage system; that is when all parties came together (R9, 2019a, translated).

Van der Pek neighbourhood is also being revitalised by the municipality. This is when interesting synergies come about (R7, 2019, translated).

7.2 Conclusion – challenges and solutions

Evaluation shows that the challenges identified by housing corporations can be addressed by focussing on no-regret options, taking generally needed renovations as a starting point for implementing energy measures, showing affordability and other benefits to tenants, and syncing renovation schedules of the various actors involved. These steps contribute to advance the effectiveness of energy-transition efforts by corporations, while at the same time making sure that the rights and well being of the tenants will not be compromised by these efforts. Figure 16 provides an overview of the challenges addressed by the different steps.

Solutions	Challenges
No-regret steps	• Balancing affordability, availability and sustainability • The alternatives to natural gas are uncertain
Renovations as a starting point	• Balancing affordability, availability and sustainability • Split incentive • Tenants need to approve
Showing benefits of the transition	• Tenants need to approve
Syncing renovation schedules	• Lacking an integral approach

Figure 16. Overview of the potential solutions for the challenges for corporations.

8. Conclusion: is the glass half empty or half full?

Housing corporations are designated by the national government to be the driving force behind the energy transition in the Dutch housing sector. Corporations are an important actor due to the fact that they, apart from their societal commitment, can introduce renewable energy renovations on potentially large scale. However, the goals set by housing corporations to improve energy efficiency by 2021 and become energy neutral by 2050 will be hard to achieve if the current pace of action is to be continued. This research has investigated the current view of five progressive housing corporations in three Dutch neighbourhoods on the energy transition with the objective to explore what specific challenges they encounter, and more importantly, how these can be addressed to advance the energy transition in the 2.5 million social homes. The following research question served as a guide:

How can a sectoral system innovation approach provide insight into challenges, and contribute to the search for solutions, for housing corporations in the current energy transition in the Dutch housing sector?

The first sub-question provided insight into the core building blocks of a SSI approach: institutional framing, agents and networks, technological regime and market demand. This approach contributes to understanding how energy innovations within the housing sector come about, and what challenges and thereby directions for potential solutions can be found.

The second sub-question elaborated on the SSI aspects, in the context of the current energy transition in the Dutch housing sector. The energy transition involves the switch from fossil fuels to renewable energy. This switch is easier said than done. Almost 7 out of 7.7 million homes are currently connected to natural gas for heat and electricity purposes, which causes major CO_2 emissions. The national government formulated multiple regulations to stimulate the transition, which are ought to be further elaborated and implemented at the local level. Multiple agents are involved locally, all with varying but yet unknown responsibilities regarding when and how to implement energy measures. The options for energy measures develop rapidly, ranging from insulation to alternative technologies. There is, however, little market demand for these options.

The third sub-question dealt with the role of housing corporations in the energy transition. Corporations own 29% of all Dutch dwellings, in which they provide affordable housing for a low-income population. In the last decade sustainability (in terms of energy) has become part of their portfolio of tasks. Corporations, however, see availability and affordability still as their core tasks; sustainability is incorporated in actions if possible, for example along with planned renovations. But, sustainability efforts are not considered highest priority and investments pertaining to the transition are highly dependent on the willingness and financial possibilities of corporations.

The fourth sub-question addressed the challenges that housing corporations experience in the energy transition, and offered a link to the core aspects of sectoral innovation theory. The *institutional framing* poses a challenge to corporations in a way that the policies set by the national government have various, yet uncertain, implications on a local level and are somewhat contradictory as they require housing corporations to pay way more taxes ánd make major investments in the energy transition. Corporations therefore face difficulties in balancing the investments needed to ensure affordability, availability and sustainability. The *agents and networks*

pose a challenge in a way that there is no municipal framework yet to guide energy renovations plans, and to make roles, communication and networks between the various agents clear. Establishing collaboration is, hence, a major time and money consuming activity. Not in the least the role of tenants, who need to agree on a renovation project with 70% or more of the vote, poses a challenge, as tenants are generally not concerned with sustainability matters. The *technological regime* is a challenge for corporations in that the available energy efficiency and renewable energy measures are expensive - because the *market demand* is not fully developed - and not generally and readily applicable. There is no 'one-fits-all' alternative energy technology available yet. Investing in energy related issues in dwellings is a complex decision as they currently mostly benefit the tenants, through a reduced energy bill, rather than the corporations, the so-called split incentive. The analysis of challenges has made clear that systematic changes are required for corporations to be able to advance their energy-transition efforts.

Systematic sectoral changes do, however, not happen overnight and require big steps that are beyond the scope of this study. This research made an inventory of relatively small steps that corporations could undertake to advance their energy-transition efforts. Firstly, corporations can focus on no-regret measures, as there is no optimal alternative to natural gas (yet), awaiting arrival of sustainable energy technologies with a better financial return. Secondly, corporations can focus on planned renovations as a starting point for applying energy measures. "Energy renovations" can be applied at such natural moments, when there is budget available. These renovations, then, contribute not only to affordability and availability, but also sustainability. Thirdly, corporations can explain the benefits of energy renovations in combination with affordability and quality to tenants to convince them of the value of such. Fourthly, corporations can synchronize their natural moments for renovations with the schedules of other local stakeholders, to ensure that investments are made together and at moments that it suits most stakeholders best. These types of collaborations will be time- and cost-effective.

In summary, and to answer the main research question, a SSI approach has been useful in clarifying the aspects involved in the energy transition for housing corporations, and in identifying multiple structural sectoral challenges as well as possible directions for solutions for the corporations themselves. In fact, the challenges currently experienced by corporations incorporate opportunities for advancing the energy transition in more than 2,5 million social homes. Moreover, the energy transition can contribute to what is now seen as most important to corporations: taking societal responsibility for affordable, good quality and sustainable social housing for those who need it. This implies that corporations do not need to focus primarily on broader systemic challenges, but could also focus on solutions that are already available. The glass is already half full.

9. Reflection: theories, methods, results

This chapter critically reflects on the theoretical usage and relevance, methodological approach and the content of this research. Based on these, suggestions for future research will be made.

9.1 Theoretical reflection – using SSI for a systemic exploration

Abundant literature on transitions is available, which try to explain historical transformations, and how these may help in understanding the future (Geels, 2005; Hermwille, 2016; Osunmuyiwa et al, 2018; Wieczorek, 2018). This is not surprising given that transitions have had and still have major implications for societies. There are, however, so many aspects involved in and of influence on transitions, that they remain inherently uncertain (Frantzeskaki et al, 2012a).

The MLP theory tries to capture all aspects, the dynamics between these aspects and their evolution (Geels, 2002). The theory focuses on the overall process, but is historically orientated and offers little insight into how sub-systems of society, e.g. the housing sector, or even individual agents, e.g. housing corporations, evolve (Geels, 2011) – and is therefore of little use in analysing and understanding the energy transition Dutch housing corporations are facing.

An SSI approach has been used and proven applicable in this study to explore the four core dimensions of the energy transition in the Dutch housing sector, using housing corporations as an entry point. The 'duality of structure' theory provides an explanation of the behaviour of one actor (housing corporations) in the context of SSI. This theory argues that behaviour of an agent can be understood by looking at the broader structures around them (Stones, 2005), in this case the four building blocks of SSI. Through this, a SSI approach is useful in systematically examining the functioning and experiences of housing corporations, and in linking these to the broader dimensions of innovation. Although SSI only captures the aspects of sectoral innovation and not the full picture of transitions outlined by MLP, it does provide insight into the status and progress of the current energy transition as a whole. Referring to section 2.1, transitions usually come about in four phases (Geels, 2018). The current state of the Dutch energy transition can be linked to the either the first or second phase (RMNO, 2010). The first phase is about testing and learning about the new technologies and regulatory frameworks, the second phase is about improving these alternative rules, designs, preferences, etc. It has been repeatedly mentioned in the interviews of this study (R9, 2019a; R2, 2019; R3, 2019a) that actors, including housing corporations, still need to learn about the energy transition: that the transition is still in its infancy. Technologies, policies and new lifestyles are available, tested and improved in pilot projects. In terms of MLP, the major transformation – in which the "alternatives" become the "dominant way" – has not yet happened.

The SSI approach has been less useful in identifying the specific details involved in the challenges encountered by corporations. For example, the limited availability of affordable and reliable technologies on the markets have been identified as a challenge through the SSI approach, but the specific technological characteristics making these technologies currently unreliable, did not become apparent. This is partly due to the fact that SSI focuses on the sectoral level rather than the specific characteristics of technologies or policies, but more importantly, due to the fact that the transition is still in its infancy and little is clear regarding details (Interview, R9, 2019a; RMNO, 2010). By consequence, the emphasis of this research is more on context and framework than on details.

Another limitation of SSI is that no feedback loops are taken into account. As MLP describes, there are complex dynamics and feedback loops between the various parts of a system in transformation (Geels & Schot, 2010). There is no one simple cause or driver in transitions. The SSI approach, in general, does not capture feedback mechanisms; these were therefore not analysed in this study. What has also been left out, due to time constraints rather than theory-limitations, is to investigate why certain challenges occur within a transition or, in other words, what the deeper mechanisms are that block the desired innovation. This, most likely, has to do with (carbon) lock-ins: i.e. the large, dominant (fossil fuel-based energy) systems that inhibit the introduction of alternative (energy) technologies (Unruh, 2002). More literature on this, to explain the deeper mechanisms and power relations that block innovations, could have made this study theoretically stronger.

9.2 Methodological reflection – using narrative inquiries to avoid steering

This research has made use of narrative inquiries. A narrative inquiry can be used as an interview technique to explore people's experiences, without steering them towards a certain direction (Paschen & Ison, 2012). Narrative inquiry proved very useful in examining the role of housing corporations in the current energy transition, a role that is subject to debate. Respondents felt free in telling how they feel about their designated role and what really matters to them.

This method had some unexpected outcomes, e.g. the government designates corporations as frontrunners in the energy transition whereas corporations do not regard energy issues as their priority (Interviews with R4, 2019; R7, 2019; R5, 2019a; R2, 2019). The results were checked in a second round of interviews, with questions structured in the theoretical context. Through this combination, it has been possible to validate the results of the first round interviews, in the context of SSI. There was, however, little room for respondents to supplement theory.

The insights of this study are only applicable to one actor: housing corporations. And it may not even apply to all corporations, as the corporations that have been examined for this research are progressive in the energy transition. This is one the main methodological weakness of the research. The strength of transition concepts such as SSI is that they allow analysing the interactions and processes among a variety of actors (Malerba, 2002), whereas this study only describes one actor.

The methodological approach chosen for this research was not necessarily the only correct way to explore the topic in question. A quantitative analysis among a larger (representative) group of corporations on what challenges they encounter (referring to the indicators mentioned in Appendix 2) and how urgent these are (relatively) would provide better insight into which aspects are seen as most obstructive in progressing the energy transition. The results would then, however, be fully guided by theory (SSI), with little possibility to grasp feelings and experiences effectively.

9.3 Reflection on results – suggestions for future research

From narrative inquiries to a narrative approach

In this research, narrative inquiries have been used as a method to examine the experiences of housing corporations in the energy transition. The components of a narrative approach *sensu* Paschen & Ison (2014) have been used to guide the narrative inquiries, to make explicit the challenges and potential solutions that corporations see for themselves in the energy transition. The elements of the narrative inquiries could, then, also be used for constructing a narrative approach.

A narrative approach is a way to formulate meaningful stories, *narratives*, about future changes that a certain community will confront (Paschen & Ison, 2014). The concept of 'narratives' has been used in a range of disciplines to address future subjects, such as the energy transition, that may be difficult to engage with (Jones & McBeth, 2010; Howarth, 2017). A certain level of engagement with future changes is necessary to create the appropriate circumstances for new measures to be introduced and implemented (Howarth, 2017). In other words, a certain level of engagement with the current energy transition is required to switch from ambitions to actions, and to close the action gap mentioned in the introduction (Bushell et al, 2017). There is, however, a lack of understanding on how people can be better engaged with the future to address the action gap (Bushell et al, 2017). Psychological research on climate communication states that changes in behaviour will not occur without both cognitive engagement (understanding the issue) and affective engagement (caring about the issue), and that the latter is most influential in shaping action (O'Neill et al, 2013). Most policy efforts around climate communication have focused on cognitive engagement: informing about causes and implications (Whitmarsh et al, 2011). This type of engagement lacks an understanding of what people actually care about (Weber, 2006). Narratives are proved to be a useful communicative tool to (affectively) engage actors to future system changes (Miller et al, 2015; Bushell et al, 2017). Future research could elaborate on this research by using the elements of the narrative inquiries to constructing a narrative approach to engage corporations, and possibly also their tenants, to a future without natural gas.

From practical insights to theoretical explanations

Not all content of this study could easily be related to theory. What has been surprising for example, but could not directly be linked to theory, is that the energy transition can actually be seen as an opportunity to housing corporations, instead of a major challenge that has been assigned as an "extra" task that conflicts with their core business. A focus on the synergies between the energy transition, and affordability, availability and sustainability, may make the transition a lot more attractive to corporations. The study of Ferreira & Almeida (2015) made a first step in identifying the "attractive" aspects of the energy transition. The authors argue that there is currently a major focus on social economic barriers regarding energy renovations, which is in line with the findings of this research. The full added value resulting from energy renovations in buildings is underestimated. In most cases, energy renovations are evaluated by only looking at the savings resulting from the reduction of energy use and the financial investments of implementing energy measures (Ferreira et al, 2014). Ferreira and Almeida (2015) developed a framework to clarify all direct and indirect benefits resulting from building renovations. A few of such benefits have already been described in Appendix 9. These insights may help in convincing corporations, or other actors, of the relevance of energy measures. Future research could dive deeper in such framework for housing corporations.

Another aspect, which could not directly be related to the theories used, is that the current energy transition is significantly different from the Dutch energy transition in the 1960s. A large-scale renovation took place in the 1960s to connect the Dutch built environment to natural gas, replacing coal (Verbong & Geels, 2007). Within a decade 80% of the Dutch households were connected to the national gas grid. The (relatively little) amount of time it took 50 years ago to connect these houses to natural gas will unfortunately not be comparable to the current transition. Some differences can be identified that favour the transition in the 1960s. First, the switch from coals to gas meant a cheaper and more constant supply; the advantages of heat from a renewable source versus fossil fuels are not very apparent to households: it seems more expensive and the supply is

not reliable (Noorman & De Roo, 2011). Second, the switch from coal to central heating implied a major improvement in comfort: rooms could be heated quicker, without the dirt of coals (Interview, R5, 2019a). The current energy transition has less visible improvements in comfort. Third, the role of the government has changed: the transition in the 1960s was managed by a few public and private organizations (RMNO, 2010). Nowadays there are more influential organizations in the (internationalized) energy sector. It is unsure who is responsible for directing the new energy system, as it is not necessarily the national government anymore (Interview, R1, 2019b). Fourth and last, there is no one alternative or solution for the future (RVO, 2017). There are multiple options within a small geographical area (Interview, R1, 2019b). A different approach or innovative energy system will be chosen for each neighbourhood. Future research could explore the aspects that may favour the current energy transition, relative to the fossil fuel-dependent system, to encourage changes towards such future.

A last result that could not be linked to theory, but is of significant importance, is the question whether corporations are the right actors to be designated as frontrunners. Although this question was not the focus of this research, it was inevitable that this would be reflected in the interviews. The answer appears to be two sided. On the one hand, corporations are a useful starting point for the transition: they own large parts of the residential sector in which they carry the public responsibility to provide social homes to today's standards (Interviews with R8, 2019a; R4, 2019a; R1, 2019a) and are a relatively easy group to communicate with, as the national government can make agreements with Aedes (Interview, R2, 2019). The role for corporations in terms of the energy transition is a broad and highly ambitious one, but also one that can be achievable when the right conditions are there (note: this is currently not the case yet) (Interview, R1, 2019b). Also, if corporations start to invest in energy efficiency and renewable energy technologies, the alternatives will become more competitive (Interview, R5, 2018). On the other hand, corporations cannot be a driving force if they get different tasks imposed on them by the national government (Interview, R1, 2019b), as explained in section 6.1 'Financing affordability, availability and sustainability'. R1 (2019a) mentioned that it is unfair to designate corporations as frontrunners. Corporations are not profit driven; they have to work with the rents they get from the least affluent parts of society (Interview, R2, 2019). Besides this, corporations are highly dependent on the decisions made by others (provinces, municipalities, tenants), and can thus not simply start acting. Frantzeskaki et al (2012b) made a similar conclusion: do not concentrate completely on the first movers (i.e. corporations) in the transition arena, but crease mass to get the regime on board. Future research could therefore examine the perspective of tenants or local authorities, as corporations are dependent on the willingness of tenants for approval of energy renovation projects and on the conditions set by local authorities (Hoppe, 2012; Hoppe & Lulofs, 2008). It may also be useful to examine the perspective of private homeowners, who own 58% of all Dutch homes, and cannot be forced yet to phase out natural gas (Ministerie van BZK, 2018). This would provide better insight into what is required to succeed the transition.

We cannot be a frontrunner simply because we are an easy point of contact or own a lot of real estate; gained over the backs of least affluent citizens of the Netherlands (R2, 2019, translated).

Corporations are seen as the pioneers in the transition, whereas they actually do not have the money (R5, 2019a, translated).

Let's be a smart follower (R1, 2019a, translated).

9.4 Conclusion – think big, act together

What has become clear to me in this research is that the energy transition requires a completely different way of thinking and acting from all of us. We live in a highly interconnected society in which changes in one subsystem of society will inevitable affect other parts (Rotmans et al, 2001). The energy transition requires system thinking. Also, with the New Environmental Law coming up in 2021 it will become more important to engage the public and other organizations/ institutions in decision-making (Ministerie van I&M, 2016). The government cannot work with blueprints anymore, or simply point housing corporations forward as the driving force. Responsibilities are shared and interdependent, and have a different meaning in every local context Housing corporations cannot "just" fulfil the task that has been put into their lap, which explains why they encounter so many challenges (Interviews with R1, 2019b; R6, 2019b). I believe that urban planners have the task to balance the different interests and challenges that come together in the physical and social environment, and to find ways forward that can be justified.

Appendix 1. A Dutch summary of the results

Nederlandse woningcorporaties staan voor een grote uitdaging, opgelegd als onderdeel van het Nederlandse overheidsbeleid om het land tegen 2050 aardgasvrij te maken, als vervolg op het Klimaatakkoord 2015 in Parijs: het afkoppelen van aardgas uit hun woningvoorraad van ongeveer 2,5 miljoen woningen tegen 2050 om klimaatverandering tegen te gaan. Hoewel woningcorporaties een unieke kans bieden om bij te dragen aan klimaatacties, is er nog steeds een grote focus op de belemmeringen in een toekomst zonder aardgas. Er wordt te weinig actie ondernomen. Dit onderzoek heeft inzichtelijk gemaakt welke specifieke uitdagingen woningcorporaties ervaren en hoe deze uitdagingen effectief kunnen worden aangepakt. De resultaten zijn gekoppeld aan de vier belangrijkste bouwstenen van innovaties in sectorale systemen: agenten en netwerken, institutionele kaders, technologisch regime en marktvraag. De volgende resultaten zijn geïdentificeerd.

Focus op no-regret opties

De toekomst zonder aardgas is onzeker is voor woningcorporaties. Dit heeft te maken met de huidige staat van het technologische regime en de institutionele kaders. Het *technologische regime* vormt een uitdaging voor woningcorporaties omdat de beschikbare maatregelen voor energie-efficiëntie en hernieuwbare energie duur en onbetrouwbaar zijn - omdat de marktvraag niet volledig is ontwikkeld - en niet algemeen toepasbaar. Er is nog geen 'one-fits-all' alternatieve energietechnologie beschikbaar die dezelfde standaarden biedt als aardgas. Woningcorporaties ondervinden moeilijkheden bij het financieren van de energietransitie, omdat er slechts een beperkte hoeveelheid geld en leningen beschikbaar is om nieuwbouw te financieren én energiemaatregelen toe te passen in bestaande districten, zonder betaalbaarheid en beschikbaarheid te beslechten. Betaalbaarheid en beschikbaarheid zijn volgens de nieuwe (inperkende) Woningwet, onderdeel van de *institutionele kaders*, kerntaken van woningcorporaties, en mogen niet ten koste gaan van de energietransitie. Woningcorporaties focussen zich daarom op dit moment op ‘no-regret’ maatregelen. Een no-regret maatregel is in het heden rendabel, maar is ook gunstig in verschillende toekomstscenario's. Een stapsgewijze investering, waarbij ruimte overblijft voor toekomstige energietechnologieën met een beter rendement, wordt momenteel gezien als de beste manier voor het ondernemen van actie.

Gebruik renovaties als startpunt

De *institutionele kaders* vormen een uitdaging voor woningcorporaties doordat het beleid van de nationale overheid enigszins tegenstrijdig is: er wordt verlangd van woningcorporaties dat ze substantieel meer belastingen betalen én grote investeringen doen in de energietransitie; tegelijkertijd zijn ze verantwoordelijk voor het verzekeren van betaalbaarheid en beschikbaarheid van sociale woningen. Woningcorporaties ondervinden daarom moeilijkheden in het afwegen van de investeringen die nodig zijn om betaalbaarheid en beschikbaarheid te waarborgen en duurzaamheid te stimuleren. En zelfs als er ruimte is voor investeringen met betrekking tot de energietransitie in sociale woningen, dan worden deze vaak gezien als een ‘split incentive’: investeringen komen ten goede aan de huurders maar resulteren in een beleggingsverlies voor woningcorporaties, omdat de investeringen niet gedekt kunnen worden door verhoogde huur. Alle sociale woningen hebben, echter, af en toe een algemene opknapbeurt nodig. Deze renovaties vinden plaats als de kwaliteit van de woningvoorraad aan verbetering toe is en bieden mogelijkheid om tegelijkertijd energiemaatregelen op te nemen. Investeren in energie-renovaties op “natuurlijke momenten” is voordelig vanwege de beschikbare financiële middelen. Daarnaast kan het de

betaalbaarheid, kwaliteit en duurzaamheid van woningen verbeteren, wat vervolgens tot meer vermogenseffect voor corporaties leidt. Algemene renovaties kunnen daarom worden gezien als een effectief startpunt voor zowel de energiedoelstellingen als kernactiviteiten van woningcorporaties.

Toon voordelen aan huurders om hen te overtuigen

De huurders, onderdeel van *agenten en netwerken*, vormen een uitdaging voor woningcorporaties. Huurders moeten met 70% of meer instemmen voor een renovatieproject. Het overtuigen van huurders van de noodzaak van een renovatie is vaak lastig als de renovaties worden gekaderd in termen van energie/duurzaamheid. Huurders vrezen voor verhoogde huur. Het is daarom van belang voor woningcorporaties om huurders op een overtuigende maar correcte manier te informeren. Bijvoorbeeld door inzichtelijk te maken dat de energierekening van huurders omlaag kan gaan na een energierenovatie, of door het eindresultaat van succesvolle renovaties te laten zien. Daarnaast is het belangrijk om duidelijk aan te geven wat energierenovaties precies inhouden: meer comfort, kwalitatievere huisvesting en toegenomen leefbaarheid in de buurt.

Synchroniseer renovatieplannen

De *institutionele kaders* vormen een uitdaging voor corporaties doordat nationale ambities en regels voor de energietransitie nog niet zijn vertaald naar reguleringen op lokaal niveau, het niveau waarop woningcorporaties acteren. Energierenovaties, met name als gas wordt afgekoppeld, vragen grote aanpassingen in (de ondergrondse infrastructuur) van de gebouwde omgeving. In de gebouwde omgeving zijn er enorm veel belanghebbende agenten betrokken. Deze *agenten* zijn afhankelijk van elkaar – het aanpassen van een aspect in de gebouwde omgeving heeft gevolgen voor de andere delen – en wachten op duidelijke richtlijnen vanuit de gemeente over hoe zij moeten omgaan met energie-gerelateerde aanpassingen. Er moeten nieuwe richtlijnen komen die rollen en verantwoordelijkheden van de verschillende agenten duidelijk maken. Hierbij kan het helpen om “natuurlijke momenten” voor renovaties van verschillende belanghebbenden naast elkaar te leggen, en ze op één lijn te brengen. Door in dergelijke coalities te werken, kunnen kosten en kennis worden gedeeld. Bovendien kan er in zulke coalities worden gestreefd naar brede sociale gebiedsontwikkeling: problemen in leefbaarheid, mobiliteit en huisvesting kunnen in één keer worden verbeterd.

Al met al kan er worden geconcludeerd dat er systemische veranderingen nodig zijn willen woningcorporaties hun rol als startmotor kunnen vervullen, maar dat er zich ook al mogelijkheden aandienen om stapsgewijs een toekomst zonder aardgas aan te jagen.

Appendix 2. Sectoral System Innovation – dimensions and indicators

This appendix provides an elaborate description of the different dimensions of the building blocks of a SSI approach, using the definitions of Faber & Hoppe (2013).

Building block	Indicator	Description
Institutional framing	Policy: sectoral context	Includes all elements of 'agents and networks'.
	Policy: regulatory design	Refers to the basic purpose of policies: a focus on technologies, innovation, experimentation, subsidiarity, or else.
	Policy: stringency	Is about the strictness of policies.
	Policy: flexibility	Is present when policies allow changes in how they are applied in practice.
	Non-policy: institutional features	Are informational regulations such as values and common beliefs agents can refer to when acting.
Agents and networks	Primary agents	Are the key players that perform core innovative activities and experiments within a sector.
	Secondary agents	Account for support in knowledge diffusion, finances and regulations within a sector.
	Agent characteristics	Involve motivations and responsibilities.
	Formal and informal interactions	Are processes of communication, cooperation and competition between agents that are shaped by the institutional framing.
Technological regime	Knowledge base	Is about the amount and characteristics of the knowledge available.
	Learning conditions	Is about freedom of learning by doing and collectively learning with and of other agents.
	Technological opportunities	Is about the easiness for technologies to be introduced, given the amount of resources.
	Appropriate conditions	Mean that there is the possibility of extracting profits from innovations.
	Cumulativeness of innovation	Means that the innovation is a logic sequel of the previous one.
Market demand	Requirements and preferences	Includes the wishes both consumers and producers have concerning innovations.
	Heterogeneity	Refers to a variety of requirements and preferences.
	Role of niche markets (market structure, size and segmentation)	Is about the structure, size and segmentation of markets in which new technologies are produced and consumed.

Appendix 3. A selection and description of the cases

This appendix includes general information about the three neighbourhoods and the housing corporations active in these neighbourhoods. What stands out is that the corporations all own more than 75% of all houses in the neighbourhoods, and that the reasons behind the efforts made by corporations for an energy transition in these neighbourhoods is similar. This is why they have been chosen for this research.

	Van der Pek	***Palenstein***	***Benedenbuurt***
Type of neighbourhood	Build in the 1920s, renovated in the 1950s 4950 inhabitants 2478 houses 84% housing corporation; 14% private 85% multiple family housing 50% between 25-65 years old	Build in the 1960s 5460 inhabitants 2879 houses 76% housing corporation; 22% private 77% multiple family housing 50% between 25-65 years old	Build in the 1950s 2190 inhabitants 1008 homes 76% housing corporation; 22% private 77% multiple family housing 50% between 25 and 64 years old
Project area	200 houses in Gentiaan (Ymere). The first block of 38 homes is currently renovated; in 2020 more blocks.	1117 multiple family houses in flats (Vestia); 120 to NOM (DGW), 28 to NOM (Vidomes).	490 houses: 170 housing corporations (DWS), 210 private homeowners, and 110 private apartments.
Why natural gas-free?	The neighbourhood requires major infrastructural renovations (in both water and grid lines). This offers the opportunity to renovate houses at the same time.	The houses in the neighbourhood require major renovations. This offers the opportunity to renovate the houses in a more sustainable way, and lower energy bills.	The sewage network and street pavement in the neighbourhood require replacement, offering a change to phase out natural gas in the infrastructure, and thereby the houses.
Alternative for natural gas?	Heating network	All electric (WKO)	Most likely a heating network
Corporations	Housing corporation Ymere	Housing corporation Vestia, Vidomes and De Goede Woning (DGW)	Housing corporation De Woningstichting (DWS)

Corporations' role	Municipality of Amsterdam initiated, Ymere went along	Municipality of Zoetermeer initiated, Vestia, Vidomes, DGW went along	Initiative of residents, DWS went along

Housing corporations	***Area***	***Housing stock***
Ymere	Amsterdam Region	75 000
Vestia	Rotterdam, Delft, Den Haag, Zoetermeer	75 000
Vidomes	Zoetermeer, Leidschendam-Voorburg, Delft en Rijswijk en Leidschenveen	18 000
De Goede Woning	Zoetermeer	63 00
De Woning-stichting	Wageningen	51 00

The information is derived from the interviews and the following sources:

- Alle Cijfers (2018a) *Overzicht buurt Van der Pekbuurt.* Retrieved from https://allecijfers.nl/buurt/van-der-pekbuurt-amsterdam/.
- Alle Cijfers (2018b) *Overzicht buurt Palenstein.* Retrieved from https://allecijfers.nl/buurt/palenstein-zoetermeer/.
- Drimble (2017) *Buurt Benedenbuurt (Wageningen).* Retrieved from https://drimble.nl/buurten/2890702/benedenbuurt.html.
- The official websites of the corporations in question.

Appendix 4. The guide for the second round of interviews (in Dutch)

This appendix provides the guidelines for the second round of interviews. The findings of the first round of interviews (through narrative inquiries) have been summarised in statements and hypothesis, and represented to the respondents to verify or falsify the findings. The information that is presented below is relatively basic; in the interviews there was more room for details.

Onderdeel 1. Uitdagingen voor woningcorporaties.

Woningcorporaties zijn aangewezen als startmotor van de energietransitie in de gebouwde omgeving in Nederland. Dit brengt de nodige uitdagingen met zich mee. Op basis van de interviews zijn de volgende vijf uitdagingen geïdentificeerd:

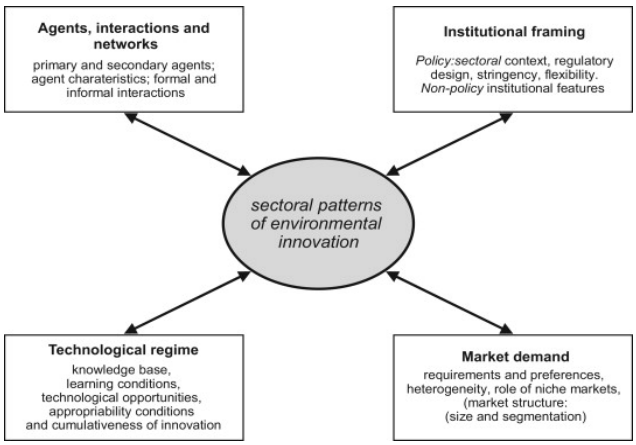
1. Er is nog geen optimaal alternatief voor aardgas. De alternatieven zijn nog duur. Daarbij is het sterk afhankelijk van contextuele gebiedseigenschappen welk alternatief überhaupt mogelijk is.
2. Betaalbaarheid en beschikbaarheid van kwalitatieve woningen staan voorop voor woningcorporaties. Het financieren van de energietransitie is daarom soms een dilemma.
3. Huurders moeten met 70% toestemming geven voor een renovatie project. Bij energie-renovaties kan dit lastig zijn, aangezien duurzaamheid voor huurders niet een hoge prioriteit is. Zij geven vooral om betaalbaarheid.
4. Er is nog geen integrale benadering voor de energietransitie in de gebouwde omgeving. Hierdoor kost het corporaties veel tijd en geld om andere partijen mee te krijgen in de plannen.
5. Het financieren van energietransitie-gerelateerde renovaties kan leiden tot een zogenaamd ‘split incentive’, waarbij de kosten bij de woningcorporatie liggen en de opbrengsten (lagere maandlasten) bij de huurder. De investeringen van de woningcorporaties kunnen niet geheel worden gedekt door een verhoogde maandelijkse huur (i.v.m. huurgrens).

Kunt u zich vinden in deze uitdagingen?

Heeft u nog aanvullingen of opmerkingen?

Onderdeel 2. Uitdagingen verbinden aan de bouwstenen van de energietransitie.

De energietransitie in de gebouwde omgeving kan worden beter worden begrepen door naar vier bouwstenen te kijken, zie onderstaande figuur.



Naar aanleiding van de interviews heb ik de geïdentificeerde uitdagingen verbonden aan de bouwstenen van de energietransitie. Hier kwamen de volgende stellingen uit:

1. Bouwsteen 'Agents and networks'. De energietransitie vraagt een andere manier van handelen van woningcorporaties, het vraagt om samenwerking met veel andere partijen. Dit is nog erg lastig aangezien de hoeveelheid partijen en daarmee het verschil in belangen groot is, en het nog niet helemaal duidelijk is wie verantwoordelijkheid neemt voor wat.
2. Bouwsteen 'Institutional framing'. Ondanks dat er een breed-gedeeld idee is dat instituties, zoals woningcorporaties, klimaatverandering en daarmee de energietransitie moeten aanjagen, is het nog een grote zoektocht hoe dit kan worden ingevuld. Algemene ambities zijn opgesteld vanuit het Rijk; op het niveau van de wijk kan daar op verschillende wijzen invulling aan worden gegeven. Het is voor woningcorporaties nog zoeken hoe zij invulling kunnen geven aan hun opgelegde rol.
3. Bouwsteen 'Technological regime'. Alternatieve technologieën voor isolatie en ter vervanging van aardgas ontwikkelen zich snel. Op dit moment zijn de alternatieven echter nog vrij duur, en niet gemakkelijk in te passen in de bestaande bouw. Woningcorporaties investeren daarom nog niet grootschalig in alternatieven.
4. Bouwsteen 'Market demand'. De vraag naar alternatieve technologieën neemt toe, maar de voorkeur gaat vooral uit naar betaalbare alternatieven. Aangezien het op dit moment nog vrij prijzig is, zijn woningcorporaties afwachtend.

Ziet u de bouwstenen uit de figuur ook als de belangrijkste bouwstenen voor het begrijpen van de energietransitie voor woningcorporaties?

Herkent u zich in de uitdagingen? Waarom zijn deze uitdagingen er?

Waar ligt de grootste uitdaging, en waarom?

Onderdeel 3. Mogelijke manieren om met de uitdagingen om te gaan.

Op basis van de interviews zijn er vier manieren geïdentificeerd waardoor woningcorporaties beter om zouden kunnen gaan met de energietransitie:

1. Focus voorlopig op *no-regret* oplossingen, aangezien de meeste technologieën nog onzeker zijn.
2. Neem algemene renovaties als startpunt voor energie-gerelateerde renovaties. Met andere woorden: verduurzaam op natuurlijke momenten.
3. Leg de natuurlijke momenten van de verschillende partijen in een buurt naast elkaar, en zoek gezamenlijk naar het meest voordelige moment voor een grote energie-renovatie. Op deze manier kunnen kosten en kennis worden gedeeld.
4. Leg de nadruk op de voordelen voor de bewoners, zoals het feit dat de maandelijkse energiekosten mogelijk omlaag kunnen gaan, dat het comfort van de woning omhoog gaat na een renovatie of dat de leefbaarheid in de buurt wordt verbeterd.

Kunt u zich vinden in deze "oplossingen"?

Heeft u nog aanvullingen of opmerkingen?

Appendix 5. The dependency on natural gas in the Netherlands

In the beginnings of the 20th century, the Dutch energy system was small-scale, and based on coal and renewables (Correljé & Verbong, 2004). This system began to change after WWII when the post war economic growth led to increased consumption and energy use, amongst other things, due to availability of domestic electric appliances. The discovery of large stocks of natural gas in Groningen in 1959 came at the right time.

A large-scale renovation took place in the 1960s to connect the Dutch built environment to natural gas, replacing coal. The technology to extract natural gas was known by that time. The government and few energy companies were able to start operating (exploiting and distributing) quickly. Almost 80% of the Dutch households were connected to the national gas grid within a decade (Verbong & Geels, 2007). This resulted in major financial profits for the few privies (RMNO, 2010). Besides this, nuclear power was seen as the technology for the future, which encouraged involved parties to exploit and sell the gas as quickly as possible before it became worthless (Verbong & Geels, 2007).

Remarkably, the exploitation and consumption of gas survived the oil crises in the 70s, the nuclear debate in the 80s, and the renewable energy wave in the early 2010s. In 2013, the gas revenues were still more than 15 billion euros (CBS, 2017). The fossil-fuel dependent industry is of high value to the government and exploiting companies. The revenues, however, have been declining since 2013.

The discovery of the Groningen field led to a large national dependency on low caloric natural gas (Schoots & Hammingh, 2015). This dependency is still present, see figure 17. In 2015, 3200 Peta Joules (PJ) of primary energy was used, from which 2481 PJ came from natural gas and oil (Van Leeuwen et al, 2017). The built environment represents the largest sector of the total final energy consumption: it covers 33% of the total energy consumption, and includes the category "households", a large part of the category "services" and a small part (only the buildings) of the category "industry" (van Leeuwen et al, 2017). More than 90% of the building related thermal demand comes from natural gas combustion; more than 84% of the building related electrical demand comes from gas and coal combustion. The share of coal combustion in the Netherlands has been relatively little compared to other European countries.

The dependency on natural gas has in particular led to a lock-in of the Dutch residential sector, category "households", where currently 93% is connected to the low caloric natural gas grid for heating purposes (Schoots & Hammingh, 2015). Households used a little more than 14,2% of the total energy consumption for heating their homes (350 PJ) and providing electricity (85 PJ) (van Leeuwen et al, 2017). The average demand of a Dutch household is about 1500m^3 natural gas for heating, warm water supply and cooking per year (CBS, 2016). This comes down to 11 billion cubic meters of gas consumed by households, which is about half of the current production of gas from the Groningen field on a yearly basis.

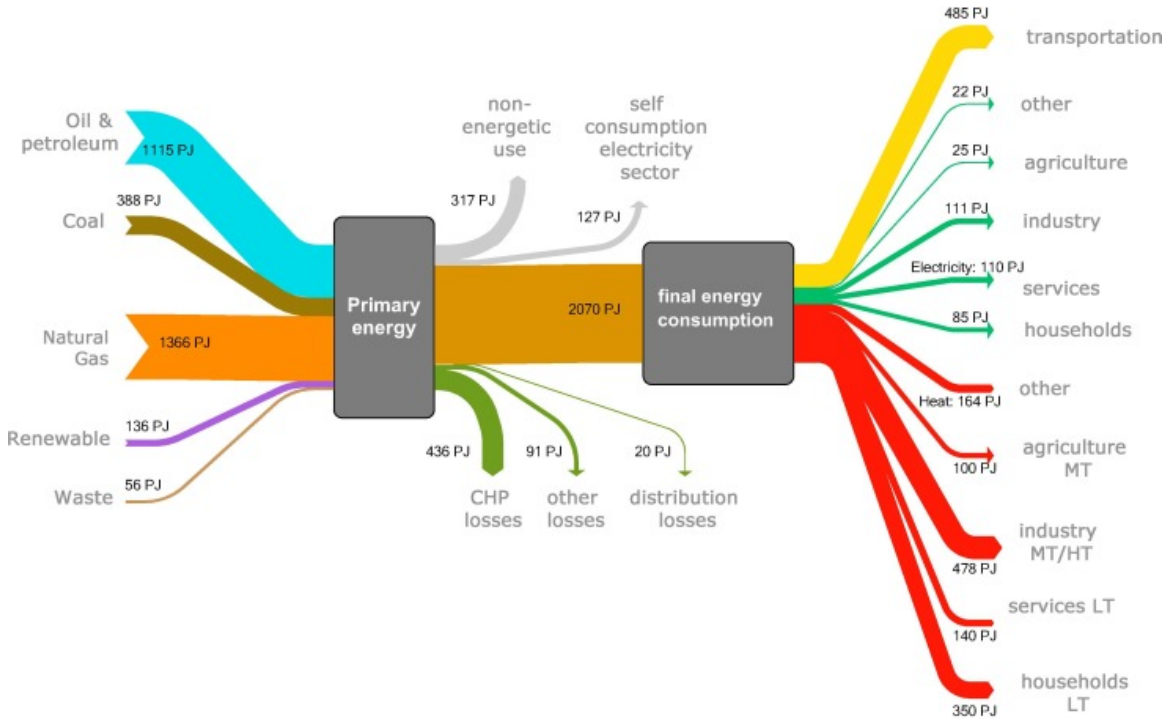


Figure 17. Primary and final energy consumption in the Netherlands in 2015 (van Leeuwen et al, 2017).

Appendix 6. The institutional framing (formal) & agents

The necessity for a transition of the energy system is determined by a number of factors on different geographical scales (Miedema et al, 2018). On a **European scale** key targets for 2030 have been set to cut 40% in CO_2 emissions, to increase the energy consumption from renewables up to 27% and to increase in energy efficiency with 27%, compared to the year of 1990 (European Commission, w.y.). Besides this, the **European Union (EU)** facilitates free flow of energy across EU borders; a secure energy supply in every EU country and support schemes to make certain renewable energy technologies competitive. Although the EU is competent to act in all areas of environment policy (waste, air, water, climate change), the scope for action is limited by the principle of subsidiarity and unanimity in the Council in the fields of, among others, fiscal matters, land use, choice of energy sources and structure of energy supply (European Parliament, 2018).

The objectives made at the European level have trickled down to the individual member states, that all have their individual challenges related to the design of their specific energy systems (Miedema et al, 2018). This resulted in national renewable energy action plans, which show what actions nations intend to take to meet their renewables targets, including policy measures, renewable technologies, and sectoral targets for, for example, the energy performance of buildings (European Commission, w.y.). The **Dutch national government** has already been working for years on the transition to a low carbon future. This has resulted in an Energy Agreement in 2013, a Heat Vision document in 2015, a commitment to the Paris Agreement in 2015, and a Dutch Climate Act in 2018 (Klimaatakkoord, 2018), which can be seen as changes in *institutional framing* (section 4.1).

The **Energy Agreement** in 2013 has been signed by 47 organizations and formed the basis for Dutch energy efficiency and renewable energy policies. In the **Heat Vision** document in 2015, Eric Wiebes, former Minister for Economic Affairs and Climate, introduced various measures to stimulate fossil fuel reduction, specifically in the built environment. All newly constructed buildings must be gas-free from 2018 onwards (Rijksoverheid, 2018); existing districts that currently rely on natural gas have to switch to alternatives through a gradual transition. Energy renovations in the existing built environment offer unique opportunities to reduce the use of fossil fuels and greenhouse gas emissions (Hoppe, 2012) and are considered to be more sustainable and cost-beneficial than demolishing and rebuilding (Itard & Klunder, 2007). This is because the energy quality of old Dutch houses is poor (Hoppe, 2012), as legislation on energy efficiency was only implemented after 1975. Before that time, there were no standards that required insulation (Jong et al, 2005). Regulations for insulation of new houses have become more ambitious after 1975, and since the Heat Vision, ambitions for renewable energy technologies have become more prominent too. The Heat Vision suggests that a tripling of renewable heat production from 6.1 PJ to 18 PJ between 2013 and 2023 (Rijksoverheid, 2015a). The renewable heat should originate from biogas, heat pumps, geothermic or else, depending on the context.

The commitment to the **Paris Agreement** in 2015 resulted in a **Dutch Climate Agreement** in 2018, and the decision to gradually stop extracting natural gas at Groningen, which was a historical moment for the Netherlands being highly dependent on the billion-euros-worth gas industry (Klimaatakkoord, 2018). Multiple stakeholders at the so-called climate tables are currently negotiating how these ambitions should be achieved and ipmlemented. These tables include: electricity, built environment, industry, agriculture and land use, and mobility. The stakeholders joining the table for the built environment have to deal with the ambition to make the Netherlands

free of natural gas by 2050, as the built environment currently consumes over 30% of the total energy consumption causing major CO_2 emissions. A **Dutch Climate Act** has been introduced to ensure that the ambitions and measures will yield results. The Climate Act has three legally-binding, ambitions: by 2030, greenhouse gas emissions must have been reduced by 49% compared to 1990, by 2050 that percentage must be 95% and, finally, the entire electricity production must be sustainable in the same year.

The spatial impacts of the ambitions set by the national government are translated in **Regional Energy Strategies** (RES). In RES governments and other societal organizations decide on what energy sources and technologies will be exploited and developed in a specific region. **Provinces** play an important role in determining the spatial implications of the ambitions in the RES. Provinces make spatial choices above ground (eg wind energy) and underground (such as geothermal energy and shallow soil energy) for areas that exceed the municipal scale, such as the RES regions (RVO, 2017). Provinces also offer knowledge. For example, they draw up integral plans that connect to municipal heat plans. The **municipality** has been given the directing role in the transition: The local level suits best for determining the alternatives for meeting the energy demand (Klimaatakkoord, 2018). The municipalities should adapt to the decisions made in the RES, and are responsible for implementing the various measures in their neighbourhoods. A unique location-specific approach can be developed for each neighbourhood, documented in the **Municipal Heat Transition Visions** for 2021. A few selected neighbourhoods have received financial support to already start acting on the energy transition. In March 2017, 31 municipalities (including Zoetermeer), 3 ministries and multiple grid operators signed the Green Deal Natural Gas Free Neighbourhoods (KwinkGroep, 2018). The parties agreed to jointly accelerate the development of gas-free neighbourhoods. One year later, in 2018, 27 municipalities (including Amsterdam, Zoetermeer and Wageningen), 2 ministries, water boards and more signed the '**experiment**' Natural Gas Free Neighbourhoods, in which newly selected neighbourhoods received a substantial amount of money (120 million euros in total) to foster the transition towards a gas-free built environment, and to experiment with new energy technologies and partnerships (Rijksoverheid, 2018).

Appendix 7. The technological regime – innovative energy systems

The first steps towards a future without natural gas have been made. What such a future precisely entails is, however, still uncertain (RVO, 2017). It is in fact in the name 'a future *without'*, but what will replace it? There is a wide range of technologies available, which could significantly reduce CO_2 emissions from buildings. Many of these technologies are now or in the near future economically feasible, taking the costs and returns into account (IEA, 2010; Smekens et al., 2011). These technologies can be defined as 'innovative energy systems': renewable energy and energy efficiency technologies that clearly differ from conventional technologies (Hoppe, 2012). The potential of the technologies varies among new houses, existing houses and social homes, due to varying policies and subsidies (Faber & Hoppe, 2013).

This appendix presents innovative energy systems, but some demarcations have been made. The overview is limited to heat and electricity technologies that enable the switch from natural gas to alternatives in the existing building stock in the Dutch residential sector, excluding offices and other utility buildings, see figure 18 for the corresponding numbers. Everyday use of electric appliances as well as transport is excluded from the analysis too.

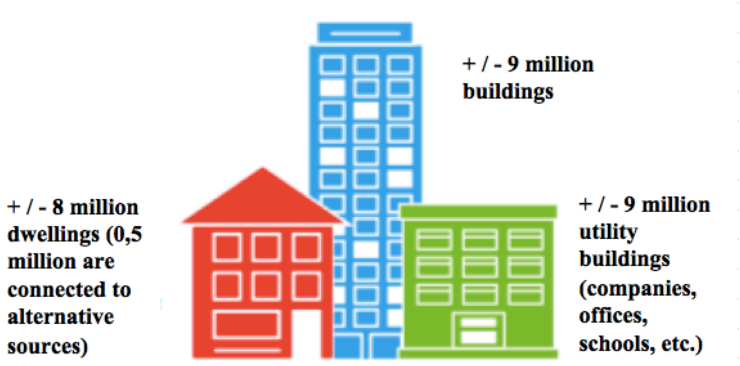


Figure 18. Relative amount of dwellings in the Netherlands (RVO, 2017).

The most promising innovative energy systems – in heat and electricity technologies for residential houses - are collective networks (heat districts) and individual solutions (all electric) (Rijksoverheid, 2015a). These will be applied in the majority of the buildings. A limited part of the buildings will be heated with green gas. Almost all alternatives include insulating, because the most sustainable energy is the energy that you do not use. Little can be said about the exact reduction in CO_2 emissions these measures imply, as it depends on, among others, the source of energy used. An overview of the three promising innovative energy systems can be found on the next pages (note: the descriptions may not be comprehensive).

Heat District

Description	Heat districts use hot water to heat houses (AardgasvrijPalenstein, 2018). This hot water is stored in one central boiler in a certain district and distributed to houses through pipelines. The hot water can directly be used for consumption, but can also be used to heat the houses (using a heat exchanger). The heat used in heat districts can come from a variety of sources. Heat often comes from power stations (electricity or waste incineration plants), but it can also come from deep reservoirs that store geothermal heat from the ground. The temperature of the water coming from the heat source determines whether it could facilitate a high temperature or low temperature heat district.
Options	• There are high temperature heat districts. This is the case when the water is 70 degrees or higher when transported into the houses (HierVerwarmt, w.y.b). Because of these high temperatures, houses do not need insulation. This is, for example, favourable for homes that are very old or with cultural-historical value. The houses must be close to a sustainable source of heat, such as a heat source underground (geothermal energy). • There are low temperature heat districts, which means that the water is 50 degrees or colder (HierVerwarmt, w.y.b). Houses, in contrast to high temperature districts, need to get insulated. But, because of the relatively low temperature, more types of heat sources can be used such as low-value residual heat or solar thermal. How to connect different types of sources to one heating district is still uncertain.
Advantages	• A heat networks with a sustainable source can create full independence from natural gas (HierVerwarmt, w.y.b) • The supply of heat is legally ensured (Aedes, 2018).
Disadvantages	• A heat network only works if it is collective, which means that it leaves residents no other choice than to connect to this energy supply system (Aedes, 2018). • Whether a heat network is possible depends on the energy sources available in the surrounding area (Interview, R5, 2019a).

All electric

Description	Going “all electric” implies a variety of measures (HierVerwarmt, w.y.b). It means that the central heating boiler of a house is replaced by a heat pump. A heat pump extracts warm air from outside or the ground and uses that to heat the house. The heat is spread through the house via very many small pipes, for example in the floor or the walls. A heat pump does everything that a central heating boiler does – heating your house and supplying hot water- only more sustainable, because it often uses Solar Photovoltaic (PV) Panels as an energy source. Houses are only suitable for a heat pump if well insulated. This is because heat pumps work with a heating temperature of a maximum of 45 to 55 degrees, whereas a central heating boiler supplies water of 60 to 80 degrees (Aardgasvrij Palenstein, 2018). A poorly insulated house does not get warm enough with a heat pump.

Options	• Air-source heat pumps. These are mostly used for low-rise buildings (4 or less floors) (Aardgasvrij Palenstein, 2018). These include PV panels, heat pumps and solar boilers. The generated temperatures are low, which requires well-insulated houses. Such renovations are defined as 'zero on the meter' (NOM). In the Netherlands, the concept of NOM is defined as a building in which the yearly energy consumption equals the generated renewable energy. • Ground-source heat pumps, in Dutch known as "Warmte Koude Opslag" (WKO) are mostly used for high-rise buildings (4 or more floors) (Aardgasvrij Palenstein, 2018). The heat pump has pipes going 30-150 meters into the ground. They often have a large capacity and are therefore used for collective purposes. The temperature of the water is low so the building will also have to be well insulated.
Advantages	• Energy is generated by the building itself, which significantly reduces monthly energy costs (Aardgasvrij Palenstein, 2018).
Disadvantages	• Natural gas or another kind of fuel is still needed in case the heat pump cannot function (HierVerwarmt, w.y.b). Going all electric is in this sense an intermediate step towards phasing out natural gas entirely. • All electric measures are pricey, as it requires many adjustments in the houses (Aardgasvrij Palenstein, 2018).

Green gas

Description	Green gas is an alternative for natural gas with a (mostly) sustainable source (HierVerwarmt, w.y.b). The use of green gas does not imply drastic changes in homes: the radiators and stove can be used in the same way as with natural gas. Green gas can be extracted from biogas or hydrogen power. The latter has, however, been less promising.
Options	• Biogas can be produced from, among other things, sludge, waste from landfills, or residues of fruit, vegetables and animals (HierVerwarmt, w.y.b). Biogas is purified and dried and brought to the same quality as natural gas. After this operation, it is called green gas and a sustainable alternative to fossil natural gas. Whether your neighbourhood is suitable for biogas depends on the availability of biomass in the area. • Hydrogen fuel is a zero-emission fuel when burned with oxygen (Aardgasvrij Palenstein, 2018). Sustainable hydrogen fuel must be produced from a primary energy source such as solar energy, biomass or electricity (e.g. in the form of solar PV or wind turbines).
Advantages	• Green gas can be fed into the existing gas network (HierVerwarmt, w.y.b). • No adjustments need to be made to the houses (HierVerwarmt, w.y.b).
Disadvantages	• The factor of conversion from green gas to energy is very low (for both biomass and hydrogen) (Palenstein Aardgasvrij, 2018). • It is uncertain whether these alternatives are more sustainable: natural gas is still required to produce these alternatives (HierVerwarmt, w.y.b).

Appendix 8. The challenges experienced by housing corporations – linked to SSI

This appendix describes the challenges involved for housing corporations in the energy transition, related to the SSI dimensions and associated indicators. The respondents have not been asked during the second round of interviews to elaborate on the indicators specifically, however, some statements can be made.

Building block	Indicator	Challenge?	Why?	In general
Institutional framing	Policy: sectoral context	Yes	The sectoral context is uncertain, see 'agents and networks'.	The institutional framing of the sector poses a challenge to corporations, as broad national ambitions have to be worked out on the local level, in which other parties cannot be forced to cooperate, and while corporations actually need to be focussing on affordability and availability.
	Policy: regulatory design	Yes	The design of policies is based on broad ambitions that still have to be worked out on the local level.	
	Policy: stringency	Yes	There are some contradictions in stringency: corporations are restricted to (only) focus on affordability and availability, while also assigned as frontrunners in the transition (for which the rules are rather vague than strict).	
	Policy: flexibility	Partly	On the one hand policies are too flexible (uncertainty about future directions), on the other hand broad targets give agents freedom to fulfil them in their own manner.	
	Non-policy: institutional features	No	There is a common belief that corporations and other agents need to undertake action, but without affecting affordability and availability.	
Agents and networks	Primary agents	Yes	There are no municipal guidelines, making it unsure with whom and how to cooperate.	Agents and networks form challenges for corporations as both the characteristics of and networks with other agents are uncertain.
	Secondary agents	Yes	Dependency on decisions made by others (by the national government, in RES, by municipalities).	
	Agent characteristics	Yes	It is unsure who is responsible for paying and doing what, and who will gain the benefits.	
	(In)formal interactions	Yes	There is no formal framework for collaboration on the local level. The informal interactions are not known.	

Technological regime	Knowledge base	Partly	Knowledge is currently developed but not yet optimal.	The technological regime comes along with various challenges for corporations, as the alternative technologies are not yet compatible, reliable and easily applicable in different contexts.
	Learning conditions	Partly	Government supports experiments and housing corporations are currently learning about new options, but there is no general approach to collectively learn.	
	Technological opportunities	Partly	Some areas provide good opportunity to implement new technologies (availability of sources, need for renovations); in other situations it involves a divestment for agents.	
	Appropriate conditions	Yes	Little profits can be extracted from new technologies, resulting in a split incentive.	
	Cumulativeness of innovation	Yes	Technological alternatives are not a logic sequel of natural gas.	
Market demand	Requirements and preferences	Yes	Preference is the option that is most affordable and reliable. There is little availability of such.	The market demand is not yet fully matched to the energy transition, which makes corporations hesitant in making major investments in alternatives.
	Heterogeneity	Yes	Every neighbourhood or housing block requires another strategy, which requires time and effort to find out.	
	Role of niche markets	No	Niche markets are rapidly developing, but do not offer alternatives that fulfil all requirements and preferences.	

Appendix 9. The benefits of energy renovations for corporations

The role that housing corporations have received in the energy transition comes along with various challenges. Steps have been identified that help in addressing these challenges. One of these steps is to focus on renovations as a starting point for incorporating energy measures. Currently, corporations are hesitant to invest in energy renovations. This is partly because these "energy" renovations require extra money, from which the benefits are not directly visible. The full added value resulting from energy renovations is underestimated (Ferreira & Almeida, 2015). The results of this research show that energy renovations can also contribute to affordable, qualitative and sustainable homes. Further, energy renovations positively affect the worth of social homes (on paper) and offer the possibility for corporations to get a glimpse behind the scene of who is living in their houses. A focus on the wider social and economic advantages of such renovations may help in fostering the energy transition.

Through renovations you can bring your housing stock up to present-day-standards. Sustainability standards can be included in these renovations at once (R6, 2019a, translated).

The contributions of the energy transition to the core business of corporations

- *Affordability.* The primary task for housing corporations is to provide affordable housing to a public of low-income groups (Boelhouwer & Priemus, 2014; Interviews with R7, 2019; R5, 2019a; R2, 2019). Municipalities, often, sign agreements with corporations to ensure that they maintain a minimum amount of affordable houses in a certain area, known as the 'core housing stock' (*kernvoorraad* in Dutch). These houses are often not extremely well renovated, resulting in low energetic performance. The energy performances of houses affect monthly living expenses of tenants. Low energy performance, especially in combination with rising natural gas prices, affects the affordability of social homes. This conflicts with the task of the corporations to provide affordable housing. The affordability of housing is therefore an important driver for corporations to invest in energy renovations. In other words, the energy transition provides an opportunity for corporations to maintain an affordable energy bill for their tenants. But, according to the interview with R4 (2019a) tenants will mainly have a financial benefit when energy renovations take place up to label B. Tenants that live in houses with a better energy label think that consuming more energy will not necessarily make a difference. Informing is important.

  We apply the principle that tenants will never pay for energy renovations. In this sense, money should not be a barrier for them (R6, 2019a, translated).

  A lower energy bill after energy renovations is an incentive (R9, 2019a, translated).

- *Availability of quality houses.* Renovations are needed every now and then (Interview, R7, 2019). Nowadays, housing corporations try to take energy measures into account with every renovation. These energy measures (insulation and/or a new technology) can actually benefit the quality of housing. It creates a more comfortable and safer home, which are seen as the most important issues for tenants (Donkelaar et al, 2006).

  Renovations are rather linked to maintenance and repair than to sustainability (R6, 2019a, translated).

- *A comfortable home.* Energy renovations reduce drafts and moisture (Interview, R5, 2019a), and are in some cases accompanied by the installation of a completely new kitchen and bathroom (Interview, R7, 2019). These kitchens will have an induction plate, which is easier to clean and releases less gases and particulate matter during cooking. The latter is beneficial in terms of health (TNO, 2017). Renovations also come along with new HR+++ windows and better-insulated facades (Interview, R1, 2019a). This is helpful regarding noise reduction in a complex. Another benefit arising from renovations is that heat retention will be better, resulting in a more stable temperature (Interview, R1, 2019a). Energy renovations therefore offer opportunity to create more comfortable homes, something that tenants (of which the majority is focused on surviving) value more than sustainability. In many cases, the application of (environmentally friendly) energy measures follows primary motives, such as comfort (Van der Waals et al, 2003; Ferreira & Almeida, 2015). An energy renovation is easier to sell when tenants directly feel the benefits (Braanker, 2015).

  Most of our tenants are not very concerned with sustainability issues (R6, 2019a, translated).

- *A safer living.* Energy renovations that involve an alternative to natural gas come along with a safer environment for tenants. The use of gas in a home is not without its dangers; it is associated with fire hazard (Interview, R6, 2019a). Natural gas burns easily, releasing high temperatures - that is why we use it for our stove, boiler, and more. When gas is not immediately burned and ends up in a closed room, there is a risk of carbon monoxide poisoning (Interview, R8, 2019a) and explosion and fire (Interview, R6, 201a9). Especially among elderly, gas-related fires occur frequently, for example because they forget to turn off the gas. Phasing out natural gas in homes is therefore an opportunity to increase the safety. But, according to R4 (Interview, 2019a), safety is not yet decisive factor for energy renovations. It may require a disaster, with a few explosions, for 'safety' to outweigh the challenges regarding energy renovations.

  The children of elder people living in Van der Pek said: just allow those renovations (R6, 2019a, translated).

- *Sustainability*. One of the main (obvious) reasons for and opportunities arising of the energy transition in the built environment for housing corporations is reducing CO_2 emissions (Interviews with R6, 2019a; R7, 2019a). Corporations bear the societal responsibility to go along with the ambitions of our time, which is striving for a low carbon future to combat climate change (Interview, R9, 2019a). This implies a responsibility to reduce the emissions produced in the homes they officially manage and own (Interviews with R8, 2019a; R4, 2019a; R1, 2019a). In fact, it is not just a responsibility; it is an obligation that they have committed themselves to (Interviews with R8, 2019a; R5, 2019a). The gas tap in Groningen is slowly turned off, dependence on Russian natural gas shall be reduced and alternatives are rapidly entering our markets to reduce gas usage and CO_2 emissions (Interview, R4, 2019a). It is becoming increasingly important for corporations to increase energy efficiency and

phase out gas. Also, societal costs for maintaining the gas infrastructure are high; billions of euros are involved (Interview, R8, 2019a). Independence of natural gas could reduce these costs. Besides this, CO_2 reductions can be an opportunity for corporations to market themselves and improve their public image. Further, corporations will have to set a good example to their tenants, who will often be concerned with financial matters instead of environmental goals (Interview, R6, 2019a).

We have signed agreements to reduce CO_2 emissions, as we would like to change the way we currently consume our planet's resources (R6, 2019a, translated).

We strive for CO_2 reductions, not necessarily a specific energy label (R7, 2019, translated).

The core business of corporations	How does it relate to the energy transition?
Affordability	• Energy renovations offer the opportunity to reduce monthly energy costs of tenants
Quality (of available houses)	• Energy renovations offer the opportunity to increase the quality of existing housing stock of corporations
Sustainability	• The energy transition brings forward the societal responsibility corporations have to reduce CO_2 emissions

Figure 19. Contributions of the energy transition to the core business of housing corporations.

By catches of the energy transition for corporations

- *A more profitable housing stock.* Housing corporations build, rent and manage affordable homes. But, they often also perform other (commercial) activities. The new Housing Act states that corporations must separate these commercial and social activities from each other (Rijksoverheid, 2015b). Corporations are allowed to give 10% of their social real estate a commercial function. Corporations are also, under strict conditions of the new Housing Act, allowed to sell houses. Selling houses is a crucial condition for the existence and functioning of housing corporations, according to R6 (2019a). The money raised by these sales is required to maintain a qualitative, affordable rental offer. And of course, a renovated sustainable house is worth more than a house with arrears of maintenance. There is some evidence that energy labels, and improving overall quality of buildings, positively affect the value of houses (Brounen et al, 2009; Ferreira & Almeida, 2015). R8 (2019a) mentioned: renovating a neighbourhood creates a more attractive and safer atmosphere, which will result in a higher market value of houses. A higher market value will, in turn, create new possibilities to increase loans to be able to increase renovation rates (Interview, R5, 2019a), as you can lend up to 75% of the invested capital (real estate portfolio), with a maximum of 3,5 billion euros (Interview, R6, 2019a).

May there ever be a surplus of rental houses, it will be easier to sell or commercially rent houses that are well renovated (R6, 2019a, translated).

Our wealth on paper will increase, which will increase our loan capacity (R8, 2019a, translated).

Renovated houses actually result in new buildings (R7, 2019, translated).

- *Renovations offer a glimpse behind the scenes.* Renovations not only offer an improvement physically, but also the opportunity to take a look behind the front door (Interview, R2, 2019). In advance of a renovation, all residents must be informed. Through this, corporations will get an idea of who is living in their houses, and whether these residents require (more) social help. This is, however, possible with every renovation, and not necessarily energy renovations only.

  Internally we use moments of major maintenance to link it to social management (R2, 2019, translated).

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First round of interviews, by means of narrative inquiries (in person)

- R6 (2019a). *An interview about the role of housing corporations, in this case Ymere, in the energy transition, specifically in the Van der Pek neighbourhood in Amsterdam*. Amsterdam: Netherlands.
- R7 (2019a). *An interview about the role of housing corporations, in this case Ymere, in the energy transition, specifically in the Van der Pek neighbourhood in Amsterdam*. Amsterdam: Netherlands.
- R8 (2019a). *An interview about the role of housing corporations, in this case Ymere, in the energy transition, specifically in the Van der Pek neighbourhood in Amsterdam*. Amsterdam: Netherlands.
- R9 (2019a). *An interview about the role of housing corporations, in this case De Woningstichting, in the energy transition, specifically in the Benedenbuurt neighbourhood in Wageningen*. Wageningen: Netherlands.
- R4 (2019a). *An interview about the role of housing corporations, in this case Vestia, in the energy transition, specifically in the Palenstein neighbourhood in Zoetermeer*. Rotterdam: Netherlands.
- R5 (2019a). *An interview about the role of housing corporations, in this case Vestia, in the energy transition, specifically in the Palenstein neighbourhood in Zoetermeer*. Rotterdam: Netherlands.
- R1 (2019a). *An interview about the role of housing corporations, in this case De Goede Woning, in the energy transition, specifically in the Palenstein neighbourhood in Zoetermeer*. Rotterdam: Netherlands.
- R2 (2019a). *An interview about the role of housing corporations, in this case Vidomes, in the energy transition, specifically in the Palenstein neighbourhood in Zoetermeer*. Rotterdam: Netherlands.
- R3 (2019a). *An interview about the role of housing corporations, in this case Vidomes, in the energy transition, specifically in the Palenstein neighbourhood in Zoetermeer*. Rotterdam: Netherlands.

Second round of interviews, by means of semi-structured interviews (through the telephone)

- R1 (2019b). *An interview about challenges that housing corporations encounter in their role in the energy transition, how these may be related to SSI and how these may be addressed.* Utrecht: Netherlands.
- R6 (2019b). *An interview about challenges that housing corporations encounter in their role in the energy transition, how these may be related to SSI and how these may be addressed.* Amsterdam: Netherlands.
- R8 (2019b). *An interview about challenges that housing corporations encounter in their role in the energy transition, how these may be related to SSI and how these may be addressed.* Amsterdam: Netherlands.
- R9 (2019b). *An interview about challenges that housing corporations encounter in their role in the energy transition, how these may be related to SSI and how these may be addressed.* Amsterdam: Netherlands.
- R4 (2019b). *An interview about challenges that housing corporations encounter in their role in the energy transition, how these may be related to SSI and how these may be addressed.* Amsterdam: Netherlands.
- R5 (2019b). *An interview about challenges that housing corporations encounter in their role in the energy transition, how these may be related to SSI and how these may be addressed.* Amsterdam: Netherlands.
- R3 (2019b). *An interview about the challenges that housing corporations encounter in their role in the energy transition, how these may be related to SSI and how these may be addressed.* Amsterdam: Netherlands.