FROM NATURAL GAS TO DISTRICT HEATING

Municipal strategy to increase homeowner engagement in the heat transition in Reyeroord, Rotterdam

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Abstract

The national Dutch government has set the goal of disconnecting 95% of households from natural gas by 2050. The country, however, continues to rely heavily on natural gas, particularly in the housing sector. As a result, a system conversion within the housing sector is required to transition from natural gas to alternative heating sources, also known as the heat transition. With the current Dutch regulations (July 2023), homeowners are critical players in the execution of the heat transition. As a result, the Dutch municipalities must encourage homeowners to disconnect from natural gas in order to meet the 2050 objective. To do this, new municipal strategies are essential. Therefore, this thesis investigates the research question: how can the municipality of Rotterdam stimulate homeowners to disconnect from natural gas in Reyeroord Rotterdam, the Netherlands?

The case study method is the foundation of the thesis. The case study is Reyeroord, a neighbourhood in Rotterdam where a pilot project has been implemented to engage homeowners in the heat transition. Within the pilot project, a district heating system (DHS) is constructed containing residual heat from the harbour in Rotterdam. To provide a comprehensive municipal strategy, the impact of various contextual, attitudinal, and socio-demographic factors on homeowners' decision-making to connect to DHS is analysed. In addition, the interventions used in the pilot project were studied. The analysis contains a survey (N = 116), interviews (N = 6), and internal documents containing the analyses of a prior survey conducted by the project team of Reyeroord.

The findings of the thesis reveal that the following factors discourage homeowners from connecting to DHS: the high investment costs, the nuisance of construction, low trust in the municipality, very low trust in the energy provider, and a lack of felt urgency. Whereas the results indicate that these factors stimulate homeowners to connect to DHS: a high level of perceived knowledge, strong biospheric values, positive effects on climate change, and potential energy bill savings. It is concluded in the research that Dutch municipalities can motivate homeowners to engage in the heat transition by implementing a neighbourhood approach that contains the following steps:

1. Get to **know the neighbourhood**
2. Provide a good **information provision** and consider a **wide range of personal values**
3. Implement **personal attention** and **provide tailor made advice**
4. Offer a **temporary financial incentive**

Furthermore, it would be beneficial if the national government implemented regulations to increase homeowners' sense of urgency. As a result, more homeowners would be motivated to participate in the heating transition. The results of this thesis contribute to the body of literature on homeowners' participation in the heat transition. Furthermore, the findings of this study can help municipalities accelerate the heat transition in order to meet the 2050 climate goals.

Key words: Heat transition, Homeowner engagement, Energy behaviour, Engagement tactics, District heating (DHS), Municipal interventions

Table of Contents

List of tables

List of figures

List of abbreviations

TPB: Theory of Planned Behaviour
DHS: District heating system

Chapter 1: Introduction

1.1. Background

"*We are the first generation to feel the effect of climate change and the last generation who can do something about it*" Barack Obama's famous words during his speech for the U.N. (Whitehouse, 2014). Statements like these nowadays occur more often as the effects of climate change increase. To mitigate the negative effects of climate change, 196 countries have signed the Paris Agreement. This is a legally binding document that stipulates that global temperatures cannot exceed 1.5 °C above their 1990 levels (UNFCCC, 2022).

To adhere to this goal, all participating countries are required to implement measures. The Netherlands is one of these countries. To reduce its own carbon emissions and combat rising temperatures, the Dutch government has developed the Klimaatakkoord. This national accord states that by the year 2050, 95% of the CO2 emissions must be reduced compared to the level of emissions in the Netherlands in 1990 (Rijksoverheid, 2019). However, the Netherlands remains heavily reliant on fossil fuels, as it generates and consumes the most natural gas in comparison to the rest of the EU.(Index Mundi, 2020). In 2019, natural gas accounted 44% of the total Dutch energy consumption (CBS, 2021).

The largest sector using natural gas in the Netherlands is the housing sector. In 2019, 92% of Dutch households were still heated by natural gas (CBS, 2021). This shows that the significant changes must be made in the housing sector in order to adhere to Klimaatakkoord. Therefore, the Dutch national government is aiming to disconnect 7 million buildings from natural gas by 2050 (Rijksoverheid, 2019). To achieve this goal, a system conversion is needed in the housing sector from natural gas to renewable heating sources (Kort et al., 2020). In this thesis, the system conversion is conceptualised as the heat transition.

In the Netherlands, municipalities are responsible for the execution of the heat transition (Ebrahimigharehbagh et al., 2019; Jansma et al., 2020; Beauchampet and Walsh, 2021). Currently (July 2023), there are no regulations in the Netherlands that force homeowners to disconnect from natural gas. Beauchampet and Walsh (2021) explain that this signifies that a part of the responsibility for the heat transition lies with private homeowners. After all, the connection to a heat source is a matter that takes place on the private property of the homeowner. Therefore, with the current regulations, a homeowner's decision to disconnect from natural gas is entirely voluntary (Beauchampet and Walsh, 2021). According to Jansma et al. (2020), this means that the support and engagement of homeowners has a significant influence on the heat transition.

Due to the municipalities' dependency on homeowners to execute the heat transition, municipalities must engage homeowners to become active participants. However, this is a challenging task given that homeowners are used to have a passive consumer role when it comes to energy (Nye et al., 2010; Beauchampet and Walsh 2021). On top of that, Genus et al. (2019) found that Dutch homeowners are less interested in implementing alternative energy sources in their homes compared to other European countries. This is explained by Klöster (2020), who states that a significant number of Dutch citizens respond unfavourably towards the heat transition.

In conclusion, Dutch municipalities must include homeowners' needs in their heat transition strategy. This thesis will explore how municipalities can do this by investigating which factors influence homeowners' decisions to engage in the heat transition.

1.2. Research aim

One of the municipalities in the Netherlands working on the heat transition is Rotterdam. To provide a strategy for the heat transition, the municipality of Rotterdam developed a heat transition vision (transitievisie) (Gemeente Rotterdam, 2022). In Rotterdam's heat transition vision the cheapest and easiest alternative heating sources for each neighbourhood in Rotterdam are identified. In most neighbourhoods, district heating systems (DHS) appears to

be the best fit (Gemeente Rotterdam, 2022). DHS means that the residual heat of industries, in this thesis the harbour of Rotterdam, is captured and converted into hot water. This hot water will be distributed via large tubes to heat the houses in Rotterdam (Gemeente Rotterdam, 2022).

A neighbourhood in Rotterdam where a DHS will be implemented is the pilot project Reyeroord. Currently, the homeowners in Reyeroord are not obligated to connect to the DHS (Gemeente Rotterdam, n.d.). Therefore, the municipality of Rotterdam implemented a participation strategy consisting of several measures to engage the homeowners of Reyeroord in the heat transition (Gemeente Rotterdam, n.d.). In this thesis, this participatory trajectory and its measures are being researched to understand what the best engagement tactics are to increase homeowners' engagement in the heat transition.

Overall, the objective of this thesis is to identify effective engagement strategies based on people's experiences in order to increase homeowner engagement in the heat transition in Rotterdam, the Netherlands. This will be researched by investigating the factors that influence Dutch homeowners' preferences and obstacles to disconnect from natural gas. Following the difficulty of this process and the importance of achieving the climate goals, the following research question is established:

How can the municipality of Rotterdam stimulate homeowners to disconnect from natural gas in Reyeroord Rotterdam, the Netherlands?

To answer the research question, the following sub-questions are formulated:

1. *What motivates and discourages homeowners in Reyeroord to disconnect from natural gas?*
2. *How can engagement tactics be designed or improved to better engage homeowners to disconnect from natural gas?*
3. *To what extent can policymakers stimulate homeowners to disconnect from natural gas?*

1.3. Societal relevance

This research has a clear societal relevance. After all, Dutch municipalities are responsible for engaging homeowners in the heat transition in order to accomplish the climate goals and disconnect eight million households from natural gas by the year 2050. However, the current disconnecting process is rather slow (Iskandarova and Genus, 2019). An explanation for the this is that current engagement tactics of the municipalities are focused on facilitating early adopters (Verbong & Loorbach, 2012; Scholte et al., 2020). For instance, one of the current engagement tactics of the government is to offer subsidies for homeowners to install heat pumps (Rijksoverheid, n.d.A). Scholte et al. (2020) show that only homeowners who are already interested in the transition use these types of subsidies.

In addition, early adopters are generally people who have the resources and ability to participate in transitions (Scholte et al., 2020). As a result, there is a risk that policies aimed at promoting the heat transition may disproportionately benefit those who are already in a privileged position (Scholte et al., 2020). This results in the less privileged not being facilitated by the current engagement tactics of the Dutch government, which may result in this population group falling behind more and more.

This shows that there is a risk that the heat transition will create a separation in society. Those who can and want to disconnect from natural gas exist alongside those who cannot, do not wish to, or are unfamiliar with the heat transition. Carley & Kolinsky (2020) explain that in energy transitions there are often winners, those who benefit from cleaner sources of energy, and losers, those who bear the burdens and lack access to opportunities. To ensure that this will not happen in the heat transition in the Netherlands, it is important that the municipalities provide engagement tactics and energy policies that focus on the engagement of all homeowners and not only on the early adopters.

Municipalities in the Netherlands can apply the lessons from this thesis to implement and accelerate the heat transition. Such data is especially relevant for policymakers of municipalities facing difficulties in executing the heat transition in the housing sector. In addition, this thesis can also serve as inspiration for other countries, such as Germany, who also desires to become gas-free (Duurzaam Zuidplas, n.d.).

1.4. Scientific relevance

Research on the engagement of homeowners in the heat transition in the Netherlands is understudied, making this study scientifically relevant as well. Engelken et al. (2018) state that *"the current literature provides inconclusive results for understanding households' aspiration to purchase renewable energy system components"* (p. 4).

There are researchers that have studied the engagement of homeowners in the heat transition within the context of foreign countries (e.g., Mahapatra & Gustavsson, 2008; Sardianou & Genoudi, 2013; Perlaviciute and Steg, 2014; Vainio et al., 2020; Ebrahimigharehbaghi et al., 2019; Engelken et al., 2018). However, Mahapatra & Gustavsson (2008) argue that the circumstances determining homeowners' willingness to engage in the heat transition differ per country and change over time. Therefore, it is helpful that this thesis focuses on the specific circumstances in the Netherlands.

So far, eight authors (Jansma et al., 2020; Beauchampet and Walsh, 2021; Scholte et al., 2020; Kort et al., 2020; Koning et al., 2020; Suurs et al., 2019; Bouw 2017; Broers et al., 2019) researched the factors influencing homeowner engagement in the heat transition in the context of the Netherlands. They concluded that future research on this topic would be beneficial to better understand residents' decision-making in the heat transition to provide well fitted municipal strategies and accelerate the heat transition. As Beauchampet and Walsh (2021) state:

> "*Future research should investigate how citizens experience their role in the gas-free transition at the household and community level in the Netherlands, including their experience of the citizen engagement approaches adopted by the Municipalities […]. This would further aid our understanding of the opportunities and barriers to decarbonisation at household level*" (P. 8).

This thesis will elaborate on Beauchampet and Walsh (2021) by providing more insights on the ability to increase the engagement of homeowners in the heat transition in the Netherlands by researching the factors stimulating and discouraging homeowners to participate. This study is based on the perspective of homeowners on engagement tactics of the municipality and is executed on the household level. Therefore, this thesis will add to the body of literature on theory and practice on the best fitted engagement tactics of municipalities to increase homeowner engagement in the heat transition in the Netherlands.

1.5. Readers guide

In the next chapter, homeowners' engagement in the heat transition is described from a theoretical point of view. The focus lies on the factors that influence homeowner engagement on the one hand and the current homeowner engagement strategies employed by Dutch municipalities on the other hand. Chapter 3 operationalizes the research questions and outlines the research methods that were used to answer the research questions. In chapter 4 the results of the research are summarized, after which a conclusion and discussion is formulated. To be read in respectively chapters 5 and 6.

Chapter 2: Theoretical Background

In this chapter, multiple concepts are explored. First, citizen engagement is conceptualised in the context of the heat transition. Subsequently, the factors influencing homeowners' decision-making are framed and operationalized in the context of the heat transition. Furthermore, the current municipal interventions increasing homeowners' engagement in the heat transition are explained. At last, the literature exploration results in the conceptual model.

2.1. Citizen engagement in the heat transition

Many scholars have researched the concept of citizen engagement. This led to an extensive body of literature. However, Ekman and Amnå (2012) explain that due to the large amount of literature, there are also many conflicting perspectives and definitions of the concept (Ekman and Amnå, 2012).

To understand the correct definition of citizen engagement in the context of the heat transition the research of Chambers et al. (2022) is reviewed. Chambers et al. (2022) conducted a literature review on citizen engagement in transition situations. They explain that co-production is an important aspect of citizen engagement in sustainable transitions. Horlings and van der Vaart (2019) define co-production as following: *"putting the community at the centre and places professional or institutional roles in a supportive rather than a controlling role*" (p. 55). This corresponds with the phenomenon researched in this thesis, as homeowners must decide for themselves whether to disconnect from natural gas and connect to an alternative heating system. This shows that homeowners are the centre point of the transition, and municipalities are guiding citizens to accomplish the heat transition. Therefore, it is reasoned that citizen engagement in this thesis can be conceptualised as co-production.

Co-production is a different form of citizen engagement compared to traditional participation. The most known definition of participation is developed by Arnstein (1969):

> "*citizen participation is a categorical term for citizen power. It is the redistribution of power that enables the have-not citizens, presently excluded from the political and economic processes, to be deliberately included in the future. […] In short, it is the means by which they can induce significant social reform which enables them to share in the benefits of the affluent society*" (p. 216).

This definition shows that participation entails the involvement of citizens in governance decision making processes. As explained before, this is not the case for the heat transition. Homeowners must make changes to their homes; however, they are not involved in the decision making process (Jansma et al., 2020).

Furthermore, Visscher et al. (2016) explain that a behaviour change of homeowners is essential for co-production in the heat transition. In line with Visscher et al. (2016), both Mahapatra & Gustavsson (2010) and Jansma et al. (2020) argue that it is vital to understand homeowners' behaviour in the context of the heat transition in order to understand when and why they will implement renewable heating sources to their homes.

In order for municipalities to design effective interventions to stimulate homeowners' behaviour, it is necessary to understand how homeowners' behaviour is determined (Jansma et al. 2020). As Steg et al. (2015) argue, "*we need to understand to what extent and under which conditions individuals and households are willing to accept and adopt different renewable energy sources"* (p. 2). Therefore, in the next section, the components determining behaviour are specified.

2.2 Determination of energy behaviour

People's behaviour is complex and determined by various factors (Stern, 2000). To study the complexity of behaviour, several academics created theories and models to understand the determinable factors.

One of the most well-known models to explain energy-relevant behaviour is the Theory of Planned Behaviour (TPB) developed by Azjen (1988, 1991; see figure 1). The TPB model is widely used in the academic world to determine environmentally related behaviour (for literature review: see Bamberg and Möser, 2006, and Morren and Grinstein, 2016).

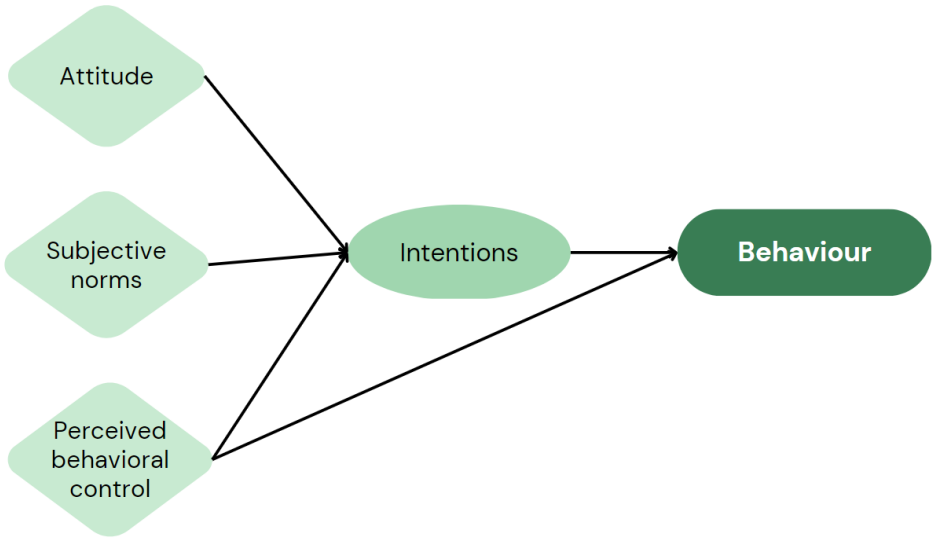

Figure 1: Theory of planned behaviour shown schematically (Author, 2023; inspired by Ryan and Worthington, 2021)

Nonetheless, the TPB model does not include the influence of contextual factors. However, Several authors (Vainio et al., 2020; Jansma et al., 2020; Ruggiero et al., 2015; Perlaviciute and Steg, 2014; Steg and Vlek, 2009) argue that contextual factors are of great influence on people's energy behaviour. Since the heat transition always takes place in a specific context, it influences the behaviour of homeowners.

An academic researcher that does include contextual factors in an energy-relevant behavioural model is Stern (2000). Stern's behavioural ABC-model is an action-oriented behavioural model that considers both internal and external factors (see figure 2). The model determines people's environmental behaviour based on the idea that behaviour is formed by individuals' internal values and their environment. Stern (2000) explains this as follows: *"behaviour is 'an interactive product of personal sphere attitudinal variables and contextual factors"* (p.408). In this model, the attitudinal factor is described as a variety of specific personal views, standards, and values, as well as generic pre-dispositions to act in various ways. The contextual factor can include a wide range of factors such as physical, financial, legal and social, differing per context.

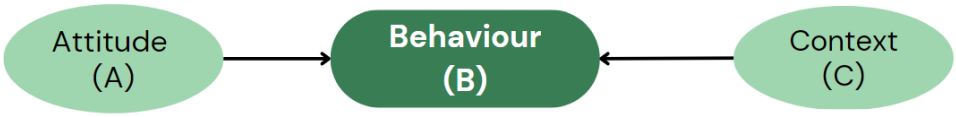

Figure 2: ABC-model of Stern (2000) (Author, 2023)

In addition, recent literature shows that there is another group of factors influencing homeowners' behaviour in the context of the heat transition. The authors Jansma et al. (2020), Vainio et al., (2020), Ebrahimigharehbaghi et al. (2019) , Kastner and Stern (2015) and Broers et al. (2019) all found that peoples' energy behaviour is also determined by their socio-demographic factors. In addition, Ebrahimigharehbaghi et al. (2019) and Broers et al. (2019) claim that, especially during the decisional phase, where homeowners must decide if they want to disconnect from natural gas, socio-demographic factors are of great influence. Therefore, in this thesis, the ABC model of Stern is extended with an extra component, namely socio-demographic factors (see figure 3).

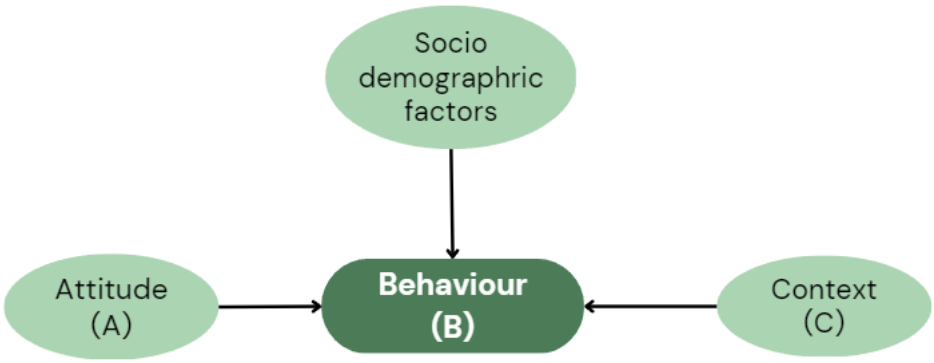

Figure 3: ABC-model of Stern (2000) with additional socio-demographic factors (Author, 2023)

Altogether, it is important to state that, these factors are in practice not strictly separated from each other. The factors are all interlinked. However, for clarity reasons in this thesis, attitude, context, and socio-demographic factors are viewed as separate components.
Moreover, it is also important to state that people's behaviour and attitudes change rather radically over time (Owens et al., 2008). This means that there is always a level of unpredictability when focusing on people's behaviour. Yet, it is still beneficial to identify these factors in the context of the heat transition to understand how homeowners form their behaviour. The next sections of the theoretical framework specifies what the factors attitude, context, and socio-demographic factors imply in the context of the heat transition.

2.3 Homeowners' attitudinal factors in the heat transition

Firstly, the attitudinal factors for the heat transition are explored.

2.3.1. Attitudinal factor 1: Personal values

The first influential attitude factor are people's personal values. Horlings (2015) describes the relation between people's attitudes and values as follows: *"attitudes can be considered to be emergent from values, and therefore an expression of values"* (p. 260). This shows that people's attitudes and personal values are correlated. In this thesis, personal values are defined as "*deep-rooted personal criteria on which thoughts and actions are, often unconsciously, based and evaluated*" (Bouman, 2018 p.2).

According to several authors (Steg and Vlek, 2009; Steg, 2016; Bouman et al., 2020; Perlaviciute and Steg, 2014), four personal values are most influential in determining people's environmental behaviour: biospheric, altruistic, egoistic, and hedonic values. Perlaviciute and Steg (2014) and Bouman et al. (2018) explain that every person has all four personal values however, the prioritisation of the values differs per individual.

First, people with strong biospheric values have concerns about the environment and the negative consequences of climate change (Steg, 2016). Not surprisingly, literature shows

that homeowners with strong biospheric values are more likely to implement energy-efficient measures in their homes (Broers et al., 2019; Ebrahimigharehbaghi et al., 2020). Therefore, it can be reasoned that homeowners with stronger biospheric values are more willing to engage in the heat transition.

However, the type of alternative heating source may affect the participation of homeowners with stronger biospheric values. Kort et al. (2020) claim that environmentally conscious homeowners are very critical of alternative heating solutions. Some natural gas-free heating technologies, such as fossil fuel-generated heat networks, are still too polluting for this group to install them (Kort et al., 2020).

Second, people with strong altruistic values are motivated to increase the well-being of others and society (Steg, 2016). Bouman et al. (2020) state that people with strong altruistic values often also perform pro-environmental behaviour. This can be explained by the fact that climate actions often mitigate societal problems (Bouman et al., 2020). For homeowners with dominant altruistic values, engaging in the heat transition is crucially motivated by the desire to improve the world for future generations (Steg, 2016).

Third, people with strong hedonic values focus on their own pleasure and comfort (Steg, 2016). Perlaviciute and Steg (2014) explain that this group is less inclined to take environmental action since they often find it uncomfortable.

At last, people with stronger egoistic values focus on the safekeeping of their own resources, such as status and money (Steg. 2016). Bouman et al. (2020) show that people with stronger egoistic values often inhibit climate action. Yet, people with strong egoistic values can still engage in the heat transition for non-environmental reasons. For instance, Jansma et al. (2020) and Engelken et al. (2018) found that some people implement renewable heating systems for financially appealing reasons. Steg (2016) and Koning et al. (2019) both discovered that some people install renewable heating systems to increase their social status.

Altogether, it is shown that people interpret certain situations differently based on their personal values. As a result, homeowners' personal values have an impact on how they perceive the heat transition and its contextual factors. In order to involve homeowners with different values in the heat transition, the municipality may benefit from understanding the relationship between contextual factors and homeowners' decisions to disconnect from natural gas. The following section explains the second attitudinal factor: trust.

2.3.2. Attitudinal factor 2: Trust

Trust in the municipality and energy provider is the second attitudinal factor affecting homeowners' behaviour in the heat transition. In this thesis, the well-known definition of Mayer et al. (1995) is used, stating that trust is:

> *"the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party"* (p.712).

The heat transition consists of very complex technologies that often go beyond homeowners' interests and knowledge (Steg et al., 2015). Therefore, homeowners must rely on the information of the municipality and energy provider to help them understand the transition. Several authors (Hamersma et al., 2018; Steg et al., 2015; Koning et al., 2020; Jansma et al., 2020) explain that due to this level of dependency, the extent to which citizens trust these responsible actors influences their acceptability and engagement.

First, zooming in on the current level of trust homeowners have in the energy provider. If a DHS were to replace the current heating system, the energy provider would be in a monopolistic position (Bouw et al. 2017). Li et al. (2015) found that in monopolistic market structures, there is often a lack of transparency for homeowners on the determination of

pricing, as it is not possible to compare prices with other suppliers. As a result, Kort et al. (2020) explain that homeowners often question the fairness of the price setting, leading to a low level of trust in the energy provider. Furthermore, Bouw et al. (2017) demonstrate that homeowners cannot shift to another energy provider when they are connected to a DHS. This is again caused by the monopolistic market structure, alternatively described as the lock-in effect (Bouw et al., 2017). Both Kort et al. (2020) and Bouw et al. (2017) found that the lock-in effect also negatively affects homeowners' trust in the energy provider.

Second, the degree of trust homeowners have in the municipality is considered. According several authors (Steg et al., 2015; Kort et al., 2020; Scholte et al., 2020), homeowners are more willing to accept energy policies if they trust the decision-making process of the municipality. Homeowners often base their trust on previous experiences with the municipality and their level of trust in the national government (Koning et al., 2020). The report of Miltenburg et al. (2022) found that the current level of trust among citizens in the Dutch national government is very low. This can have a negative effect on the trust homeowners have in their municipality. In relation, Jansma et al. (2020) also state that *"homeowners doubt whether the municipalities have the capacity to guide the transition and the willingness to consider their interests"* (p.9). This also demonstrates that the current trust of homeowners in the municipalities is generally low.

To conclude, the degree of trust homeowners have in the municipality and the energy provider has an influence on their decision to disconnect from natural gas. Table 1 shows the attitudinal factors influencing homeowner engagement in the heat transition.

Table 1: Typology of attitudinal factors in the heat transition

Attitudinal factors	
Personal values	• Biospheric values • Altruistic values • Hedonic values • Egoistic values
Trust	• Municipality • Energy provider

2.4 Homeowners' contextual factors in the heat transition

Besides the attitudinal factors, the contextual factors influence the decision of homeowners to engage in the heat transition as well. In this section, the influential contextual factors for the heat transition are explored.

2.4.1. Contextual factor 1: Costs

The costs related to the heat transition can be divided between the investment costs and monthly energy costs.

Investment costs are defined as the payments homeowners must make to change their heating installation, as well as the costs for an induction hob and new pans (Perlaviciute and Steg, 2014). Several authors (Perlaviciute and Steg, 2014; Beauchampet and Walsch, 2021; Jansma et al., 2020; Noir et al., 2010) found that investment costs are perceived as one of the disadvantageous factors for homeowners to engage in the heat transition. This is mainly due to the fact that investment costs are high (Jansma et al. 2020), and due the fact that there is uncertainty about the amount of the investment costs (Koning et al., 2019).

The amount of the investment costs ranges between 12,000 and 35,000 euros per household (Beauchampet and Walsh, 2021). Compared to the average yearly income of Dutch households of 75,200 euros (CBS, 2022), this investment can be considered as large. Therefore, it is not surprising that Scholte et al. (2020) and Jansma et al. (2020) found that most Dutch homeowners are not able to make these expenses.

Furthermore, the investment costs differ per household depending on the physical state of the house, the type of alternative heating source, and the energy provider (Bouw, 2017; Koning et al. 2019). The variation in investment costs is quite large. According to Koning et al. (2019), this uncertainty and discrepancy of investment costs negatively impacts homeowners' willingness to engage in the heat transition. Overall, according to the literature most homeowners perceive the investment costs as a burden instead of a smart investment (Beauchampet and Walsh, 2021). Financial incentives can be an effective means to alleviate this burden (further elaborated upon in section §2.6.2).

Besides the investment costs, the monthly energy prices are also influential in the engagement of homeowners in the heat transition. On average, the monthly energy costs of alternative heating systems are lower compared to those of heating systems containing natural gas (Koning et al. 2020). This means that homeowners can earn back their investment costs in the long run, approximately this takes 20 years (Beauchampet and Walsh, 2021). However, some homeowners find it difficult to assess the long-term financial benefits of connecting to an alternate heating source (Beauchampet and Walsh, 2021). In contrast, according to Kort et al. (2020) there are homeowners who do engage in the natural gas-free transition due to the prospect of profits and lower monthly energy costs in the future. Koning et al. (2019) also show that energy bill savings are occasionally cited as a reason for some homeowners to disconnect from natural gas.

All in all, homeowners generally perceive the investment costs as a negative aspect of alternative heating sources. The high expenses and uncertainty surrounding investment costs result in disengagement among homeowners. At the same time, the monthly energy bills are seen as a motivation for homeowners to engage, as these are relatively cheaper (depending on the situation) compared to the monthly gas prices.

2.4.2. Contextual factor 2: Residence

The second contextual factor is related to homeowners' residences. This contextual factor consists of four components. The first component is the nuisance of construction. Several authors (Jansma et al., 2020; Wilson et al., 2015; Ebrahimigharehbaghi et al., 2019) state that homeowners frequently perceive the installation of a new heating system as an inconvenience. Often, they experience the nuisance of construction as a negative disruption to their daily lives (Koning et al., 2019). Beauchampet and Walsh (2021) even discovered that construction

nuisance is perceived as such a significant disruption to the comfort of householders that it can result in disengagement.

Second, several authors (Perlaviciute and Steg, 2014; Broers et al., 2020; Kort et al., 2020) found that homeowners are concerned about the perceived thermal comfort of the alternative heating sources will not be sufficient for their standards. According to Kort et al., (2020) this can be explained by homeowners' fear of losing control of the thermal heat in their home once connected to an alternative heating system. Nonetheless, Van Lidth de Jeude & Midden (2014) discovered that some homeowners believe that connecting to an alternative heating system would be beneficial for the temperature regulation in their homes.

The third aspect of a homeowners' residence is the current status of the house. According to Koning et al. (2020), homeowners are more likely to connect to an alternative heating source if they are already intending to make home improvements or are in need of a new boiler for central heating. In contrast, when homeowners have just renovated, they will be less likely to engage in the heat transition (Koning et al., 2020)

The last component of the contextual factor residence is the value of the residence. According to Mahapatra and Gustavo (2009), the value of a home may increase when it is disconnected from natural gas. In addition, they explain that some homeowners disconnect their homes for this reason.

All in all, the residence homeowners live in has an influence on whether they disconnect from natural gas based on the potential nuisance of construction, concerns about thermal comfort, current status of the house and possible increase of home value.

2.4.3. Contextual factor 3: Uncertainty of the process

Uncertainty surrounding the procedure is the third contextual factor influencing the decision of homeowners to disconnect natural gas. The process of disconnecting existing buildings from natural gas is relatively new and therefore relatively unknown (Sardianou and Genoudi, 2013). According to Sardianou and Genoudi (2013), the level of uncertainty about the process influences homeowners' decisions to purchase alternative heating sources.

This is not surprising, as Bagozzi et al. (2016) show that when there is a level of uncertainty, people are less likely to make a purchase. They explain that in times of uncertainty, people will often choose the safe and known option. In terms of the heat transition, this means that homeowners are more likely to remain connected to natural gas. Furthermore, Kort et al. (2020) discovered that the level of uncertainty of the process is seen as a deterrent for homeowners to participate in pilot projects.

2.4.4. Contextual factor 4: Positive effects on climate change

The fourth contextual factor influencing homeowners' decisions in the heat transition are the perceived positive effects on climate change. According to Uphum and Jones (2012) and Viviano et al. (2020), an important motivation for homeowners to disconnect from natural gas is the belief that there will be a positive impact on climate change. Suurs et al. (2019) discovered that homeowners with various beliefs are motivated to switch to an alternative heating source based on environmental concerns. As a result, the contextual aspect of improving the effects of climate change is a motivator for homeowners to engage in the heat transition.

2.4.5. Contextual factor 5: Social network

The municipality's ability to respond to neighbourhood social networks is the final contextual factor. Kort et al. (2020) found that a social network in the neighbourhood can positively influence homeowner engagement in the transition. If many homeowners in a neighbourhood are implementing alternative heating sources, it is more likely that other homeowners in the neighbourhood will do the same (Koning et al., 2019). According to Steg et al. (2015), this can be explained by homeowners' desire to be accepted by their surroundings. An example of this is given by Sardianou and Genoudi (2013), as their empirical result confirmed that homeowners "would install a renewable energy system in their home if their family or friends would encourage them to do so" (p.3)

Furthermore, according to Jansma et al. (2020) and Ebrahimigharehbaghi et al. (2019), experiences will be more readily shared in a neighbourhood with a strong social network. An example would be neighbours sharing their positive or negative experiences with the heat transition. According to Broers et al. (2019) and Engelken et al. (2018), homeowners' discussions about the heat transition can increase the adoption of alternative heating systems. To sum up, a neighbourhood's social network can boost participation by distributing information more quickly and appealing to people's desire for social acceptance.

An overview of all influential contextual factors discussed in this section is given in table 2.

Table 2: Typology of contextual factors in the heat transition

Contextual factors	
Costs	• Investment costs • Monthly energy costs
Homeowners' residence	• Nuisance of construction • Concerns about thermal comfort • Current status of the house • Potential increase of home value
Uncertainty of the process	• Uncertainty of the process
Positive climate effects	• Positive climate effects
Social network	• Quick distribution of information • Desire of social acceptance

2.5. Homeowners' socio-demographic factors in the context the heat transition

In this section, the socio-demographic factors are explained. In the context of the heat transition, the relevant socio-demographic factors are age, income, and education/ knowledge.

2.5.1. Socio-demographic factor 1: Age

According to several authors (Scholte et al., 2020; Noir et al., 2010; Jansma et al., 2020; Mahapatra and Gustavsson, 2008), there is a correlation between age and willingness to engage in the heat transition. The authors all state that older homeowners are less inclined to make energy-efficient investments since they don't know if they will reap the benefits during the remainder of their lives. Scholte et al. (2020) show that this also applies the other way around. Young adults (18 – 34) are more positive towards the heat transition. Boers et al. (2019) found that the attitude of this population translates into actions, as it appears that younger homeowners are more willing to invest in energy efficiency measures.

2.5.2 Socio-demographic factor 2: Income

Several authors (Beauchampet and Walsh, 2021; Noir et al., 2010; Broers et al., 2019; Scholte et al., 2020) show that homeowners with a relatively low income engage less in the heat transition compared to homeowners with a higher income. People with comparatively lower incomes are more frequently unable to afford the high investment costs. In addition, Broers et al. (2019) and Sardianou an Genoudi (2013) found that when monthly incomes increase, homeowners' willingness to engage in the heat transition also increases.

2.5.3. Socio-demographic factor 3: Education and knowledge

According to several authors (Scholte et al., 2020; Broers et al., 2019, Sardianou & Genoudi, 2013), homeowners with a relatively higher education level are more likely to engage in the heat transition. In addition, this also results in people with a lower education level to be less likely to engage in the heat transition. Kort et al. (2019) explain that the lower engagement of homeowners with a lower education level can be explained by the fact that this population group often does not have the right information, skills, or resources to understand the complexity of the transition. Moreover, an increased level of knowledge is beneficial for homeowners' engagement in the heat transition (Broers et al., 2019). Since homeowners with a lower education level have fewer skills to understand the information, it can present difficulties for their engagement in the heat transition.

An overview of the three socio-demographic factors influencing homeowner engagement in the heat transition is shown in table 3.

Table 3: Typology of socio-demographic factors in the heat transition

Socio-demographic factors	
Age	• Older homeowners are less likely to participate in the heat transition • Younger homeowners are more likely to participate in the heat transition
Income	• Homeowners with a higher income are more likely to participate in the heat transition • Homeowners with a lower income are more likely to participate in the heat transition
Education	• Homeowners with a higher level of education are more likely to participate in the heat transition • Homeowners with a lower level of education are more likely to participate in the heat transition

2.6. Municipal interventions in the context the heat transition

The previous sections provided an overview of factors determining homeowners behaviour and, therefore, their decision to engage in the transition. It is beneficial to know these factors to understand which municipal interventions would best to help homeowners engage in the heat transition. This section explores how municipal policymakers can mobilise homeowners to engage in the heat transition.

According to Mahapatra and Gustavsson (2008), public policies can influence homeowners' decisions to switch to alternative heating sources. Therefore, it is relevant to explore the various ways public policies can target homeowners' behaviour to connect to new heating sources. In this thesis, public policy is defined as "*the sum of government activities, whether pursued directly or through agents, as those activities have an influence on the lives of citizens*" (Peters, 2013, p. 4). To implement public policies, governmental bodies can adopt various policy instruments. In this thesis, policy instruments are defined as "*the set of techniques by which governmental authorities wield their power in attempting to ensure support and effect or prevent social change"* (Vedung, 1998, P. 2).

Vedung (1998) developed a well-known threefold classification to categorise policy instruments. His threefold classification states that public instruments can be either part of regulations (stick), economic measures (carrot), or information provision (sermons). Table 4 provides an explanation of the policy instruments in the context of the heat transition.

Table 4: The three categories of policy instruments developed by Vedung (1998) explained in the context of the heat transition (Author, 2023)

Policy instruments	Explanation in the context of the heat transition
Regulations (Stick)	The homeowners are obligated to take certain actions implied by the municipality
Economic means (Carrot)	The municipality helps to soften the desired action of homeowners by implementing economic incentives. Or the municipality increases the difficulty of the non-desired action of homeowners by adding or removing of material sources
Information (Sermon)	The municipality uses communication and argumentation to pursue homeowners in the desired direction

To understand if the current public instruments used by Dutch municipalities are effectively increasing homeowners' engagement in the heat transition, a review of the current municipal public interventions are described below, according to the threefold classification of Vedung (1998).

2.6.1 Current regulations in the heat transition

Bemelmans-Videc et al. (2017) define regulations as "*measures undertaken by governmental units to influence people by means of formulated rules and directives which mandate receivers to act in accordance with what is ordered in these rules and directives*" (p. 31). Currently, there is only one regulation in the Netherlands regarding alternative heating sources. This regulation is the heat law (warmtewet). The heat law is established to monitor the rights and obligations of homeowners by setting maximum tariffs for heat prices (Rijksoverheid n.d.B). The maximum tariffs are related to the current gas prices. This means that when gas prices increase, so will heat prices, and vice versa (Wettenbank, 2023). This construction is meant to protect homeowners connected to a DHS from overpaying. As explained before, homeowners who connect to a DHS can no longer switch between energy providers. The heat law came into force on October 1, 2022 (Wettenbank, 2023).

Nevertheless, the Dutch government is currently (July 2023) in the process of drafting a new regulation regarding alternative heating sources. This new regulation is known as the collective heat supply (collectieve warmtevoorziening) and will go into effect on January 1, 2025 (EZK, 2022). The new regulation includes rules for DHS, and entails that by the year 2025, all DHS infrastructure should be owned by the public sector (EZK, 2022). The reasoning behind this regulation is to decrease the power of energy providers (who are currently the owners of the DHS) and arrange fair pricing for homeowners who are connected to the DHS (EZK, 2022). With this regulation, the Dutch national government attempts to increase the attractiveness of connecting to DHS, by removing the monopolistic market structure of the energy provider.

As there are only two regulations regarding alternative heating sources, it shows that the current focus of the Dutch public instruments is not on regulations. However, Jansma et al. (2020) and Beauchampet and Walsch (2021) argue that this lack of national regulations is a big obstacle to the heat transition. These researchers found that the current absence of national policies decreases the willingness of homeowners to disconnect from natural gas. Due to the lack of regulations, homeowners feel a lack of urgency to engage and thus choose not to (Jansma et al., 2020).

On the contrary, Engelken et al. (2018) advise governmental bodies to focus on policies supporting and subsidising pro-environmental (carrot) behaviour instead of restricting policies (stick). The reasoning behind this statement is that every household and building is unique, and imposing regulations can be precarious (Engelken et al., 2018).

2.6.2. Current economic policy instruments in the heat transition

Bemelmans-Videc et al. (2017) state that *"economic policy instruments involve either the handing out or the taking away of material resources, be they in cash or in kind"* (p.32). Currently, the focus of the Dutch national government is on providing financial incentives (e.g., RON, n.d.). The national government provides financial incentives directly to homeowners and municipalities working on neighbourhood approaches to disconnect residents of natural gas. The municipality, in turn, hands out these subsidies to the homeowners. The national subsidies directly offered to homeowners is the national climate fund (Nationaal Warmtefonds). This fund contains 1.1 billion euros to help homeowners invest in energy-efficient home renovations and provides a subsidy of 3.325 euros to homeowners who to connect to DHS (RON, n.d.).

According to several authors (Bouw, 2017; Beauchampet and Walsh, 2021; Perlaviciute and Steg, 2014; Koning et al., 2019 ; Jansma et al., 2020), financial incentives are very effective in decreasing the obstacle of investment costs and increasing homeowners' willingness to disconnect from natural gas. For instance, Jansma et al. (2020) show that neighbourhoods that receive subsidies to disconnect from natural gas score higher on the willingness to disconnect than non-subsidized neighbourhoods.

In addition, Koning et al. (2019) found that it is even more beneficial to offer the financial incentives temporarily. They explain that the temporariness of the incentive can trigger the "now or never" feeling among homeowners and therefore increase their willingness to participate. In addition, offering a temporary financial incentive is more feasible for municipalities because they do not need to provide a continuous flow of money but can release a large sum of money all at once. Nonetheless, Steg et al. (2015) argue that only offering financial incentives is not enough to entice all homeowners to engage. Some homeowners desire more information or understanding before they engage in sustainable energy behaviour.

All in all, it can be stated that financial incentives can be effective in motivating homeowners to engage in the transition, especially when offered temporarily. However, additional policy instruments should also be in place to engage all homeowners.

2.6.3. Current information provision in the heat transition

Bemelmans-Videc et al. (2017) state that information provision *"covers attempts at influencing people through the transfer of knowledge, the communication of reasoned argument, and persuasion"* (p.33). This shows that information can thus increase an individual's knowledge. As explained in §2.2, the level of knowledge homeowners have is influential in the decision-making to disconnect from natural gas. Kort et al. (2020) explain that, in general, Dutch homeowners lack knowledge about the natural gas-free transition. This lack of knowledge can lead to nonengagement for two reasons.

First, Broers et al. (2019) explain that there is a correlation between the provision of information and homeowners' engagement in the transition. According to them, people who have easy access to information (and thus increase their knowledge) about energy efficient measures are more likely to adopt alternative heating systems. Wilson et al. (2015) even state that homeowners who lack dependable information about energy-efficient installations are more hesitant to implement these measures. This can be explained by the fact that these measures are relatively technical, which increases the difficulty for many people to understand what these measures would entail in their personal situation (Broers et al., 2019; Wilson et al., 2015). Thus, when there is not a clear explanation of these measures, it is less likely that homeowners will engage.

Second, people who lack information can develop misunderstandings about the transition, leading to prejudices (Kort et al., 2020). Perlaviciutec and Steg (2014) explain that nonengagement often occurs when people have misperceptions about the consequences of the transition. However, it is important to claim that not all homeowners who have more information would automatically engage in the transition. Kort et al. (2020) show in their research that homeowners who do not engage in the transition are sometimes well-informed. In this instance, their lack of engagement is due to factors other than a lack of knowledge.

Dutch municipalities are currently intensively focusing on information provision for homeowners. It depends on the municipality as to what the information provision entails. According to the literature there are several ways to beneficially provide information to homeowners.

First, according to Kort et al. (2020) it is beneficial for municipalities to offer information on a wide spectrum of channels. Hamersma et al. (2018) explain that people desire different levels of engagement based on their personal preferences and lifestyles. For example, some homeowners prefer to receive information by reading, while others prefer to receive information via oral communication. In other words, providing a large spectrum of information is essential.

Second, multiple researchers state that homeowners are more likely to perceive the information as trustworthy and more likely to participate, when they were provided with transparent and objective information, (Steg et al., 2015; Jansma et al., 2020). In addition, Bouw et al. (2017) stated that it is also beneficial for the trust of homeowners if the energy provider was transparent about the information on heat pricing determination. In turn, the increased trust of homeowners in the energy provider would also increase their willingness to engage (Bouw et al., 2017). Thus, providing transparent information is beneficial for both municipality, and homeowners.

Third, Steg et al. (2015) claim that homeowners are more likely to participate when the offered information is easily accessible and understandable. As all people have their own values and installations, it can be difficult for homeowners to understand what the provided information means for them individually or how they can access the offered subsidies (Ebrahimigharehbaghi et al., 2019). Therefore, Ebrahimigharehbaghi, et al. (2019) and Engelken (2018) state that it can become more understandable for homeowners when they perceive tailor-made information. Therefore, offering easy accessible and tailor-made information can help for homeowners to understand the advice.

Fourth, Koning et al. (2019) and Broers et al. (2019) claim that it is beneficial if homeowners experience personal, face-to-face attention when they receive tailor-made advice. This increases the level of trust homeowners have in the municipality. Stampa et al. (2020) and Engelken (2018) state that by providing an argumentation based on someone's personal values, the willingness to disconnect from natural gas increases. All in all, profiding personal attention is helpful for homeowners and the municipality

Fifth, since social cohesion is influential in encouraging homeowners to engage in the transition (see §2.4.5), it is beneficial for the municipality to respond to it. This can be done by organising informative events where people can gather socially while receiving information. Kort et al. (2020) explain that some homeowners are more eager to receive information while also experiencing social benefits. Using active, well-known citizens as local ambassadors to inform the rest of the community is another socially influential strategy (Steg et al., 2015; Ebrahimigharehbaghi et al., 2019; Engelken et al., 2018). This can create broader support and increase trust between the homeowners and the municipality (Beauchampet and Walsch, 2021; Jansma et al., 2021). Hence, responding to the social network in a neighbourhood can increase the process of homeowner engagement in the heat transition.

Finally, the timing of informing and involving homeowners is crucial. Kort et al. (2020) and Jansma et al. (2020) argue that it is beneficial to involve homeowners in an early stadium to increase their willingness to engage. However, Beauchampet and Walsh (2021) state that in the early stages of the process, many aspects are still unknown and uncertain, which can create confusion or a lack of interest among citizens. Thus, it is essential to identify the juncture of the process at which sufficient information is available, but homeowners still feel like they are being involved early on.

2.7. Conceptual model

In the conceptual model shown below, energy behaviour theory and heat transition theory are combined. The conceptual model demonstrates that the energy behaviour of homeowners can be affected by their attitude, socio-demographic factors, and context. The literature suggests that the attitude of homeowners in the heat transition is formed by two factors, peoples personal values and homeowners trust in the municipality and energy provider. The literature also indicated that the sociodemographic factors age, education, and income influence homeowners energy behaviour in the heat transition. Additionally, existing literature suggests that there are five contextual factors that could potentially influence the energy behaviour of homeowners during the heat transition. The costs homeowners must pay to disconnect from natural gas, homeowner residences (including construction nuisance, concerns about low thermal comfort, and increasing house value), the potential negative effects of the process' uncertainty, the potential positive effects of disconnecting from natural gas on the climate, and the social network in a neighbourhood are the factors.

Through the use of interventions can municipalities encourage homeowners to cut off their natural gas supply at home. These interventions can be classified into three different categories. These are financial incentives, information provision, and regulations. Literature shows that municipal interventions can encourage homeowners behaviour by influencing their attitude and context.

Finally, there are also exogenous, unpredictable factors that may impact homeowners' behaviour during a heat transition. For instance, the war between Russia and Ukraine has caused gas prices to rise exponentially (Rijksoverheid, n.d.C). This can have a significant impact on homeowners' decisions during the heat transition; however, due to the unpredictability of this factor, it is not considered in the conceptual model.

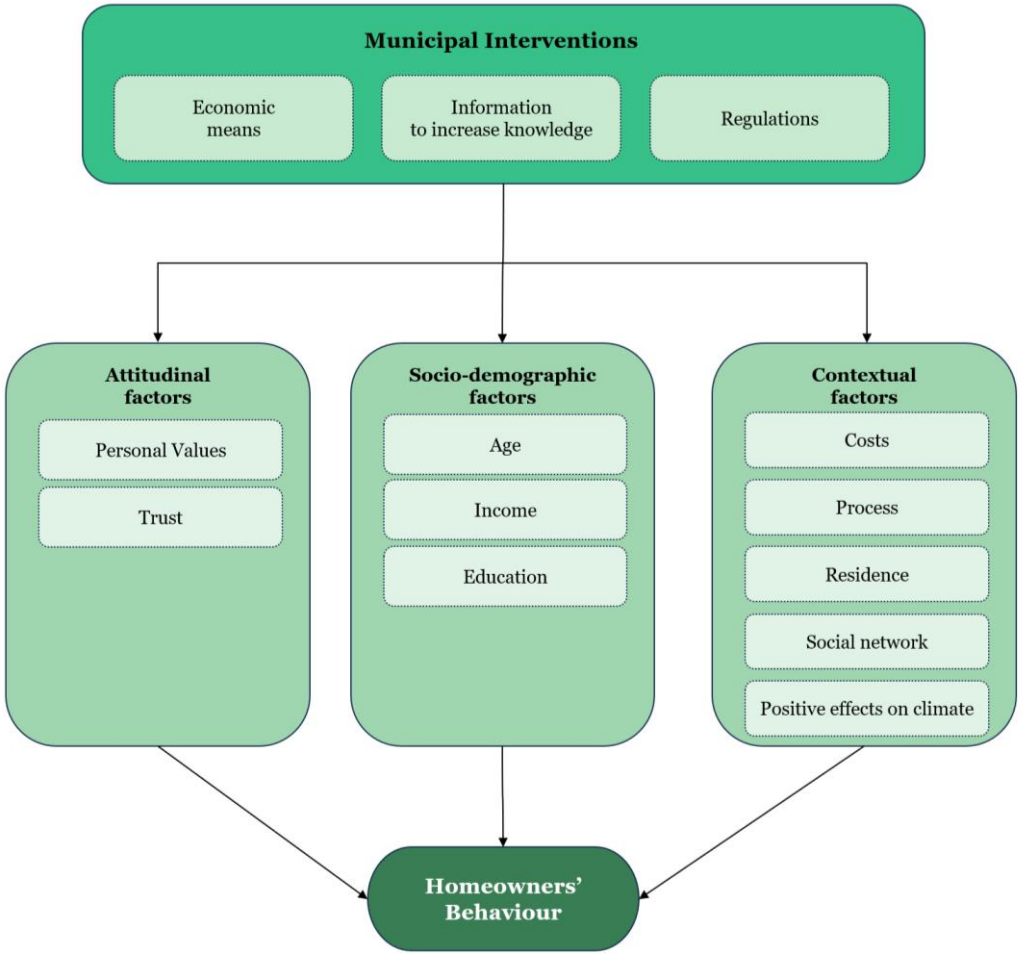

Figure 4: Conceptual model

Chapter 3: Methodology

The research methodology is described in this chapter. The research design is developed first, followed by the introduction of the case study. Following that, the data collection and analysis methods are specified, and finally, the ethical considerations are explained.

3.1. Research design

To analyse the case study of Reyeroord, a combination of quantitative and qualitative data research methods have been applied; review of internal documents of the project, a survey, interviews, and the outcome of a prior survey conducted by the project team of Reyeroord. By combining both qualitative and quantitative research, it is possible to find patterns (quantitative) and research the deeper meaning behind the patterns (qualitative) (Clifford et al. 2016). This can improve the quality of the research because it offers a more comprehensive perspective on the case study, according to Yin (2003). The rationale behind the selection of these particular research methods is given below.

The internal documents of the project team Reyeroord were reviewed to get a better understanding of the context of the project. With the additional project details learned from internal documents, it was possible to comprehend the project better, allowing for the creation of more in-depth survey and interview questions.

A survey was chosen in this study to acquire information about the factors influencing homeowners' decisions to engage in the heat transition in Reyeroord. Ryan and Worthington (2021) explained that it is most beneficial to use statistical data when researching the factors influencing people's behaviour.

Interviews with the project team were held to gain a more in-depth understanding of the project natural gas-free Reyeroord. According to Clifford et al. (2016), using interviews enables researchers to understand the underlying causes, which cannot be discovered by using only quantitative research. Experts were also interviewed in order to learn more about the reasons why homeowners disconnect from using natural gas and the obstacles they face, as well as about potential strategies to boost homeowner participation in the heat transition. The expert interviews enabled the researcher to ascertain whether the findings of the survey and interviews with the project team were also found in other projects throughout the Netherlands. This aided in reaching more solid conclusions.

At last, the results of a previous survey have been evaluated. The project natural gas-free Reyeroord conducted a survey among the residents of Reyeroord (N=132). The purpose of this survey was to determine which informative interventions Reyeroord residents preferred and thought were most effective. Thus, by reviewing the outcome of this survey, it was possible to get an understanding of homeowners' perspectives on the implemented interventions of the project. A schematic overview illustrating how the data is used to answers the research questions is given in figure 5.

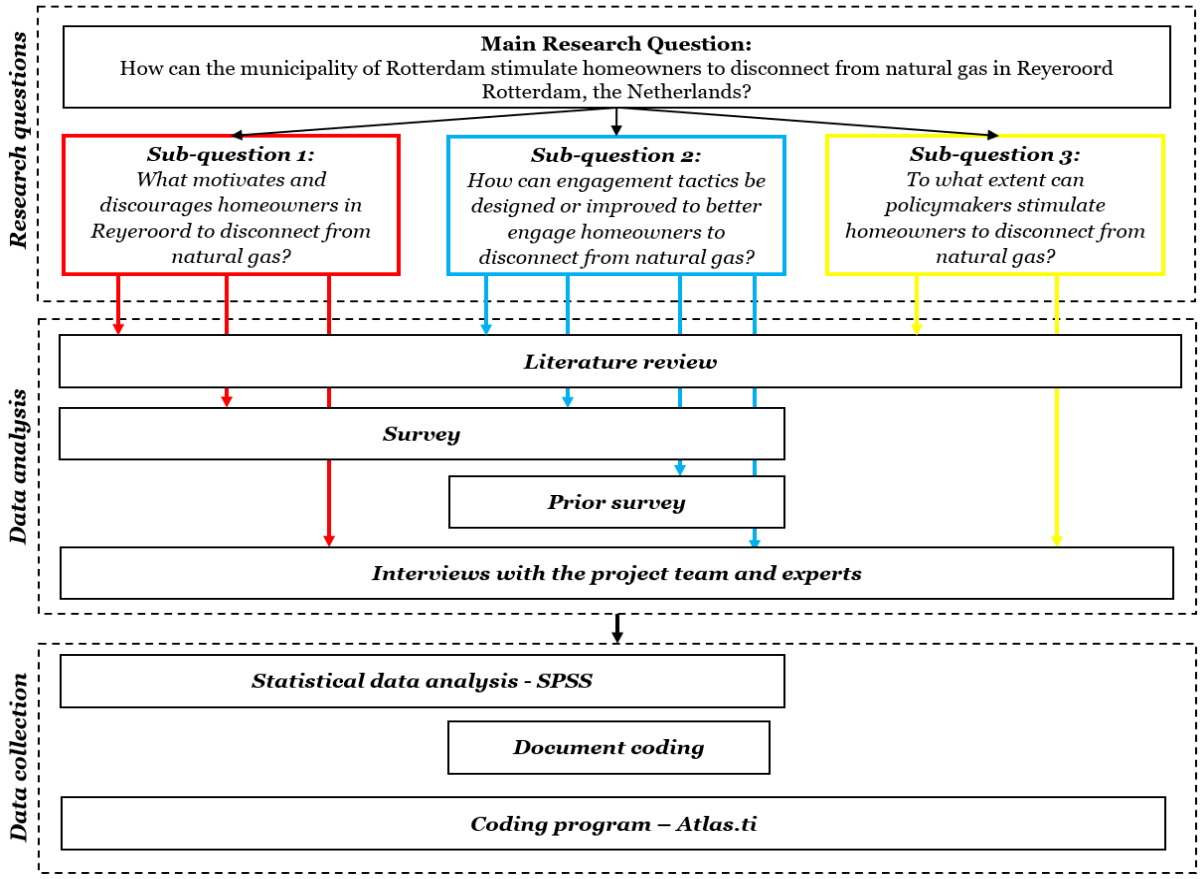

Figure 5: Schematic overview of framework answering sub-questions (Author, 2023)

3.2. Case study

In this thesis, a case-study approach is adopted. According to Yin (2003), a case study approach is useful when researching social aspects, such as people's perspectives and actions. This relates to the research question of this thesis, which focuses on homeowners' perspectives on the heat transition and how municipalities can best respond to it.

It is also important to note that the risk of using a single case study approach is overgeneralization because the study was conducted within a specific boundary of circumstances and time, which can vary depending on the situation (Flyvbjerg, 2006). However, in later research, Flyvbjerg (2011) explains that the conclusions of a single case study are applicable to similar cases. This shows the conclusions of this research can be valid for other neighbourhoods in the Netherlands as well. Therefore, the case study method is still relevant for this thesis. The risk of overgeneralization will be considered again in the concluding part of the thesis. The selected case study will be specified in the next section.

3.2.1. Case description

The municipality of Rotterdam is actively working on the implementation of the heat transition across the city through six pilot projects (Gemeente Rotterdam, n.d.). Within these pilot projects, the city of Rotterdam assists residents in disconnecting from natural gas by implementing neighbourhood-specific approaches (Gemeente Rotterdam, 2022).

One of the six pilot projects is the neighbourhood Reyeroord, located in the region of Groot-IJsselmonde (see figure 6). Reyeroord was chosen as one of the experimental projects by the municipality of Rotterdam because it already had a heat source nearby: a pipeline carrying hot residual water from the port (Gemeente Rotterdam, n.d.). In addition, the existing sewage system in the neighbourhood was in need of replacement (Gemeente Rotterdam, n.d.). The municipality saw the combination of the pipeline and sewage replacement as the perfect

opportunity to disconnect Reyeroord from natural gas and connect it to a DHS (Gemeente Rotterdam, n.d.).

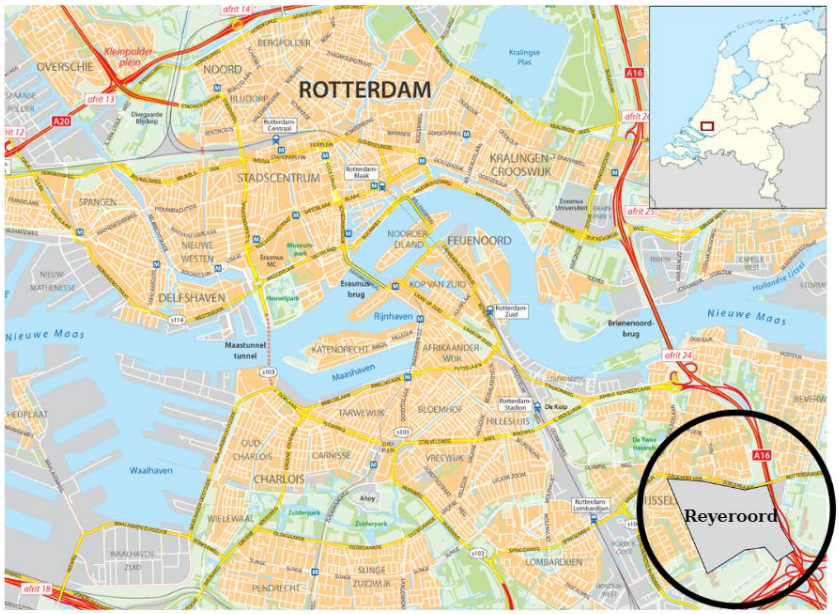

Figure 6: Location of Reyeroord in the Netherlands (Author, 2023)

To execute the project, the municipality of Rotterdam (together with three private companies) had chosen to implement a design approach method for the participatory trajectory. With this strategy, the municipality aimed to give Reyeroord's citizens the best advice possible to encourage their participation in the heat transition (internal document, n.d.). As a result, new, experimental participation strategies were put into place, such as pop-up information meetings. The DHS will be implemented in stages across several subareas in Reyeroord, see figure 7.

Figure 7: Reyeroord divided in subareas (duurzaam010, 2021)

Because subareas A, B, and C will be the first to receive DHS implementation, the municipality chose to prioritise these parts of the neighbourhood within the participatory trajectory (Gemeente Rotterdam, n.d.). As a result, the participatory trajectory was only implemented in subareas A, B, and C, while subareas D and E were only informed that the DHS would be implemented in a couple of years.
To investigate the effects of the interventions, both sections of the neighbourhood were analysed and compared to see if there were any differences. In this thesis, subareas A, B, and C are called the *informed part of the neighbourhood,* and subareas D and E are referred to as *the control part of the neighbourhood.*

3.2.2. Case selection
The natural gas-free Reyeroord project was chosen for this thesis for two reasons. The first reason is that the Reyeroord participatory trajectory has already been completed, and the project is now in the implementation phase. This enables reflection on the various interventions implemented in the project as well as analysis of the project's results. The second reason is the implemented design approach for the participatory trajectory. By using this innovative strategy, a distinct emphasis was placed on assisting homeowners with the transition to a new heating system. Therefore, it is very intriguing to investigate the interventions implemented in the project and learn how the municipality helped the homeowners along the way.

3.3. Data collection methods and data analyses
This section will go into greater detail regarding the data collection procedures and analyses. First specifying the internal documents, then the survey and interviews, and finally the prior conducted survey.

3.3.1. Secondary document analysis
This section will go into greater detail regarding the data collection procedures and analyses. First specifying the internal documents, then the survey and interviews, and finally the prior conducted survey.

Several sources about the project were consulted for the secondary document analysis. The project team's google drive was accessed in order to gather the documents. One of the project team members granted access to the drive. Within this thesis are the documents referred to as internal document (n.d.). The documents that were examined are listed below:

- Ontwerepende aanpak Aardgas vrij;
- Report_Reyeroord aardgas vrij;
- Energietransitie_toolbox;
- Tabel interventies;
- Factsheet Reyeroord;
- Vragenlijst online Aardgas-vrij.

All sources were examined, and from the documents, intriguing information was gleaned.

3.3.1. Survey
The survey was created using the software Qualtrics XM and can be found in Appendix A. The survey was tested before use to eliminate ambiguities. The questions regarding trust were based on prior research by Grimmelikhuijsen and Knies (2015), while the questions about people's personal values were taken from research conducted by de Groot and Steg (2007).
The sampling of the survey was conducted in person with a combination of a door-to-door approach and by approaching people in the streets in Reyeroord. This technique was chosen

to increase the response rate of the survey. The houses selected for the door-to-door approach were selected using a random sampling technique.

The quantitative data set consists of 116 valid cases. The data set counts 57 respondents in the informed part of the neighbourhood and 59 respondents in the control part of the neighbourhood.

The data from the survey was analysed with the software SPSS. For the questions about trust, social cohesion, and personal values, a 5.Likert interval scale was used. To determine the reliability of these variables, the Cronbach's Alpha of the various questions was checked. For all variables tested with the 5.Likert scale, the Cronbach alpha was 0.698 or higher and therefore valid to use in this research; see Appendix A table 1.

To analyse the quantitative data set, several tests were run. To begin, One-way ANOVA tests were generated to analyse the differences between the informed part of the neighbourhood and the control part of the neighbourhood and to declare the one-to-one relationships between the potential influential factors and the intention for homeowners to participate. Within the One-way ANOVA test, the Tukey HSD was selected due to the three answering options to the question about homeowners intentions to connect to DHS. To further examine the one-to-one relationship between the potential influencing factors and the intention of homeowners to participate, chi-square tests were conducted for the nominal variables. In addition, a generalised linear model (a type of regression) was used to investigate the relationship between people's intention to participate and contextual, attitudinal, and social demographic factors. Finally, a correlation test was generated to review the relationship between people's personal values and their contextual values.

3.3.2. Semi structured in-depth interviews

Next, six semi-structured interviews were conducted for this thesis. Semi-structured in-depth interviews are used because they allow the researcher to understand respondents' answers while still providing enough structure in the interview guide to perform comparable analyses (Clifford et al., 2016).

The interviews include three expert interviews and three interviews with Reyeroord project team members (see 3.1 for the purpose of the interviews). The interviews were conducted online and recorded using Google Meet. The recordings were saved in a password protected file. Furthermore, prior to the interview, the respondents were given a letter of informed consent developed by the research Ethics committee of that faculty of spatial science (see Appendix B). By signing the informed consent form, the interviewees agreed to their participation and recording of the interview. Finally, the respondents are anonymized in this thesis.

Table 5: Overview of respondents (Author, 2023)

Type of interview	Code	Occupation	Date	Duration
Expert interview	Respondent 1	Energy transition specialist at implementing organization Regional Energy Desk	25-04-2023	00:36:15
Expert interview	Respondent 2	Program manager Neighbourhood of the Future & founder of Diep	24-04-2023	00:59:14
Expert interview	Respondent 3	Project leader aardgasvrije Tuinen Tilburg	04-05-2023	00:44:03
Project group interview	Respondent 4	Sustainability policy advisor Municipality of Rotterdam	25-04-2023	00:48:34
Project group interview	Respondent 5	Participation and design advisor	24-04-2023	01:00:09
Project group interview	Respondent 6	Communication and design advisor	08-05-2023	00:47:24

To analyse the interviews, transcriptions were made of the Google Meet recordings. The transcriptions are coded in ATLAS.ti. by using deductive and inductive labels. The coding labels are categorised in two separate coding trees, one containing the labels about the factors influencing homeowner engagement in the heat transition. And the other includes labels for potential municipal measures to stimulate homeowner engagement; see Appendix B.

3.3.3. Secondary survey

Finally, a review of the findings from a previously conducted and analysed survey has been conducted. The project team created a document that included a summary of the survey results. This document was analysed by coding, using the same coding trees as the interviews (see Appendix B). In this thesis, the secondary survey is referred to as the prior survey (2023).

3.4. Ethical considerations

To provide credible research, ethical considerations are considered during the execution of the research. The principles of the Dutch code of conduct were considered throughout the entire study process. These are honesty, scrupulousness, transparency, independence, and responsibility (NWO, 2018).

Furthermore, this research partially consists of interviews, and thus the code of conduct for social research is also considered. The National Ethics Council for Social and Behavioural Sciences (2018) explains that this code highlights the need to use informed consent, store the interviews in a protected file, and anonymize the respondents. In 3.3.2., it is shown that these three steps have been executed. Besides the interviews, this research is also partially dependent on a survey. Prior to receiving the survey questions, respondents were informed of the survey's purpose, anonymity, and voluntary nature. Only after the respondents agreed to these terms did the survey begin.

It is also important for a researcher to be aware of her position. According to Berger (2015), it is impossible for a researcher to analyse data without any biases. Therefore, the results of the study were discussed with both supervisors, without harming the privacy of the data or respondents, to provide a more objective outcome.

Chapter 4: Results

In this chapter, the results of the research are described and interpreted. First, the project natural gas-free Reyeroord is analysed to determine the goal and implemented interventions of the project. Second, an indication is made about the factors influencing the homeowners in Reyeroord to connect to DHS, as well as the interventions that would best respond to these factors. At last, the homeowners preferred municipal interventions are predicted.

4.1. The project natural gas-free Reyeroord

In this section, the interviews are analysed to learn more about the project's intended results and to consider the choice to use a design approach.

4.1.1. The goal of the project natural gas-free Reyeroord

The pilot project natural gas-free Reyeroord consists of four project goals. Respondent 6 explains that the project's first and most prominent goal is to begin with the disconnection of natural gas in existing buildings in Rotterdam. However, respondents 4 and 5 indicated that there is still much to learn before the process can be truly initiated. This leads to the project's second goal, which is to innovate and discover ways to speed up the disconnecting process throughout the rest of Rotterdam (R-4).

> *"On the one hand, the goal is for people to switch away from natural gas, with DHS as the preferred alternative. However, it is also the goal to simply learn from what we do in order to implement it in the rest of Rotterdam" (R-4).*

The third goal of the project, according to respondents 4 and 5, is to inform homeowners in Reyeroord about their options for cutting off their natural gas supply and assist them in choosing whether or not to switch to DHS.

> *"Ultimately, our primary goal is to give information. When I speak to a resident, I say: Whether you switch to DHS or not is not my concern. My primary concern is that I've now told you everything you could know, including the financial offer. I don't want people to make the wrong decision due to an information deficit"* (R-4).

The last goal of the project was established due to the deal with the energy provider. The project team explained that a deal was made that required at least 30% of the homes in Reyeroord to connect to the DHS in order for Vattenfall (the energy provider) to install the DHS.

> *"The initial goal of the project was to boost the energy transition; however, we also needed to meet the business case and connect 30% of the homes to district heating. Otherwise, the project would not continue"* (R-5).

Thus, the intended outcomes of the project is to increase homeowners' knowledge about the natural gas-free transition, help them make a decision about the connection to DHS, and learn from the process for future implementations. While at the same time connecting at least 30% of the existing buildings to the DHS.

4.1.2. The design approach of the participatory trajectory

To achieve the desired project goals, the municipality of Rotterdam chose to adopt a design approach. The distinctive feature of the design approach is the emphasis on people and the imposition of a learning-by-doing mentality throughout the project's development (Internal document, n.d.). Respondent 6 explained that this was accomplished by constantly reviewing and analysing previous implemented interventions to determine whether these were the best interventions to assist Reyeroord homeowners.

> *"A design approach on that part, which is somewhat broader than simply filling in resources but really looking at: what is needed and what are the residents concerned about?"* (R-5).

The design approach should allow for the achievement of two objectives. Respondent 5 brought up the first goal and said that since the procedure for transferring existing buildings to DHS is new, it is unclear how to accomplish it. The entire project team agreed that the unfamiliarity of the process had produced a level of uncertainty that enhanced the project's complexity. By using the design approach, it would be simpler to deal with the level of uncertainty because the project team would be more adaptable when putting interventions into practise than it would be with a traditional participation approach (R-5).

> *"The degree of uncertainty made it ten times more difficult than if it were a well-established procedure. This complicated matters not only for residents but also for the municipality."* (R-5).

In addition, the increased complications of the uncertain process of the heat transition was also acknowledged by the experts (R-1, R-3).

> *"It's very complicated. We talk about becoming natural gas-free, but that's not just replacing one button with another, there's a whole world around it"* (R-3).

The second desired beneficial objective of the design approach was the ability to focus on people's personal situations. The project team stated that homeowners' personal situations influence their decision to engage in the heat transition. For instance, their home's status or the impact of their social environment (R-6). Therefore, respondents 4 and 6 explain that it is crucial to get to know the neighbourhood in order to truly understand homeowners' personal situations and help them in the process of the heat transition. According to Respondent 5, they initially attempted to do this by looking at statistical data, such as BSR-lifestyles (BSR-leefstijlen). However, this did not really correspond with the "type" of homeowners in Reyeroord because the BSR-lifestyles were too general (R-5). Therefore, it is necessary to personally get in contact with the homeowners to understand their perceptions and experiences (R-4). Both respondents 5 and 6 explained that the design approach allows for more personalised interventions responding to the personal situations of the homeowners in the neighbourhood.

> *"You can read so much and examine so many statistics about a neighbourhood, but in the end you learn the most about a neighbourhood by personally engaging with the residents"* (R-4).

4.2 Implemented interventions in project natural gas-free Reyeroord

In order to establish a connection between the project's outcome and methodology, the interviews with the project team and the internal documentation of the project are examined in this section. The goal is to gain an understanding of the motivation behind the implementation of the various interventions. In addition, to see if the reasoning behind the implemented intervention was also acknowledged by the experts, the expert interviews were also analysed.

4.2.1. Regulatory interventions

As previously stated, no regulations obligate homeowners to disconnect from natural gas. As a result, no regulations were imposed in the project natural gas-free Reyeroord. However, both the experts and all members of the project team mentioned that the lack of regulations prompted homeowners to disconnect from natural gas.

Respondent 1 noted that homeowners must have an inner motivation to make changes to their homes and thus engage in the heat transition. This corresponds with the statement of respondent 3, explaining that it is necessary that homeowners feel a certain level of urgency in order to engage; otherwise, they will not participate.

> *"I think that urgency plays an important role in this. If people don't see the added value of why they need to do something, then why would they invest money and undertake a renovation* (R-3).

Respondent 2 noted that homeowners motivation to engage in the heat transition can differ per individual. As an illustration, some individuals are motivated to engage due to heat discomfort, whereas others are encouraged by their progressive surroundings (R-1, R-2). Respondent 1 argues that for this reason, it is frequently insufficient to encourage all homeowners' inner motivation to participate in the heat transition by only offering financial incentives and information. In light of this, respondents 1, 3, 4, and 5 agree that regulations are essential for boosting homeowners' motivation to participate in the transition.

Implementing a regulation that allows municipalities to declare that certain neighbourhoods will be disconnected from natural gas within a few years would heighten homeowners'' sense of urgency to act and, as a result, encourage their inner motivation to participate in the heat transition (R-3, R-4). To add, Respondents 1, 3, and 4 also specify that it is not necessary to force people to disconnect from natural gas and especially not to obligate them to connect to a specific alternative heating source, but it would be beneficial to allow municipalities to disconnect the natural gas supply.

> *Eventually, there is hopefully going to come a time when we can very explicitly say: in that neighbourhood, in eight years' time, the gas tap is going to close. Then you have a framework and create urgency*" (R-3).

Nonetheless, the implementation of regulations is beyond the municipalities' control, as only the national government is able to implement such regulations. Therefore, respondent 3 mentioned that if the regulations are not implemented in the future, it can help to find linkages with other aspects of a neighbourhood to increase the sense of urgency. For instance, start with executing the heat transition in a neighbourhood where the energy labels are very low, as this population group will have a higher inner motivation to make changes compared to homeowners with high energy labels (R-3).

4.2.2. Economic interventions

The project contained several economic interventions. Respondent 5 mentioned that the most prominent economic intervention was the financial incentive implemented to decrease investment costs (R-5). The current investment costs to connect to DHS can be between €10.000 and €30.000. By adopting the financial incentive, homeowners only had to pay €1500 (R-4, R-5, R-6). The €1500 is based on the average cost of a new central heating boiler (R-4, R-6). The financial incentive covers the installation payments of DHS; however, it does not contain a new hob, pans, or other (personal) installation payments in the house (R-6). Moreover, respondent 5 also noted that homeowners who were not able to afford the €1500 could access additional subsidies (covering a new hob, pans, and other installation expenses). This demonstrates how the municipality considered income disparities by providing additional assistance to those who could otherwise not afford to participate in the heat transition.

Thereafter, the project team explained that the financial incentive was offered temporarily to increase a sense of urgency among the homeowners to get involved right away. They hoped that the temporariness of the financial offer would increase homeowner engagement (R-4, R-5, R-6).

> "*There was a sense of urgency in that; for example, we explained quite often that Reyeroord is currently on the planning and if you join now, it is cheaper. Otherwise it is not possible to make use of the discount"* (R-6).

4.2.3. Informative interventions

Besides the economic interventions, the municipality also implemented many informative interventions. Respondent 4 explained that, in fact, almost all implemented interventions were based on providing information. Not surprising, the project team pointed out that providing enough transparent information is highly important to help homeowners engage in the heat transition (R-4, R-5, R-6).

> *"90% of good participation is information and communication. It is important to really meet the information desires on all spectrums*" (R-5).

Respondent 4 explained that due to the complexity of the process, technical difficulties, and personal impact of the transition, a solid information flow is especially crucial. Moreover, respondent 6 noted that the internet contains much false information about the heat transition or information that is irrelevant to the case of Reyeroord. This confuses homeowners and therefore increases the importance of providing them with accurate information so that they do not draw incorrect conclusions. The large range of implemented informative interventions in the project and the intended outcome of the intervention are shown in table 6.

Table 6: Overview of implemented information interventions in Reyeroord (Author, 2023)

Intervention	Envisioned outcome
Red art objects	• Create awareness of the project • Increase homeowners knowledge
Warm winter Reyeroord	• Respond to social network • Respond to social cohesion • Increase homeowners knowledge
Warm walk	• Respond to social network • Increase homeowners knowledge
Statements on the street	• Increase homeowners knowledge
Outdoor cinema	• Respond to social cohesion • Increase homeowners knowledge
Neighbourhood talks	• Respond to personal values • Increase trust in municipality • Increase trust in energy provider • Increase homeowners knowledge
Information meetings	• Respond to personal values • Increase trust in municipality • Increase trust in energy provider • Increase homeowners knowledge
Door-to-door	• Create awareness and sense of urgency • Increase homeowners knowledge
Offer package	• Respond to personal values • Increase homeowners knowledge
Offer video's	• Increase homeowners knowledge
Newsletters natural gas-free	• Respond to personal values • Increase homeowners knowledge

For an in-depth explanation of all the informative interventions shown in table 3, see Appendix D. In the next section of this chapter the effects of the project are analysed with the quantitative data set.

4.3. The effects of the project natural gas-free Reyeroord

This section discusses the outcome of the project by analysing the differences between the informed part of the neighbourhood and the control part of the neighbourhood in the quantitative data set. In addition, the outcome of the quantitative analysis is compared with the interviews of the project team.

4.3.1. Comparison of homeowners intention to connect to DHS between both parts of the neighbourhood

First, homeowners' intention to connect to DHS in both parts of the neighbourhood is viewed (see figure 8).

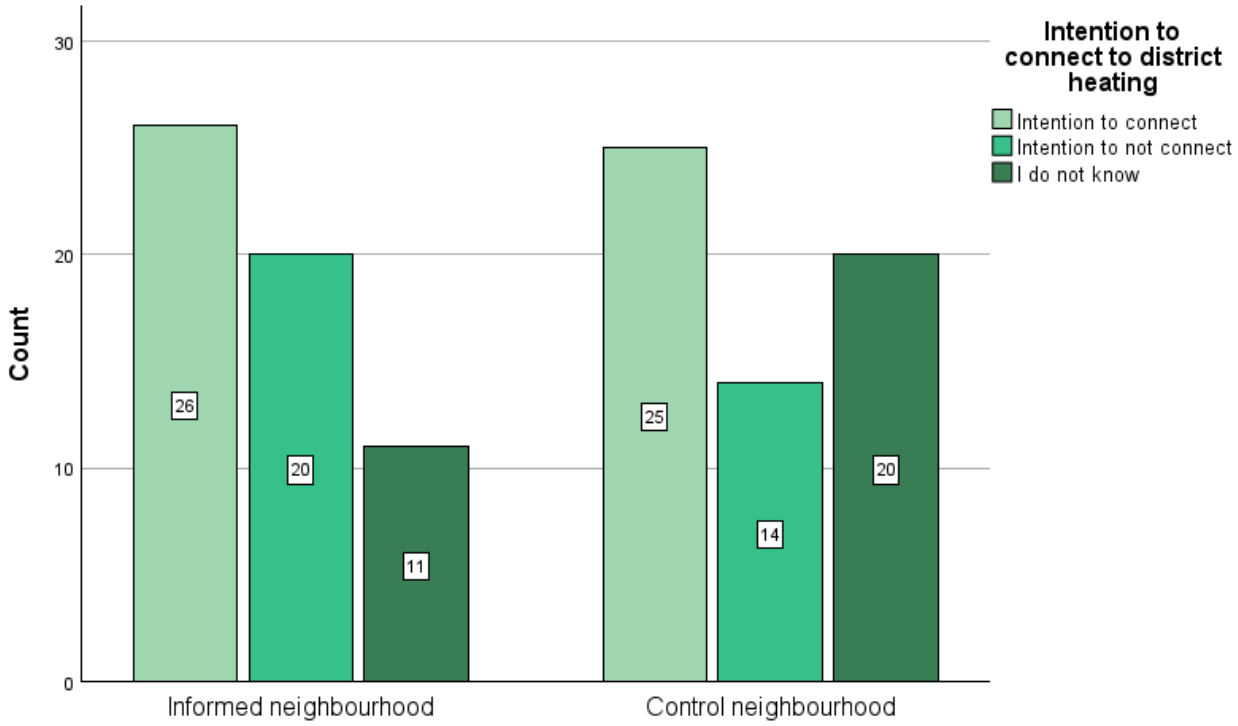

Figure 8: Homeowners' intention to engage in both parts of the neighbourhood (Author, 2023)

Figure 8 shows that the largest difference between the informed and control parts of the neighbourhood is the group of homeowners who are undecided about their intention to connect to DHS. Figure 8 demonstrates that the group of homeowners in the control part of the neighbourhood who are undecided is much larger (N=20) compared to the informed part of the neighbourhood (N=11). Therefore, it can be reasoned that the implemented interventions described in §4.2 assist homeowners in making a decision about connecting to DHS.

However, figure 8 also shows that in the informed part of the neighbourhood, the group of homeowners who do not want to connect to DHS has especially grown, whereas the group of homeowners who do want to connect to DHS has only increased by one. In other words, the implemented interventions described in §4.2 had the effect that the majority of the homeowners chose not to connect to DHS. This suggests that the interventions implemented may not have been the correct ones to stimulate homeowner engagement.

4.3.2. Comparison of influential factors between both parts of the neighbourhood

A second quantitative analysis is done between both parts of the neighbourhood to determine which contextual and attitudinal factors are perceived differently by the homeowners in the informed part and the control part of the neighbourhood (see figure 9). This allows one to observe the results of the interventions that have been implemented in the informed part of the neighbourhood.

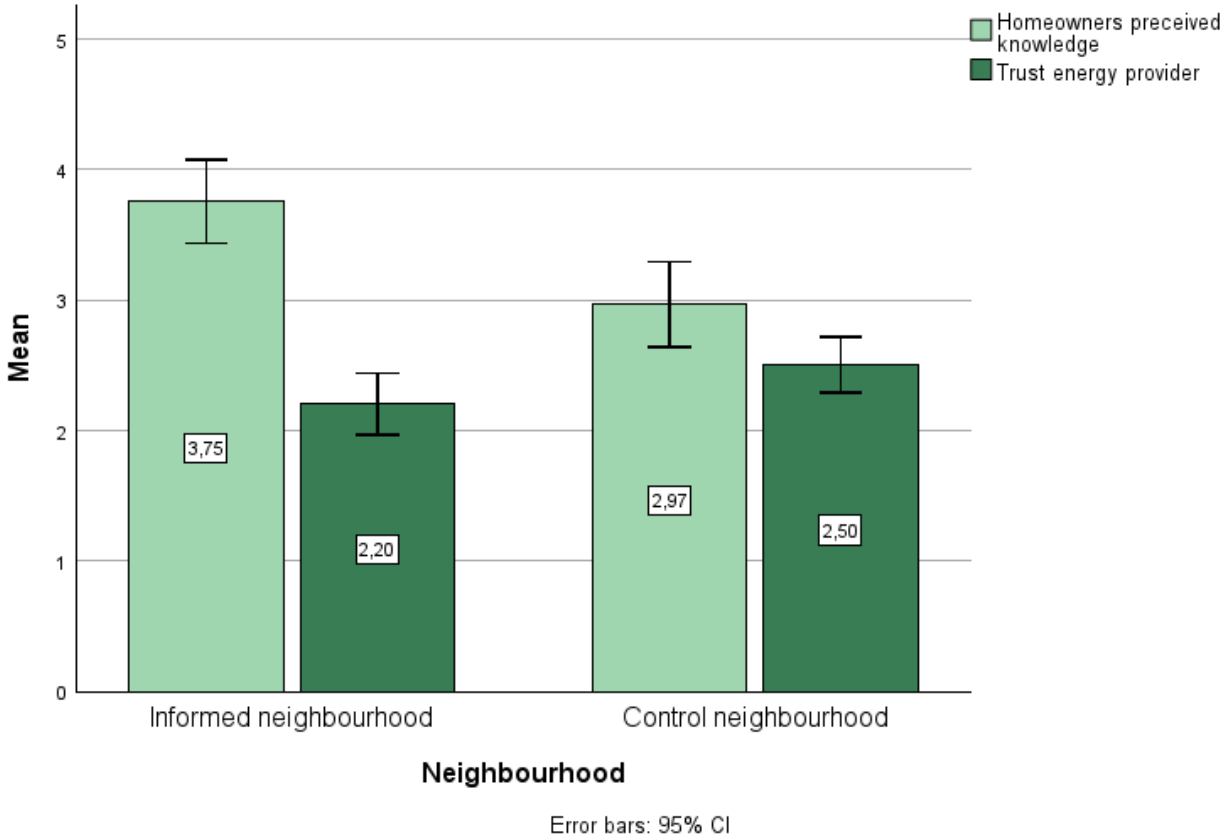

Figure 9: Difference in average of knowledge and trust in the energy supplier in both parts of the neighbourhood (1= low and 5 = high) (Author, 2023)

The test indicates (see figure 9) that the informed part of the neighbourhood differed significantly from the control part of the neighbourhood with regards to the knowledge homeowners felt they had about the topic of DHS (One-way ANOVA; p=0.001). The homeowners in the informed neighbourhood scored significantly higher on their self-perceived knowledge compared to the homeowners in the control neighbourhood. This shows that the extensive amount of informative interventions implemented in the project were beneficial to increasing homeowners self-perceived knowledge.

Furthermore, the test also showed that there was a trend towards different levels of trust homeowners have in the energy provider (p=0.068). Figure 9 shows that the homeowners in the informed part of the neighbourhood leaned towards a lower level of trust in the energy provider compared to the homeowners in the control part of the neighbourhood. This result is remarkable because respondent 4 explained that he stressed that the effects of the energy provider's monopolistic market structure are not particularly detrimental during the information meetings and neighbourhood talks.

[…] "we frequently emphasise that when gas prices rose, you did not suddenly pay a lot less with your provider compared to other providers. Maybe they paid five or ten cents less, but it really doesn't make a difference. […] Consequently, the effects of only having one energy provider are not so large" (R-4).

Quantitative data, however, suggests that homeowners' attitudes towards the energy provider grew more unfavourably as a result of the increased focus on it. Therefore, it can be concluded that the extra attention paid to the energy provider within the information provision has led to a decrease in homeowners trust in the energy provider.

In conclusion, the natural gas-free Reyeroord project has stimulated homeowners to decide whether or not to connect to DHS. However, most homeowners decided not to connect to DHS. Furthermore, the project also increased homeowners self-perceived knowledge about DHS and decreased their trust in the energy provider. To get a better understanding of the best way to stimulate homeowner engagement, the potential influencing factors for homeowner engagement in the heat transition are analysed in the next sections of this chapter.

4.4. The influence of attitudinal factors

To get an indication about which attitudinal factors influence homeowner engagement in the heat transition, the quantitative data is analysed and interpreted below. Subsequently, the outcome of the quantitative analyses is compared with the statements of the attitudinal factors made in the interviews (by both experts and the project team). At last, both the prior survey (2023) and interviews (with both experts and the project team) are analysed to get an understanding of which interventions should be implemented to target influential attitudinal factors.

4.4.1. The impact of the attitudinal factor 1: people's personal values

The first attitudinal factor that may influence homeowners' intentions to connect to DHS are people's personal values. A test was run, and the outcome showed that the personal values altruistic (One-way ANOVA; p=0,615), hedonic (p=0,165), and egoistic (p=0.079) were not significantly different from homeowners' intentions to connect to DHS. This means that these personal values had no influence on homeowners' intentions to connect to DHS in Reyeroord.

Nevertheless, a significant difference was found between higher biospheric values and the intention to connect to DHS (p=0,020). The test showed that the higher biospheric values were found by homeowners who intend or do not intend to connect to DHS, compared to the homeowners who were undecided about their connect to DHS. This indicates that homeowners with stronger biospheric values have a stronger opinion about their intention to connect to DHS.

In addition, in chapter 2 (§2.3.1.) it is stated that people's personal values influence the reasoning behind homeowners' decisions to connect to DHS. This means that homeowners perceive the effects of contextual factors differently depending on their personal values. To see if this statement applies in Reyeroord, a test is run to compare people's personal values with the contextual factors (see table 2, Appendix A). The outcome of the test shows that there are correlations between homeowners' personal values and contextual factors; see table 7.

Table 7: Correlation between homeowners' personal values and contextual factors

Personal values	Contextual factors
Biospheric	• Social cohesion • Positive climate effects
Altruistic	• Positive climate effects
Hedonic	• Investment costs (negative) • Uncertainty
Egoistic	• -

The correlations in table 7 show that homeowners' personal values influence how they perceive certain contextual factors. Because of this disparity in perception of contextual factors, homeowners may develop different reasons to connect or not connect to DHS.

Similar results were found in the qualitative data. According to respondents 1, 2, 3, 4, and 5, the personal values of the homeowners impact their decision to participate in the heat transition. Respondent 2 explained that homeowners have different personal values and that

these values form the argument for why homeowners make a particular decision regarding whether or not to connect to DHS. In addition, the project team noted that they frequently encountered individuals with varying justifications for their decision to connect or not connect to DHS. Therefore, the project team placed a clear emphasis on utilising a variety of interventions and messages to respond appropriately to different personal values (R-4, R-5, R-6).

All in all, the quantitative data showed that only strong biospheric values influence the decision of homeowners to connect to DHS. However, the quantitative data also shows that homeowners reasoning to either connect or not connect to DHS is influenced by their personal values. To add to this, the qualitative data confirms the correlation between homeowners personal values and their decision about the connection to DHS. Therefore, to support all homeowners (with different values) in the engagement of the heat transition, it is important to take homeowners' personal values into consideration.

4.4.2. The impact of the attitudinal factor 2: trust

The second attitudinal factor that can influence homeowners' intentions to connect to DHS is the degree of trust homeowners have in the municipality and energy provider. This potential influence was analysed with the quantitative data set, see figure 10.

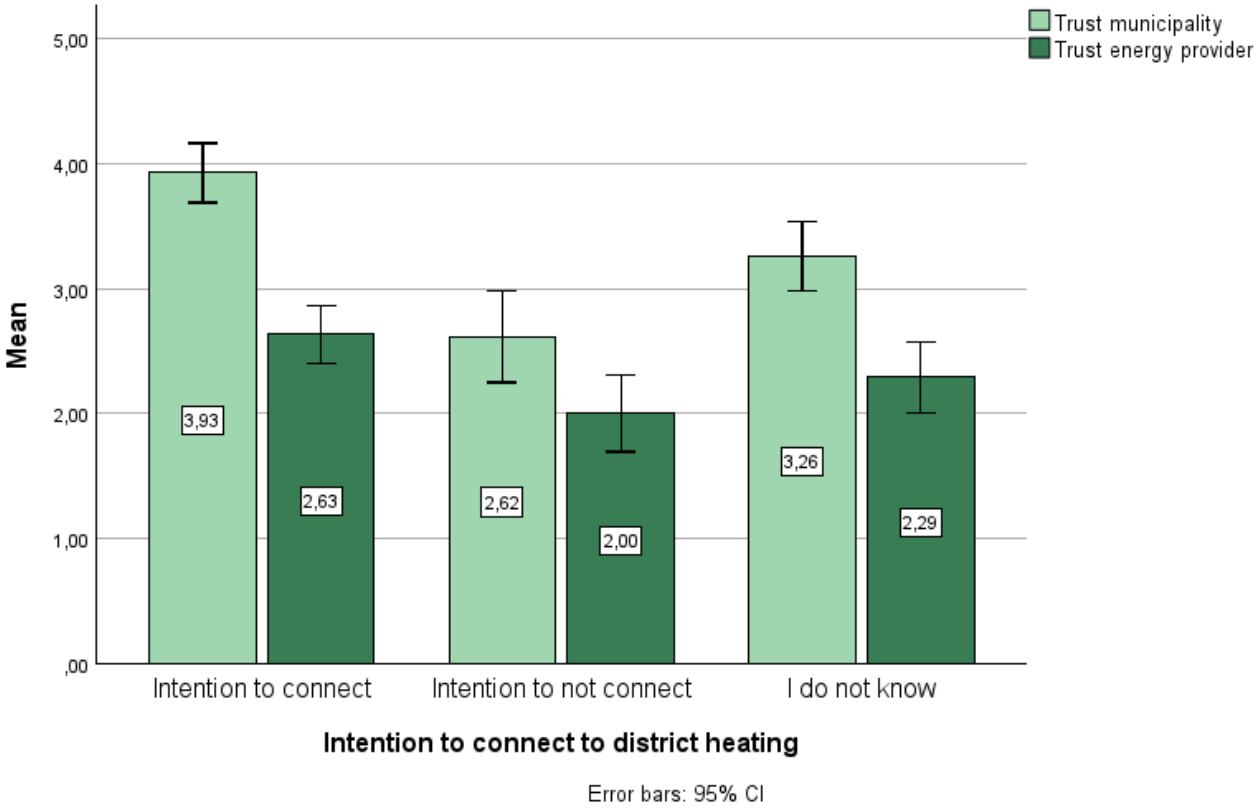

Figure 10: Average amount of homeowners trust in the municipality and energy provider compared to their intention to connect to DHS (1= low level of trust and 5 = high level of trust) (Author, 2023)

The results of the test showed that there is a significant difference in the degree of trust homeowners have in the municipality and their intention to connect to DHS (p=<0.001). The test demonstrated that homeowners who want to connect to DHS have significantly higher trust in the municipality compared to those who are undecided, and those in turn have significantly higher trust than those who do not want to connect to DHS (see figure 10). In other words, homeowners are more likely to connect to DHS if they have a higher level of trust in the municipality.

The results of the test also show that there is a significant difference in the amount of trust homeowners have in the energy provider and their intention to connect to DHS (p=0.003).

The test again demonstrates that homeowners who intend to connect to DHS have more trust in the energy provider compared to those who do not intend to connect to DHS (see figure 10). Again, this means that homeowners are more likely to connect to DHS if they have greater trust in their energy provider. Figure 10 also demonstrates that homeowners' trust in their energy provider is generally low, with almost all scores falling below the average (scale from 1 to 5). The qualitative data (all respondents) also revealed how critical it is for the homeowners to have trust in the municipality and the energy provider in order for them to connect to DHS.

> *"Trust is very important, how the process is set up, how the participation is set up and the image of the residents towards the municipality and the energy supplier. Those are really big predictors of whether people will participate or not"* (R-1).

All respondents mentioned that the current level of homeowner trust in the municipality and energy provider is relatively low. According to both the experts and the project team, the low level of trust that homeowners have in the energy provider can be explained by the energy provider's monopolistic market structure. Homeowners are concerned that, as a result of this market structure, energy providers will abruptly raise their prices.

> *"That monopoly-like thing is a very big obstacle for a lot of residents to engage"* (R-5).

Respondents 1, 2, 3, 5, and 6 explain that people's dissatisfaction with the national government and previous municipal projects are the two main causes of homeowners' lack of trust in the municipality. According to the experts, homeowners' previous interactions with the municipality have a significant impact on their trust. When something went wrong in previous projects, people are less likely to have trust in the municipality for future projects.

> *"I also experienced in neighbourhoods that previous projects from the municipality that were not delivered had bad consequences for homeowners trust in future projects. Then you start with a trust deficit"* (R-1).

Furthermore, respondents 2 and 6 both mentioned that they often experienced homeowners having little trust in the municipality due to the actions of the national government. Because homeowners do not differentiate the actions of the national government from those of the municipality.

> *"So some people don't make that distinction between the municipality and government"* (R-6).

Hence, both the quantitative and qualitative data show that the attitudinal factor trust influences homeowners' intentions to connect to DHS. The degree to which homeowners trust their municipality and/or energy provider directly correlates with their intentions to connect to DHS. However, the level of trust homeowners have in both parties is currently quite low. Therefore, it is crucial to increase homeowners trust in the municipality and energy provider to stimulate homeowner engagement. In the next section, interventions to address the attitudinal factors are described.

4.4.3. Interventions to respond to the attitudinal factors

First, addressing the interventions focused on homeowners personal values. The project team noted that three interventions from the project were most effective in responding to personal values. The first two were the *information meetings* and the *neighbourhood talks*. Respondents 4 and 6 explained that personal contact and face-to-face conversations are very helpful for sensing people's personal values. With information meetings, it was possible to get into contact with the homeowners and thus correctly respond to their personal values.

> *"The personal approach and face-to-face conversation work so well because you can sense whether someone has certain personal values or not, and then you can correctly respond to these"* (R-4).

Nonetheless, respondent 4 points out that the people visiting the information meetings were always the same people. This low turnout has led to the development of the neighbourhood talks. The neighbourhood talks had the same goal as the information meetings, but the difference was that the project team came to the residents rather than the residents having to travel to the project team (Internal document, n.d.). As a result, the project team set up tents in the streets of Reyeroord and approached people on the streets to deliver tailor-made information (internal document, n.d.). This intervention was also very beneficial in responding to the homeowners personal values. Additionally, according to the entire project team, through the neighbourhood talks, it was possible to communicate with homeowners who otherwise would not be informed.

> *"At neighbourhood talks, we have committed to being where residents are. Everyone has different kinds of questions, and that makes it tailor-made. By engaging with residents, it is possible to answer these personal questions"* (R-5).

The third beneficial intervention to respond to personal values was to incorporate all personal values in the information provided in the text (R-5, R-6). Respondent 5 explained that this resulted in texts containing several types of arguments for connecting to DHS.

> *"In the texts, there are multiple perspectives described. For example, if you are very driven by the financial aspects, then there is a good paragraph about the financial side. However, if you're very driven by the comfort of your home, there's a good paragraph that tells more about the comfort of your home. So we tried to accommodate all those perspectives"* (R-5).

Second, the focus is on the interventions addressing the attitudinal factor trust. All respondents state that an effective way to increase trust in the municipality is to have personal contact with the homeowners and provide them with transparent information. The personal contact allows for the establishment of a bond with the homeowner, the transparent explanation of desired information by honestly explaining all advantages and disadvantages of DHS, and genuine assist homeowners in their decision-making process (R-3, R-4, R-6). Due to these aspects, it is possible to increase homeowners' trust. The project team explained that the neighbourhood talks and information meetings allowed for personal contact, and thus increasing homeowners' trust in the municipality.

> "*Maybe in the beginning some residents were a bit sceptical, but when you actually have a good conversation with them, explain what you are doing, and explain why we are doing it, it can create trust"* (R-4).

Furthermore, respondent 3 stated that when trust in the municipality is low, it is beneficial to carry out personal contact with homeowners through an independent party (financed by the municipality). Nonetheless, respondent 1 stated that it is critical that the municipality be involved in the project in some way. He experienced that in projects where the municipality was not involved, some people had mistaken the campaign for an advertisement (R-1).

The project team provided more information about the monopolistic structure of the energy provider in an effort to reduce the negative effects of the homeowners' fear of the monopolistic market structure of the energy provider and increase their trust in the energy provider. However, as shown in §4.3.2, this increase in information had a negative effect on homeowners trust in the energy provider. This leads to the conclusion that in this thesis, no successful municipal initiatives to boost homeowners' trust in their energy provider were

identified. Table 8 summarises the interventions to increase homeowner engagement in the heat transition based on the influential attitudinal factors.

Table 8: Influential attitudinal factors for homeowner engagement in the heat transition and promising interventions to respond these attitudinal factors

Influential attitudinal factors	**Municipal intervention to respond to the attitudinal factor**
Personal values	• Information meetings • Neighbourhood talks • Various argumentation in text
Trust municipality	• Information meetings • Neighbourhood talks • Transparent information
Trust energy provider	No interventions were identified

4.5. The influence of the contextual factors

To get an indication about which contextual factors influence homeowner engagement in the heat transition and which municipal interventions are helpful to target these factors, the same analyses is performed as with the attitudinal factors.

4.5.1. The impact of the contextual factors 1, 2, 3 and 4: costs, residence, process and climate effects

The survey respondents were asked to rank the advantages and disadvantages of the contextual factors in order to determine which contextual factors encourage or discourage homeowner engagement in the heat transition. The statistical data showed that the homeowners who intend to connect, do not intend to connect, and are undecided about their intention to connect to DHS all rated the contextual factors similarly on the scale of advantages and disadvantages. Additionally, the informed and control parts of the neighbourhood rated the contextual factors similarly on the scale of advantages and disadvantages. This means that, on average, the same contextual factors are viewed as stimulating and discouraging for the connection to DHS. This makes it even more important to understand these factors and use them to develop interventions to stimulate homeowner engagement. The outcome of the ranking of the advantages of the contextual factors of DHS is shown in figure 11.

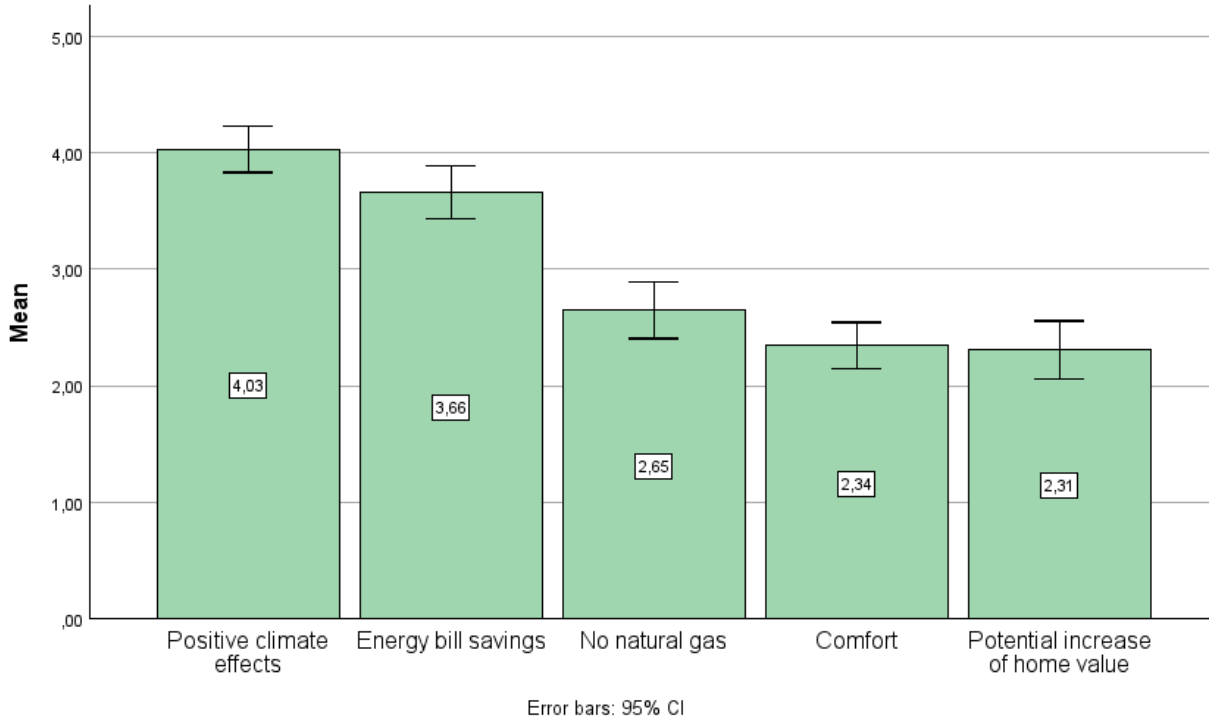

Figure 11: Ranking of the averages of the contextual advantages of DHS (1= least advantage and 5= highest advantage) (Author, 2023)

Figure 12 shows that the highest perceived benefits of DHS for homeowners in Reyeroord are the positive effects on climate change and potential energy bill savings. Therefore, it is reasoned that these two contextual factors stimulate homeowners to engage in the heat transition.

When the quantitative and qualitative data were compared, a difference was discovered. The qualitative data set did not reveal that, on average, all homeowners ranked positive climate effects as the most advantageous contextual factor. The project team explained that they initially believed that the majority of homeowners would be motivated to participate in the heat transition due to environmental concerns. However, during the project's execution, they frequently spoke with homeowners who were unconcerned about the positive climate effects of DHS and refused to participate for environmental reasons. A plausible reason for this

difference, explained by respondent 6, is that homeowners who are against sustainable alternatives often express their opinions loudly. It is possible that for this reason this population group appeared larger to the project team, but in reality it is only a small part of all homeowners.

Furthermore, the fact that potential energy bill savings is ranked as the second most beneficial contextual factor does correspond with the findings of the interviews. Respondents 3, 5, and 6 explained that since gas prices have skyrocketed, homeowners have become much more concerned with their energy bills and therefore energy consumption. According to respondent 1, as a result of this increased awareness, most homeowners are considering implementing sustainability measures in their homes to save money. However, respondent 6 also stated that the DHS is not always less expensive than a natural gas connection. In her experience, people were initially more eager to connect to DHS because of the potential energy bill savings, but later in the project, a few homeowners backed down as they also heard that DHS is not always cheaper than natural gas. The statement of respondent 6 can possibly explain why potential energy bill savings are ranked second rather than first most advantageous contextual factor. Next, the outcome of the ranking of the disadvantages of the contextual factors of DHS are shown in figure 12.

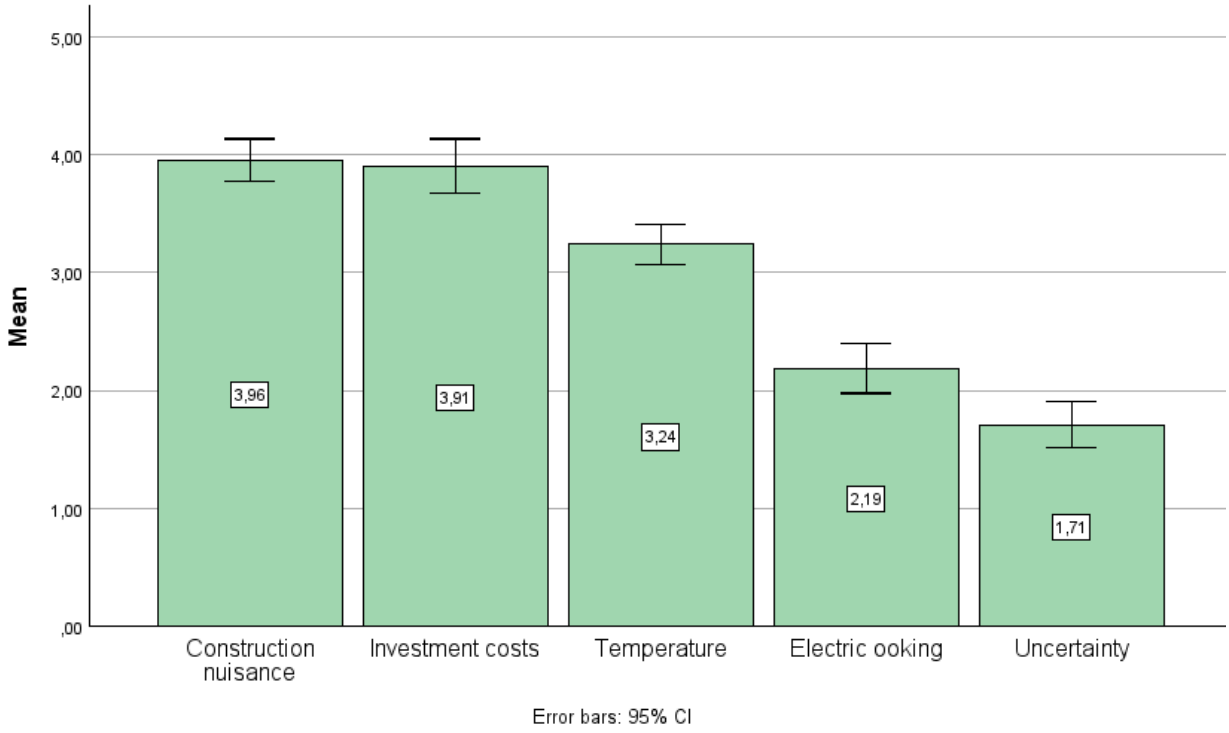

Figure 12: Ranking of the averages of contextual disadvantages of DHS (1= least disadvantage and 5= highest disadvantage) (Authors, 2023)

Within the disadvantages perceived by the homeowners, the largest disadvantageous contextual factors are the construction nuisance and investment costs (see figure 13). This suggests that these two contextual factors discourage homeowners from connecting to DHS. The discouraging effect of these two contextual factors were also acknowledged in the qualitative data.

First, all respondents mentioned that the investment costs are a large obstacle for homeowners to connect to DHS. Respondent 4 even stated that the investment costs are possibly the most important factor preventing homeowners from connecting to DHS. This is due to two factors: first, homeowners simply do not want to make these investments, and second, many people are unable to make these payments (R-1, R-2, R-4, R-5).

Second, zooming in on the nuisance of construction. Respondent 1 mentioned that in his projects, homeowners frequently do not participate because they are dreading the hassle of

construction. This is not surprising, as respondent 4 explained that the construction can take up to five days. On the other hand, respondent 6 stated that she had observed that homeowners who were already planning to construct their homes were more eager to connect to DHS, as they thought it would be better to have one large construction. However, in general, people see the possibility of construction-related inconvenience as a disadvantage to taking part in the heat transition (R-1, R-2, R-4).

In addition, figure 13 shows that the least discouraging contextual factor for homeowner engagement is the uncertainty of the process. However, the interviews revealed claims to the contrary. As shown in 4.1.2., the experts and project team explained that the project's uncertainty increases the complexity of the process, which in turn increases the difficulty of homeowners to participate in the heat transition.

> *The level of uncertainty just leads to incomprehension; residents often said: why do we need to be the firsts?"* (R-5)

As a result, there is a distinction between the homeowners and the project teams perspectives on the impact of uncertainty on participation. A plausible explanation for this disparity is that the project team and experts had to deal with numerous uncertainties, which complicated their work. It is possible that they believed the homeowners would find the level of uncertainty challenging as well and would therefore be less motivated to participate in the heat transition.

In conclusion, it can be said that the contextual factors that encourage homeowners to engage in the heat transition are the positive effects on climate change and the potential energy bill savings, while the contextual factors that discourage homeowners from engaging in the transition are the nuisance of construction and investment costs. In addition, qualitative data indicated that project uncertainty influenced homeowner engagement, but this was not the case in Reyeroord. The impact of the final contextual factor, social network, is examined in the following section.

4.5.2. The impact of contextual factor 5: social network

At last, the possible influence of the contextual factor social network is analysed with the quantitative data set. The results of the test show that in Reyeroord, there is no significant difference between social network and homeowners' intention to connect to DHS ($p=0.161$). This suggests that the contextual factor social network does not influence homeowners' intention to connect to DHS in Reyeroord.

The same conclusion was reached by the project team. The prior survey (2023) showed that the informative interventions implemented with the goal of responding to the social network in Reyeroord did not stimulate homeowner engagement. An explanation for this outcome is given by respondents 5 and 6, who state that the social cohesion in Reyeroord is low. Responding to a neighbourhood's social network to encourage homeowner engagement is less effective when social cohesion is low (R-5, R-6).

Although the project team (R-4, R-5) and experts (R-1, R-2, R-3) did mention that when social cohesion is strong, it can be beneficial to respond to a neighbourhood's social network. For instance, respondent 1 explained that in one of his projects he encountered a large number of social followers. As a result, they designed interventions to create the feeling of a common goal, responding to the social network of the neighbourhood, which successfully increased homeowner engagement. Respondents 4 and 3 made comparable claims in their projects in Tilburg and in a different Rotterdam pilot project. This shows that in other projects, neighbourhood social networks did influence homeowner engagement. Consequently, it can be said that when social cohesion in a neighbourhood is high, it is advantageous to respond to the social network; however, when social cohesion is low, it is not advantageous to implement interventions that respond to a neighbourhood's network. The following section demonstrates interventions addressing the influential contextual factors.

4.5.3. Interventions to respond to the contextual factors

To stimulate homeowner engagement in the heat transition, the following interventions are recommended to respond to the influential contextual factors. To begin, there are two contextual factors that stimulate homeowners to engage in the transition. These elements should be emphasised in the information given to homeowners to encourage them to connect to DHS. According to the prior survey (2023), the two best ways to provide information to homeowners are in person or via text. Therefore, it is recommended to emphasise the positive effects of climate change and the potential energy bill savings of DHS in both written and verbal information dissemination.

In addition to the motivating factors, it is discovered that two contextual factors—the nuisance of construction and high investment costs—discourage homeowners from participating in the transition. Nevertheless, no specific interventions to lessen the construction nuisance were discovered in the qualitative data. As a result, this section cannot offer any potential solutions to reduce the discouraging nuisance of construction.

For the discouraging factor investment costs, did the qualitative data provide a promising intervention. All respondents stated that the best intervention to mitigate investment costs is to implement a financial incentive. Respondents 1, 3 and 4 even assert that the most effective measure to boost homeowners' participation in the heat transition is a financial incentive. A test was conducted using the quantitative data to determine how much of a financial incentive would be necessary for the majority of homeowners to agree to connect to DHS. The outcome of the test showed that on average, homeowners in Reyeroord are willing to pay €2596,25 to connect to DHS. This demonstrates that homeowners are prepared to spend more money than the current financial incentive in Reyeroord (see §4.2.2).

In addition, the offered financial incentive in Reyeroord is a temporary offer intended to increase homeowner engagement (see §4.2.2.). According to Respondent 4, there were homeowners who did engage in the transition because of the temporary nature of the financial incentive. Whereas respondent 5 explained that it was occasionally difficult to emphasise the temporary nature of the financial incentive, as a result of which some homeowners did not realise it was a one-time offer and therefore did not participate. Even though respondents 5 and 6 both claimed that they frequently emphasised the temporariness of the financial incentive.

> "*It was still tough to communicate that this is a very excellent deal because there is a lot of government money involved. […] many people did not understand how unique this deal was"* (R-5).

To understand if the temporariness of the financial offer can trigger homeowner engagement, an additional test was generated. The outcome of the test shows that there was a significant difference between homeowners' intention to connect to DHS and a temporary subsidy (p=<0,001). The test results show that providing a financial incentive for a limited time would primarily stimulate homeowners who are currently undecided about connecting to DHS. Therefore, it is concluded that by offering a temporary financial incentive, it will be beneficial to encourage more homeowners to connect to DHS.

In conclusion, the results of the two tests and the information from the interviews indicated that it is beneficial to encourage homeowners to connect to DHS by providing a temporary financial incentive in which homeowners would pay approximately €2500 of the investment costs.

At last, potential interventions are explained to respond to the social network in a neighbourhood. Even though the quantitative data showed that the social network did not increase homeowners' engagement in the heat transition, the qualitative data gave the indication that when social cohesion is strong, it is beneficial to respond to the social network in a neighbourhood. The potential interventions to increase homeowner engagement by responding to social networks are to spotlight frontrunners in the neighbourhood and use energy coaches. Respondent 3 explained that in her project they spotlighted frontrunners

because people often copy each other's behaviour, which leads to the fact that when the first homeowners in a neighbourhood are willing to connect to DHS, it is likely that others will follow. The second beneficial method to respond to social networks is through energy coaches. In another pilot project in Rotterdam, homeowners who were enthusiastic about the heat transition became energy coaches, helping other homeowners in the process of disconnecting from natural gas. Respondent 4 explained that this was a success because homeowners often perceive information from other homeowners as more credible than information from the municipality. Altogether, an overview of the interventions to increase homeowners' engagement in the heat transition based on the contextual factors is shown in table 9.

Table 9: Influential contextual factors for homeowner engagement in the heat transition and promising interventions to respond these contextual factors

Influential contextual factors	**Municipal interventions to respond to the contextual factor**
Positive climate effects (stimulating)	• Highlight in text • Highlight during personal conversations
Energy bill savings (stimulating)	• Highlight in text • Highlight during personal conversations
Construction nuisance (Discouraging)	No interventions were identified
Investment costs (Discouraging)	• Financial incentive of an average of €2500,- • Provide the financial incentive temporarily
Social cohesion	• Spotlight frontrunners (local ambassadors) • Energy coaches

4.6 The influence of the socio-demographic factors

At last, to also understand which socio-demographic factors influence homeowner engagement in the heat transition and which municipal interventions are helpful to target these factors, the same analyses is performed as with the contextual and attitudinal factors.

4.6.1. The impact of the socio-demographic factors 1, 2 and 3: age, income and education

The socio-demographic factors (age, income, and education) are analysed by performing two tests with the quantitative data set. The first test shows that there is no significant difference between age (One-way ANOVA; p=0.209) and income (p=0.568) on homeowners' intention to connect to DHS. The second test showed that homeowners' level of education (Chi-square; p=0.164) was not significantly associated with their intention to connect to DHS. Thus, the quantitative data shows that socio-demographic factors are not influential on homeowners' intention to connect to DHS.

However, the qualitative data reveals a different picture about the influence of age and income on homeowner engagement. Respondents 1, 2, 4, 5, and 6 explained that older homeowners are less likely to participate in the transition because they are concerned that they will not be able to experience the long-term benefits. This is most common when homeowners are a lot older, beginning around the age of 80. Respondent 2 adds that some elderly homeowners disconnect from natural gas in order to leave the world in a better state. A possible explanation for the disparity between quantitative and qualitative data is that the quantitative data set includes a small group of homeowners over the age of 80 (N=6). Therefore, the quantitative data did not detect this result.

Second, all respondents mentioned that income is a very obvious influential factor. Respondent 2 explained that homeowners who are struggling to make ends meet are not going to make large investments to connect to DHS. This corresponds with the previous statement made about the investment costs (§4.5.1.). To add to this, respondent 6 highlights that in Reyeroord there is a sizable number of people who really are struggling to make ends meet. A plausible explanation for the disparity between quantitative and qualitative data is that respondents received a generous financial offer, which may have influenced homeowners' responses in the survey, resulting in a non-significant result.

Overall, it can be stated that age and income do influence homeowners' participation in the heat transition, despite the fact that this was not detected in the quantitative data set. In the next section, potential influential interventions are discussed to address the socio-demographic factors.

4.6.2. Interventions to respond to the socio-demographic factors

One municipally viable intervention is identified to address the socio-demographic variable of income. Respondent 2 acknowledged the impact of a homeowner's income and suggested adding additional financial incentives for homeowners who want to connect to DHS but are unable to do so because of their income. The additional interventions can cover additional expenses such as a new hob, pans, or other installation expenses.

Furthermore, the qualitative data showed that there are no municipal interventions responding to homeowners ages. This confirms the hypothesis of the conceptual model, showing that municipalities are not able to influence the impact of homeowners' age. An overview of the interventions to increase homeowner engagement in the heat transition based on socio-demographic factors is shown in table 10.

Table 10: Influential contextual factors for homeowner engagement in the heat transition and promising interventions to respond these contextual factors

Influential socio-demographic factors	Municipal interventions to respond to the socio-demographic factor
Income	• Additional financial incentives for homeowners with a low income

4.7 The influence of the combined of the factors

To show the relationship between homeowners' intention to connect to DHS and the potential influencing factors, single comparisons with the quantitative data set were made in the preceding sections. However, combining all factors in one model may result in a different outcome because the factors then also influence each other. Therefore, a generalised linear model (a type of regression) was generated, and the outcome is discussed in this section.

4.7.1. The impact of all factors combined

The outcome of the generalised linear model can be found in Appendix A, table 3. The outcome of the test shows that by combining all factors, the factors biospheric values (p=0.002), trust in the municipality (p=0.003), positive climate effects (p=0.037) and a high level of perceived knowledge (p=0.010 and p=0.008) are significant for the intention of homeowners to connect to DHS. This means that two new factors are found that also influence homeowners intention to connect to DHS, namely biospheric values and a high level of perceived knowledge. In the previous one-on-one comparison (§4.4.1.), it was identified that homeowners with high biospheric values had a stronger opinion about their decision to connect to DHS; however, the generalised linear model shows that after all, homeowners with stronger biospheric values are more likely to engage in the heat transition.

Furthermore, the next new finding is that homeowners who perceive themselves to have a high level of knowledge are more likely to engage in the transition. This finding is especially beneficial to know as it confirms the hypotheses of the project team, stating that information helps stimulate homeowners to participate in the transition. The next section shows which informative interventions are beneficial to respond to biospheric values, increase homeowners' knowledge, and therefore stimulate engagement.

4.7.2. Interventions to respond to biospheric values and increase homeowners knowledge

As explained in §2.3.1., people with strong biospheric values are concerned about the climate. Therefore, highlighting the positive climate effects of the DHS (as explained in §4.5.3) will also encourage homeowners with stronger biospheric values to participate.

The prior survey (2023) shows that the top three rated informative interventions to increase homeowners' knowledge were the newsletters, the information meetings, and the neighbourhood talks.

The newsletters were particularly successful, according to the project team, because they supplied a constant flow of information (prior survey, 2023). This clarified the information, making it easier for homeowners to understand (R-6). For example, another informative intervention implemented to increase homeowners knowledge was the offer box (aanbod-doos). This intervention offered all the information about the project at once (prior survey, 2023). Due to the overwhelming amount of information in the offer box, this intervention was ineffective, and some homeowners did not even bother to open the offer box (R-5, R-6).

The desire for manageable information was also mentioned by two of the experts (R-2, R-3). Respondent 2 stated that the circumstances of the heat transition change quite radically, making it more difficult for the homeowners to understand what the consequences are for them. By providing a continuous flow of information, it becomes easier for the homeowners to understand the information (R-2, R-3). However, respondent 2 did mention that there should always be a location, for instance, a website, where homeowners can find all the information they desire to prevent withholding information. In addition, respondent 6 also emphasises the importance of keeping the homeowners informed throughout the process. She noticed that some homeowners were reluctant to cancel their engagement because they had not heard from the municipality in a while.

> *"Some homeowners said that because they don't hear anything from the municipality, […] makes them consider withdrawing their intention to connect to district heating.*

> *This shows that continuity in providing information about the process of the project is very important*" (R-6).

The second and third beneficial informative interventions to increase homeowners' knowledge were the information meetings and the neighbourhood talks (prior survey, 2023). According to respondent 5, each homeowner has their own set of concerns regarding the implications of the heat transition for their specific home. With the information meetings and the neighbourhood talks, it was possible to provide personal attention and answer homeowners specific questions. This shows that these two interventions made it possible to provide tailor-made information and advice to the homeowners. Respondent 6 explains that tailor-made information and personal attention are especially important to increase homeowners knowledge.

> *"Personal contact is very important; it is noticeable that residents need personal contact and that they consider their decision based on the information they perceive through personal contact"* (R-6).

In table 11 overview is given of the influential interventions to increase homeowners knowledge and respond to biospheric values.

Table 11: Influential factors for homeowner engagement in the heat transition and promising interventions to respond to these factors

Influencing factor	Municipal interventions to respond to factor
Biospheric values	• Highlight positive climate effects of DHS
Knowledge	• Continues flow of information • Information meeting • Pop-up information meetings

4.8. Desired municipal interventions by the homeowners of Reyeroord

At last, to understand which municipal interventions are preferred by the homeowners in Reyeroord, an overview is given in table 12. It was decided to ask all homeowners in the control part of the neighbourhood which interventions they preferred, but only the homeowners in the informed part of the neighbourhood who have no intention of connecting to DHS were asked. This decision about the informed part of the neighbourhood was made to see which interventions would help change homeowners non-intention to an intention to connect. Table 12vshows that three respondents answered the question with the answer *different, namely…*". These additional answers are shown in Appendix A.

Table 12: Count of cases for desired municipal intervention in both subareas of the neighbourhood; informed neighbourhood N = 20; control part of neighbourhood N = 59 (Author, 2023)

	Informed	Control
1. Financial incentive	7	43
2. Information about technique	2	21
3. Information about process (e.g., contract signing, procedures application, possible renovations)	2	29
4. Being kept continuously informed	3	20
5. Large spectrum of information provision	2	12
6. Personal advise	2	23
7. Personal contact	2	21
8. Advisor who arranges everything for the connection to DHS	2	16
9. Early involvement in process	2	13
10. Positive stories/ experiences of neighbours	2	10
11. I do not want anything	12	9
12. Different, namely…	2	1

The first finding of table 12 is that the majority of homeowners in the informed part of the neighbourhood who have no intention of connecting to DHS stated that no municipal interventions would change their minds about their decision. This demonstrates that, despite municipal incentives, there will always be a group of homeowners who refuse to connect to DHS.

The second finding is that, aside from the homeowners who do not want any interventions, the most desired intervention in both parts of the neighbourhood is a financial incentive. This is consistent with the earlier findings discussed in §4.5.3, stating that a financial incentive is critical for engaging homeowners in the transition.

The third finding of table 12 is that there is a wide range of desired interventions. Given the variety of desired interventions, it is imperative to offer a wide range of interventions to encourage all homeowners to participate in the heat transition. However, when clustering the interventions, table 12 shows that the interventions that provide personal contact (numbers 6 and 7) and information (numbers 2, 3, and 4) are mentioned the most frequently.

Overall, the statements made in the interviews and the homeowners' preferred interventions line up. It can be concluded that the most desired intervention by the homeowners is a financial incentive, followed by interventions offering personal contact and information. Finally, it is concluded that homeowners who refused to participate in the heat transition will not change their minds if additional municipal interventions are implemented.

Chapter 5: Conclusion

5.1 Main conclusions of the thesis

The objective of this thesis was to research how municipalities can best encourage homeowners to participate in the heat transition. To provide a substantial conclusion, the project natural gas-free Reyeroord was first analysed to determine the effects of the implemented interventions in the project. Investigations were then conducted into the motivating and discouraging factors for homeowners to connect to DHS. With these findings, it was possible to answer the following research question:

How can the municipality of Rotterdam stimulate homeowners to disconnect from natural gas in Reyeroord Rotterdam, the Netherlands?

The first conclusion is made about the project natural gas-free Reyeroord. The analysis of the project led to the discovery that almost all interventions implemented in Reyeroord should encourage homeowners to connect to DHS. However, as figure 8 demonstrated, after the completion of the project, most homeowners who were initially undecided about their intention to connect to DHS changed their decision to a non-intention to connect to DHS. The reason for this disparity was discovered in the qualitative data, which revealed that homeowners lack motivation to disconnect from natural gas. The other influential factors are overshadowed by a lack of motivation.

The absence of regulations causes the lack of motivation. With the current national policies in the Netherlands, there are no disadvantages to remaining connected to natural gas. This discourages homeowners from investing money and undertaking renovations because the current status quo does not become less appealing. Therefore, it is concluded that the current participatory approach cannot increase a sense of urgency among homeowners to take action and disconnect from natural gas. It is recommended that the national government impose regulations, allowing municipalities to disconnect neighbourhoods from natural gas in a matter of years. This will increase homeowners' motivation to take action.

The second conclusion is that municipalities should guide homeowners in the transitioning phase. Due to the complex and multifaceted nature of the heat transition, the process of transitioning can be difficult. Therefore, a participatory approach is required to ensure homeowners get the help they need. The results show that there is not a one-size fits all solution. Therefore, the best way to implement the participatory trajectory is to use a neighbourhood approach. With the neighbourhood approach, it is possible to tailor the participatory trajectory to the specific circumstances and concerns of the neighbourhood. This is important because the results show that the situation in which homeowners find themselves influences their decision to disconnect from natural gas. Additionally, a design approach should be used to make sure the neighbourhood approach is properly implemented. With the design approach, the implemented interventions are constantly reviewed to see if they correctly respond to the characteristics of the neighbourhood. The following neighbourhood approach, consisting of informative and economic interventions, is suggested based on the findings of this thesis.

1. Get to know the neighbourhood

To gain an understanding of homeowners' situations, the municipality must first investigate the characteristics of the neighbourhood and the concerns of the homeowners. Within this phase, it is essential to explore the performance of previously implemented municipal projects in the neighbourhood. The results identified that homeowners' trust in the municipality influences their decision to disconnect from natural gas. Previous municipal projects can influence homeowners' trust in the municipality. If a previous municipal project failed, homeowners will probably have less trust in the municipality, which negatively affects the

current project. When this is the case, it is important to first increase homeowners' trust in the municipality before other steps of the participatory approach are implemented.

It is essential that the municipality physically visit the neighbourhood as part of this step rather than relying only on statistical data. Findings show that the statistical data is often to generic or not applicable to all homeowners in the neighbourhood. Hence, the municipality should contact the residents to gain a better understanding of the neighbourhood. When this step is carried out with care and genuine focus, it reveals the homeowners' true desires and personal situations. This aids in the implementation of effective interventions from the start, resulting in a smooth process throughout the project.

2. Information provision

The second step of the participatory approach is to provide a good information basis. The heat transition can be a difficult process due to the technical aspects and the quick changes in the process. This makes the information about the heat transition challenging to comprehend. However, the results show that homeowners who do have more knowledge about the heat transition, and in this case specifically about DHS, are more likely to participate. Hence, providing information is crucial for stimulating homeowner engagement.

Furthermore, the internet contains much false information about the heat transition, or information that is not applicable in every case. This makes it even more important to provide a good flow of information to the homeowners. The best way to make the information more understandable is by offering it in manageable bits, such as newsletters, a website, and/or information meetings. It is critical that these smaller portions of information be offered in a continuous flow, for example, once a month. Findings indicate that when municipal information is absent for a long period of time, homeowners get suspicious. This in turn decreases homeowners' trust in the municipality and their intention to participate. In other words, continuous, manageable information can increase homeowners trust in the municipality.

However, in order to ensure project transparency, it is also critical that all project-related information be available and accessible in one location. This location could be a website or a physical location in the neighbourhood. The results indicated that project transparency influences homeowners' trust in the municipality, which means that when only a portion of the information is made available (e.g., through newsletters), it can have a negative effect on homeowners trust in the municipality.

Within the provided information, it is essential to include details about the project's procedure, the technical aspects of the transition, and the cost estimates homeowners must make. Additionally, it is beneficial to highlight the positive climate effects of DHS and potential energy bill savings. The results showed that these two factors stimulate homeowners to disconnect from natural gas.

At last, the findings identified that homeowners have different considerations for connecting to DHS based on their personal values: biospheric, altruistic, and hedonic. Therefore, it is advised to use a variety of justifications in the text to encourage all homeowners, regardless of their personal values, to join DHS.

3. Personal attention and tailor made advice

Another beneficial way to offer information is to communicate the information in person. With face-to-face conversations, it is possible to provide tailor-made advice to the homeowners that corresponds with their personal situation and values. The results show that personal contact helps increase homeowners knowledge and thus stimulates engagement. Furthermore, the results imply that personal contact is beneficial in increasing homeowners' trust in the municipality.

Two effective ways to carry this out are by having information meetings and pop-up information meetings. Information meetings necessitate homeowners travelling to the project team, which can be a barrier for them and thus increase the likelihood of non-attendance. By contrast, the pop-up information meetings are carried out in the streets of the neighbourhood, which reduces attendance barriers. Therefore, the pop-up information meetings are especially beneficial in stimulating homeowner engagement. Within the given information during this step, it is again recommended to highlight the positive climate effects of DHS and potential energy bill savings to additionally encourage homeowner participation.

Finally, when trust in the municipality is extremely low, which has a negative impact on homeowner engagement, this step should be carried out by an independent body (funded by the municipality). This will help to mitigate the negative effects of homeowners' lack of trust in the municipality. However, the municipality must be visible in other parts of the project so that homeowners do not mistake the project for advertising.

4. Offer a temporary financial incentive

Besides informative interventions, it is also valuable to implement economic interventions. It is concluded that the investment costs discourage homeowners from connecting to DHS. This makes it important to mitigate this barrier by offering a financial incentive. The results show that, on average, homeowners in Reyeroord are willing to pay €2500,- to connect to DHS. Therefore, it is recommended to offer a financial incentive where homeowners only have to pay €2500,- of the investment costs. Furthermore, the financial incentive should be offered temporarily to trigger a sense of urgency among homeowners. Moreover, to facilitate homeowners who are not able to pay the €2500,- (due to lower incomes), additional financial incentives should be in place. For example, to pay for the electric hub, new pans or other additional installation costs.

In addition to the strategy described above, it is also concluded that the municipality can respond to the social network in a neighbourhood when social cohesion is high. The approach does not include this step because this is not the case in Reyeroord (see research question). However, when social cohesion is strong, highlighting frontrunners and implementing energy coaches are two beneficial interventions to respond to the social network in a neighbourhood. Therefore, it is suggested to investigate the social cohesion in a neighbourhood during the first step of the approach, to see if interventions responding to the social network can be implemented.

Another conclusion is made about the identified factors influencing homeowners' decision to connect to DHS, which cannot be influenced by the municipality. The first factor is homeowners' trust in the energy provider. The findings showed that homeowners who trust their energy provider are more likely to connect to DHS. As a result, in the natural gas-free Reyeroord project, the municipality has attempted to increase homeowners' trust in the energy provider by mitigating people's negative perception of the monopolistic market structure of the energy provider. However, the results show that the additional information about the energy provider has only decreased homeowners' trust in the energy provider. Therefore, improving homeowners' trust in the energy provider is outside the municipality's scope and should not be focused on in the participatory approach.

The second factor is the demotivating factor of construction nuisance. It has been discovered that the nuisance of construction discourages homeowners from connecting to DHS. However, no municipal interventions were discovered in this thesis to mitigate this factor. It is not concluded that no municipal interventions exist to mitigate this barrier; however, these were not found within this research.

The last factor is the homeowner's age. The results show that homeowners who are notably older are less likely to connect to DHS. Yet again, no interventions were found within this research to mitigate the influence of this factor.

Finally, the findings showed that the implementation of municipal interventions cannot encourage all homeowners to connect to DHS. This led to the final conclusion, that despite

municipal interventions, there will always be a small group of homeowners (in this study, 10.3%) who refuse to participate in the heat transition.

5.2. Implications for planning practice

The outcome of this research has implications for both planning practise and planning theory. The finding of factors influencing homeowner engagement in the heat transition and linking this outcome with potential municipal interventions to stimulate homeowner engagement in the heat transition has been understudied (see §1.4). Beauchmapet and Walsh (2021) explained that future research should investigate how homeowners perceive the heat transition and how municipal interventions can be best designed to guide homeowners in the transition. With the explained participatory approach (§5.1), is this study a step in that direction.

Then, focusing on the practical planning implications of this thesis. In 1.3, it is demonstrated that in order to achieve the Klimaatakkoord goals of 2050, it is necessary to begin with the implementation of the heat transition (Rijksoverheid, 2019). Furthermore, in section 1.3, it is explained that it is critical to develop an approach that guides all homeowners in the heat transition rather than just the frontrunners (Scholte et al, 2020). The conclusions of this thesis provide practical insight into achieving these two statements. The proposed participatory approach (§5.1) can serve as a guideline for municipal policymakers developing strategies to begin with the implementation of the heat transition. Furthermore, the proposed approach (§5.1) emphasises the participation of all homeowners. However, it is important to note that the research findings are based on a case study within Rotterdam, making the outcome specific to that neighbourhood. As a result, the first step of the approach must be carefully executed in order to align the interventions with the context of the chosen neighbourhood.

Chapter 6: Discussion

In the last chapter, a critical reflection of the thesis is given by first reflecting upon the validity of the empirical results, then comparing the theory and the empirical results, and finally explaining the limitations of the research and providing recommendations for future research.

6.1. Reflection of empirical results

To begin, the results' validity is explained. The data for the case study was gathered using four different methods: internal project documents, a prior survey, a survey, and interviews. By combining these methods, a more holistic view of the case study was created, increasing the validity of the results. However, the low number of interviews conducted may have reduced the research's validity. Nonetheless, almost all of the interviewees' responses overlapped. Therefore, I am confident in the validity of the thesis's conclusions.

Second, the relation between the empirical results and academic literature (discussed in Chapter 2) is explained. Most of the empirical results align with the academic literature discussed in Chapter 2. Within the literature, it was found that the factors: a high level of perceived knowledge, strong biospheric values, the positive effects on climate change, potential energy bill savings, investment costs, the nuisance of construction, a low level of trust in the municipality, and a low level of trust in the energy provider influence homeowners' decisions to engage in the heat transition.

Next, the empirical results (§4.7.1) confirmed the literature finding stated by Perlaviciute and Steg (2014) that people with stronger biospheric values are more eager to connect to DHS. Furthermore, §4.4.1. confirms the statement of Steg (2016), explaining that there is a correlation between people's personal values and how they perceive contextual factors.

An empirical finding that contradicts the literature is that DHS's positive climate effects motivate homeowners of all values to participate in the heat transition. Steg (2016) and Bouman et al. (2018), on the other hand, claimed that only those with stronger biospheric and altruistic values are more likely to take action based on the environmental benefits. Rahman et al. (2023) provide a plausible explanation, stating that due to the deteriorating effects of the climate crisis, people in general are more concerned and willing to make environmental-related choices.

Another empirical finding that does not correlate with the literature is that homeowners who received more information about the energy provider decreased their trust in the provider. Bouw et al. (2017) explained that additional information about the energy provider would increase homeowners trust. A possible reason for this outcome is that people who receive more information increase their knowledge and become more critical (Lakatos & Musgrave, 1970). Therefore, it is likely that the knowledgeable homeowners researched the effects of the monopolistic market structure of the energy providers online. And there are numerous negative internet articles about homeowners' interactions with energy providers, particularly about Vattenfall (e.g., NHnieuws, 2022; Parool, 2022).

6.2. Research limitations

The first limitation of the study is that the potential influential factor of efficacy beliefs has not been researched. According to Vainio et al. (2020), self-efficacy and system efficacy are two factors that influence people's environmental behaviour. This demonstrates that these factors may influence homeowners' decisions to participate in the heat transition. It was primarily intended to incorporate these factors into the research. However, the factors were not properly incorporated in the survey, making it impossible to draw conclusions about efficacy beliefs and homeowner engagement.

The second limitation of this research is that the interviews were conducted prior to the survey. It would be preferable to conduct the survey first, then analyse the results, and then conduct the interviews. This would allow to reflect on the survey results during interviews and thus better discuss potential interventions to encourage homeowner participation in the heat transition. However, due to the structure, no interventions were discovered to mitigate the construction nuisance.

The last limitation is about the conclusion of this research. As stated before, the factors influencing homeowners to disconnect from natural gas can vary greatly between individuals and their personal situations. This increases the difficulty of drawing concrete, general conclusions.

6.3. Recommendations for future research

From this research, four future research recommendations are given. To begin, the first indication for future research is to research the relationship between the factors self-efficacy and system efficacy and homeowners' decision-making in the heat transition.

Secondly, this case study concentrated on the transition from natural gas to DHS. To gain a better understanding of the heat transition, future research should also look into the transition from natural gas to other alternative heating systems. By conducting such additional research, it would be possible to determine whether the type of alternative heating source influences homeowners' decision-making in the heat transition.

The third recommendation for future research is to implement this research in different neighbourhoods and compare the results of the various neighbourhoods. As previously stated, the influential factors can vary depending on the circumstances of the neighbourhood. By conducting a comparison between various neighbourhoods, it is possible to draw more generic conclusions.

The last recommendation is to include a focus group with the homeowners to reflect on the outcome of the survey. This would allow for a better understanding of why certain factors influence homeowners' decisions to participate. This more comprehensive viewpoint can help create a participatory approach that is even more effective and efficient, genuinely assisting all homeowners in making decisions regarding the transition to a new heating system.

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In addition, I would like to give a personal reflection. In the beginning of the process, I struggled to understand the connection between citizen engagement and homeowners' decisions to connect to DHS. After correspondence with my supervisors, it became clear that citizen engagement was about co-implementation rather than traditional participation. This helped me in the process of analysing the literature, as I had a clearer understanding of the terms I was searching for. Unfortunately, in combination with other external work, this phase took a considerable amount of time, which resulted in less time being spared for the data collection and analysis.

The second major challenge I faced was combining all of my empirical findings into a logistically understandable structure. Many different findings were made, making it difficult to provide a comprehensive overview. It was also the first time I conducted a quantitative data analysis, which significantly increased the difficulty of analysing raw data. However, after watching many YouTube videos and with the additional help of a Rohaa, it became clear how the quantitative data should be analysed.

In the end, I am pleased to have learned more about the heat transition and all of the factors that influence its problems. My enthusiasm in this area has risen, and I am eager to put what I have learned into practise.

Appendix A: Statistical data

1. Survey

Intro tekst op straat

Goedendag, voor mijn opleiding doe ik een onderzoek over de energietransitie en ben ik op zoek naar bewoners die hun mening hierover willen geven. Woont u in Reyeroord en heeft u een koopwoning? Zou ik u dan een paar vragen over mogen stellen? Alle informatie die u mij geeft gebruik ik alleen voor mijn onderzoek en wordt nergens anders voor gebruikt. Verder is het helemaal anoniem.

Als bewoners mee informatie willen

- Het onderzoek gaat specifiek over bestaande woningen van het gas af halen
- Ik ben opzoek naar de drijfveren van bewoners om wel of niet mee te doen.
- En aan het achterhalen welke middelen de gemeente het beste zou kunnen inzetten om bewoners te helpen bij het maken van de keuze.

Introtekst enquête

Beste deelnemer, van harte bedankt dat u mijn enquête wilt invullen. Deze enquête wordt alleen gebruikt voor mijn scriptie onderzoek en uw antwoorden zijn anoniem. Ik onderzoek de houding van bewoners ten opzichte van de aardgasvrije transitie en hoe de gemeente het beste bewoners kan helpen bij het maken van deze keuze.

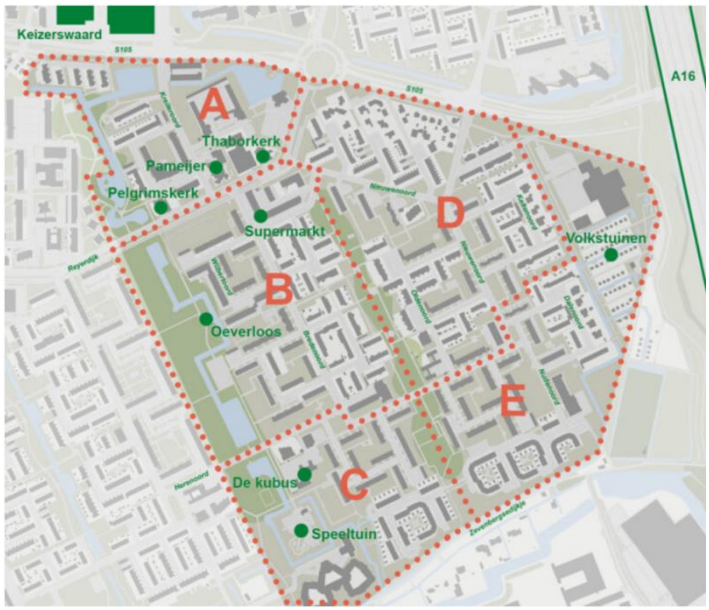
Bereidheid tot deelname

Als u deze enquête invult gaat u akkoord met het gebruik van uw antwoorden. Uw deelname is anoniem.

Vraag 1: Gaat u hier mee akkoord?

- Ja

Informatie



Vraag 2: In welk deelgebied van Reyeroord woont u?

- Deelgebied A, B, of C
- Deelgebied D of E

Vraag 3: Wat is uw geslacht?

- Man
- Vrouw

Vraag 4: Ik vind dat Nederland van het aardgas af moet

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 5: Wanneer de stadsverwarming in uw wijk wordt aangelegd, hoe groot schat u de kans dat u mee gaat doen?

- Ik wil **wel** overstappen op stadsverwarming
- Ik wil **niet** overstappen op stadsverwarming
- Ik weet het nog niet

Vraag 6: Ik weet goed wat de voordelen en nadelen zijn van het aansluiten op stadsverwarming

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 7: Hoe groot schat u de voordelen van stadsverwarming over het algemeen in? 1 = heel weinig voordelen en 5 = heel veel voordelen

- 1
- 2
- 3
- 4
- 5

Vraag 8: Als u kijkt naar het rijtje hieronder, wat vindt u de grootste voordelen? Zet ze op volgorde: 1 is grootste voordeel en 5 is minste voordeel

- Geld besparen
- Positieve effecten op het milieu
- Geen (gevaarlijk) aardgas meer in huis
- Betere warmte comfort in huis
- Waarde van de woning gaat omhoog

Vraag 9: Hoe groot schat u de nadelen van stadsverwarming over het algemeen in? 1 = heel weinig voordelen en 5 = heel veel voordelen

- 1
- 2
- 3
- 4
- 5

Vraag 10: Als u kijkt naar het rijtje hieronder, wat vindt u de grootste nadelen? Zet ze op volgorde: 1 is grootste nadeel en 5 is minste nadeel

- Overlast van de verbouwing
- Niet de gewenste temperatuur in huis
- Elektrisch koken
- De (investeer)kosten
- Ik wil niet de eerste zijn

Vraag 11: Zijn er naast de hiervoor benoemde factoren nog andere redenen die ervoor hebben gezorgd dat u wel mee gaat doen/ niet mee gaat doen/ ik weet het nog niet heeft ingevuld bij vraag 2?

- Ja namelijk:…
- Nee

Vraag 12: Er zijn meerdere mogelijkheden om uw huis te verwarmen. Welke optie heeft voor u de meeste voorkeur, zet ze op volgorde 1 is meeste voorkeur en 5 is minste voorkeur.

- Stadsverwarming
- Aardgas
- Warmtepomp
- Infrarood panelen
- Houtkachel

Vraag 13: De investeerkosten om uw woning op stadsverwarming aan te sluiten zijn ongeveer 12.000 euro. Stel de gemeente geeft u een subsidie hoeveel zou u daarnaast bereid om zelf te betalen?

- Slider tussen 0 euro en 30.000 euro

Vraag 14: Stel, de gemeente kiest ervoor om over 2 jaar deze subsidie te stoppen. Zou u dan eerder bereid zijn om nu mee te doen?

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 15: Negatieve opmerkingen van uw buren zorgen ervoor dat u minder snel uw huis zou aansluiten op een warmte net

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 16: U bespreekt eerst de gevolgen van een warmtenet met uw buren voordat u hier een beslissing over neemt

- Helemaal mee eens
- Eens
- Neutraal
- Oneens

- Helemaal oneens

Vraag 17: Wat zou de gemeente kunnen inzetten om ervoor te zorgen dat u wel mee zou gaan doen?

- Meer subsidie
- Meer informatie over de techniek
- Meer informatie over het proces (zoals contracten tekenen, procedure aanvragen en eventuele renovaties regelen)
- Meer continu op de hoogte gehouden worden van het proces (in welke fase het proces zit bijvoorbeeld, wanneer de verbouwing plaats gaat vinden)
- Op meer verschillende manieren informatie ontvangen
- Meer persoonlijk advies
- Meer persoonlijke aandacht
- Een adviseur die alles voor mij regelt rondom de aansluiting op de stadsverwarming
- Eerder betrokken worden in het proces
- Meer positieve verhalen van mijn buurtbewoners
- Helemaal niets
- Anders, namelijk…

Vraag 18: De gemeente is eerlijk en betrouwbaar in de informatie die ze mij geven

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 19: De gemeente Rotterdam is deskundig genoeg om bewoners te helpen bij dit project

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 20: De gemeente Rotterdam handelt in het belang van de inwoners van Reyeroord

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 21: Na het aansluiten op een warmte heeft u nog maar één energieleverancier. Heeft u er vertrouwen in dat deze energieleverancier u de juist energieprijs aanbied?

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 22: De energieleverancier handelt in het belang van de inwoners van Reyeroord

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 23: De energie leverancier handelt alleen uit hun eigen belang

- Helemaal mee eens
- Eens
- Neutraal
- Oneens
- Helemaal oneens

Vraag 24: passen de volgende stellingen bij u? (1 = totaal oneens en 7 = heel erg mee eens)

- Ik vind het belangrijk om milieu vervuiling te voorkomen
- Ik vind het belangrijk om het milieu te beschermen
- Ik vind het belangrijk om respect te hebben voor de natuur
- Ik vind het belangrijk om in eenheid te zijn met de natuur

Vraag 25: passen de volgende stellingen bij u? (1 = totaal oneens en 7 = heel erg mee eens)

- Ik vind het belangrijk dat iedereen gelijke kansen heeft in het leven
- Ik vind het belangrijk om te zorgen voor degene die het slechter hebben dan ik
- Ik vind het belangrijk om dat er geen oorlog is
- Ik vind het belangrijk dat iedereen gelijk behandeld wordt
- Ik vind het belangrijk om andere te helpen

Vraag 26: passen de volgende stellingen bij u? (1 = totaal oneens en 7 = heel erg mee eens)

- Ik vind het belangrijk om plezier te hebben
- Ik vind het belangrijk om te genieten van alle leuke dingen in het leven
- Ik vind het belangrijk om dingen te doen die ik leuk vind

Vraag 27: passen de volgende stellingen bij u? (1 = totaal oneens en 7 = heel erg mee eens)

- Ik vind het belangrijk om controle te hebben over de acties van anderen
- Ik vind het belangrijk om gezag te hebben over andere
- Ik vind het belangrijk om invloed te hebben/ invloedrijk zijn
- Ik vind het belangrijk om geld en spullen te hebben
- Ik vind het belangrijk om hard te werken en ambitieus te zijn

Tot slot vraag ik u nog een paar persoonlijke vragen en dan zijn we klaar.

Vraag 28: Wat is uw leeftijd?

- Exact getal invullen

Vraag 29: wat is uw hoogst behaalde opleidingsniveau?

- Geen opleiding/ onvolledige basisonderwijs
- Basisschool
- Middelbare school
- MBO opleiding

- HBO opleiding
- Universitaire opleiding
- Gepromoveerd

Vraag 30: wat is uw bruto maandelijkse inkomen?

- Slider tussen 0 en 10.000 euro

Vraag 31: tot slot, ben ik op zoek naar bewoners die ik nog wat verdiepende vragen zou mogen stellen. Dit zal ongeveer een halfuurtje duren en kan via teams of de telefoon gebeuren. Zou u daar interesse in hebben? Dat zou mij heel erg helpen!

- Ja, via email:
- Ja via online interview:
- Ja via de telefoon:
- Nee

Heel erg bedankt voor het invullen van mijn survey! Een hele fijne dag verder.

2. Outcome of statistical tests

Cronbach's Alpha

Below, the Cronbach's alphas are shown for the variables that were questioned on 5.Likert scale. The Cronbach's Alpha must be above 0.5 for the variable to be valid. Table 1 shows that this is the case for all the variables used in this thesis.

Table 1: Statistic descriptives and Cronbach's alpha of 5.likert tests; N=116 (Author, 2023)

Variable	Cronbach's Alpha	N of items	Mean	SD
Social cohesion	0.882	2	3.54	1.19
Trust municipality	0.912	3	2.65	1.07
Trust energy supplier	0.698	3	3.64	0.87
Biospheric values	0.912	4	5.63	1.16
Altruistic values	0.912	5	5.87	1.16
Hedonic values	0.904	3	6.40	1.01
Egoistic values	0.915	5	3.92	1.25

Correlation

The relationship between homeowners' personal values and how they view contextual factors is shown by the correlation coefficient in table 2. The bolded correlation coefficients demonstrate a significant correlation between contextual factors and individual values.

Table 2 shows that homeowners with stronger biospheric values perceive a high level of social cohesion and find it important that the DHS has positive effects on climate change. The test also revealed that homeowners with higher altruistic values consider the positive climate effects of DHS as an important factor. Third, homeowners with higher hedonic values perceive the investment costs of DHS as negative (note the minus sign) and also perceive the process's uncertainty as being higher than homeowners with lower hedonic values do. At last, the test found that there is no correlation between homeowners with stronger egoistic values and contextual factors.

Table 2: Outcome of correlation between contextual factors and personal values (Author, 2023)

	Personal values			
Contextual factors	**Biospheric**	**Altruistic**	**Hedonic**	**Egoistic**
Energy bill savings	0.132	0.084	0.085	0.034
Positive climate effects	**0.189***	**0.266****	-0.106	-0.028
No natural gas	-0.040	0.083	0.034	-0.027
Comfort	0.036	0.050	0.079	0.082
Residence value	0.040	0.014	-0.090	-0.049
Construction nuisance	0.146	0.058	0.101	0.100
Temperature	-0.115	-0.066	-0.062	-0.090
Electric cooking	-0.126	0.006	-0.006	-0.062
Investment costs	-0.036	-0.011	**-0.198***	-0.027
Uncertainty	0.145	0.011	**0.202***	0.085
Social cohesion	**0.237***	0.113	0.156	0.067

Generalised linear model

The generalised linear model illustrates the relationship between the homeowners' decision to connect to DHS and all the factors discussed in Chapter two that could potentially influence that decision. The factors in the table that are bolded are significant and thus have an impact on homeowners' willingness to connect to DHS.

Table 3: Outcome of generalised linear model including all factors influencing homeowners intention to connect to district heating (Author, 2023)

Parameter Estimates			
Parameter	**B**	**Std. Error**	**Sig.**
Threshold Intention = 1	0.922	4.754	0.846
Intention = 2	2.929	4.760	0.538
[Knowledge = 1]	1.080	0.944	0253
[Knowledge = 2]	0.448	0.874	0.608
[Knowledge = 3]	2.912	1.099	**0.008**
[Knowledge = 4]	2.603	1.013	**0.010**
[Knowledge = 5]	0a	.	.
[Education = 1]	-19.864	34960.412	1.000
[Education = 2]	-1.940	2.474	0.433
[Education = 3]	-0.463	1.387	0.738
[Education = 4]	-0.401	1.207	0.740
[Education = 5]	-0.871	1.147	0.448
[Education = 6]	0[a]	.	.
Energy bill savings	-0.219	0.288	0.447
Positive climate effects	-0.586	0.281	**0.037**
No natural gas	-0.065	0.252	0.796
Comfort	0.205	0.277	0.459
Residence value	0[a]	.	.
Construction nuisance	0.171	0.445	0.700
Temperature	-0.199	0.427	0.641
Electric cooking	-0.519	0.353	0.141
Investment costs	-0.137	0.379	0.718
Uncertainty	0[a]	.	.
Age	0.007	0.018	0.707
Income	0.000	0.002	0.253
Trust municipality	0.764	0.256	**0.003**
Trust energy supplier	0.556	0.353	0.116
Biospheric values	-0.810	0.266	**0.002**
Altruistic values	-0.136	0.339	0.688
Hedonic values	0.903	0.468	0.054
Egoistic values	-0.024	0.209	0.909
Social cohesion	0.111	0.230	0.628
Scale	1b	.	.
a = set to zero because this parameter is redundant b= fixed at the displayed value			

Desired municipal interventions by the homeowners of Reyeroord

The additional answers given by the option "*different, namely…"* were from the informed neighbourhood: "*my house is already natural gas-free*" and "*the guarantee that district heating will always be cheaper compared to natural gas*". The additional answer for the respondents in the control part of the neighbourhood was: "*website"*.

Appendix B: Interviews

1. Informed Consent

Agreement to participate - Research Ethics Committee (REC)
Research project: Master Thesis Environmental and Infrastructure planning
University: University of Groningen, Faculty of Spatial Planning
Researcher: Ilse Teunissen

Dear participant,
Thank you for your participation in this study on the transition to natural gas-free living in the Netherlands. The goal of this research is to gather information on the most effective methods for municipalities to encourage citizens to take part in this transition. The emphasis is on identifying the factors that motivate citizens to participate and determining the most effective ways for the municipality to influence these factors.

This interview will be recorded and transcribed to answer the research questions. It is possible to receive the transcript of the interview. For further questions or comments please contact:

Ilse Teunissen
i.teunissen@student.rug.nl
0633883111

Ina Horlings
l.g.horlings@rug.nl

Ann Lankhorst
Ann@Kickstad.nl

Hereby, I declare that:

I consent to my interview being audio-recorded	YES / NO
I wish to remain anonymous for this research	YES / NO
If YES My first name can be used for this research	YES / NO
OR A pseudonym of my own choosing can be used in this research	YES / NO

"I agree to participate in this individual interview and acknowledge receipt of a copy of this consent form and the research project information sheet."

Signature of participant:_____Date: XX-XX-XX

"I agree to abide by the conditions set out in the information sheet and I ensure no harm will be done to any participant during this research."

Signature of researcher: _____Date: XX-XX-XX

Please fill in the following information. It will only be used in case you want to be sent a copy of interview notes so that you have the opportunity to make corrections.

Address:
Email:

2. Interview guide Experts

Interview guide Expert

Hallo, ik wil u graag bedanken voor uw deelname aan mijn onderzoek. Mijn naam is Ilse Teunissen en ik rond momenteel mijn master Environmental and Infrastructure Planning af aan de Universiteit van Groningen. Voor mijn scriptie onderzoek ik hoe gemeenten bewoners het beste kunnen stimuleren om deel te nemen aan de aardgasvrije transitie. Met andere woorden, ik onderzoek welke middelen de gemeente het beste kan inzetten om zoveel mogelijk bewoners te betrekken.
Voordat we beginnen, wil ik graag vragen of ik uw toestemming heb om dit gesprek op te nemen. Na het interview stuur ik u een formulier op via de mail vanuit de universiteit, met de vraag of u mij toestemming geeft voor het gebruiken van het interview. Zou u dit willen invullen en naar mij terug willen sturen?

Inleidende vraag

Vraag 1: Zou je zichzelf kort kunnen voorstellen, hoe heet je en wat uw functie is?

Het leek mij daarom interessant om jouw mening te horen over de motivaties van bewoners en de juiste maatregelingen die de gemeente kan inzetten om bewoners te stimuleren om van het gas af te gaan.

In de literatuur heb ik gevonden dat de keuzen van bewoners om mee te doen met de aardgas vrije transitie wordt beïnvloed door de clusters hun 1. omgeving (context), 2. houding (attitude) en 3. socio-demografische factoren. Ik ben benieuwd of je deze aspecten ook tegenkomt in de praktijk, wat jouw mening hierover is en hoe gemeenten het beste kunnen inspelen op deze aspecten.

In de chat stuur ik de factoren die ik heb gevonden en samen nemen wij deze door.

Omgeving:

1. De kosten die bewoners moeten maken, dit zijn investeringskosten en de maandelijkse energiekosten.
2. Sociale cohesie en het sociale netwerk in de buurt
3. Persoonlijke comfort, zoals de verbouwing, kwaliteit van de energievoorziening en wel of geen aardgas in huis.

Houding:

4. Persoonlijke waarden:
    a. Hedonic values: gefocust op eigen plezier en comfort
    b. Egoistic values: gefocust op het beschermen en bevorderen van persoonlijke middelen (bijv. geld en status)
    c. Alturistic values: gefocust zijn het welzijn van andere mensen en de samenleving
    d. Biospheric values: maken zich veel zorgen over het milieu en de gevolgen hiervan
5. Vertrouwen in de overheid en energieleverancier
6. Zelfredzaamheid: Bewoners hebben het idee dat zij mee kunnen doen, begrijpen welke stappen er moeten worden gedaan en het idee hebben dat zij werkelijk een steentje bij gaan dragen.
7. Kennis en informatie over wat de transitie en maatregelen

Sociaal demografische factoren:

8. Inkomen
9. Leeftijd
10. Opleiding

Vraag 2: Als u naar deze factoren kijkt, ziet u in de praktijk dat deze daadwerkelijk invloed hebben op bewoners hun keuze? In welk opzicht?

Vraag 4: Welke factoren hebben volgens u de meeste invloed? En welke factoren het minste?

- Waarom?
- Kunt u een voorbeeld geven uit de praktijk?

Vraag 5: Welk cluster denkt u dat de meeste invloed heeft op bewoners? En waarom?

Vraag 6: Zijn er naast deze factoren nog andere factoren waarom bewoners wel of niet mee gaan doen?

- Zo ja, welke factoren?
- Zou u deze factoren in een van de clusters kunnen onder verdelen? Zoja, welke?

In de literatuur heb ik gevonden dat gemeenten bewoners kunnen stimuleren door de volgende maatregelen/ middelen in te zetten. Deze weer in de chat laten zien.

- Subsidies
- Informatie geven aan bewoners
- De manier van informatie geven aan bewoners:
    - Timing, wanneer geef je de informatie. In hoopjes of alles in één keer?
    - Een variatie van communicatie middelen
    - Variatie van talen
    - Een leuke activiteit koppelen aan een informatie bijeenkomst
- Bewoners vroegtijdig betrekken in het proces
- Actieve bewoners als ambassadeurs inzetten
- Persoonlijke aandacht – bijvoorbeeld met een energieloket

Vraag 8: Denkt u dat dit de juiste middelen zijn? Waarom wel/ waarom niet?

Vraag 9: Welke middelen hebben volgens u het meeste invloed? En welke het minste? Waarom? Kunt u een voorbeeld geven uit de praktijk?

Vraag 10: Zijn er andere belangrijke middelen die de gemeente kan inzetten om bewoners te stimuleren?

- Zo ja, welke zijn dat?
- En waarom werken deze goed?

Tot slot,
Vraag 11: In hoeverre kan de gemeente bewoners stimuleren om mee te doen?

Heel erg bedankt voor het beantwoorden van mijn vragen. Ik ga ze verwerken in mijn scriptie.
Vraag 12: Heeft u nog een vraag voor mij of wilt u nog iets kwijt?

3. Interview guide Project team natural gas-free Reyeroord

Interview guide Gemeente

Hallo, ik wil u graag bedanken voor uw deelname aan mijn onderzoek. Mijn naam is Ilse Teunissen en ik rond momenteel mijn master Environmental and Infrastructure Planning af aan de Universiteit van Groningen. Voor mijn scriptie onderzoek ik hoe gemeenten bewoners het beste kunnen stimuleren om deel te nemen aan de aardgasvrije transitie. Met andere woorden, ik onderzoek welke middelen de gemeente het beste kan inzetten om zoveel mogelijk bewoners te betrekken. Specifiek doe ik mijn onderzoek naar Reyeroord omdat jullie daar op verschillende manieren zeer actief zijn in het betrekken van bewoners.
Voordat we beginnen, wil ik graag vragen of ik uw toestemming heb om dit gesprek op te nemen. Na het interview stuur ik u een formulier op via de mail vanuit de universiteit, met de vraag of u mij toestemming geeft voor het gebruiken van het interview. Zou u dit willen invullen en naar mij terug willen sturen?

Inleidende vragen

Vraag 1: Zou u zichzelf kunnen voorstellen? Hoe heet u en wat is uw functie in het project aardgasvrij Reyeroord?

Vraag 2: Kunt u kort uitleggen wat het hoofddoel is van het project?

Attitude & context bewoners

Vraag 3: Wat zijn volgens u de belangrijkste motivaties/ redenen voor bewoners om deel te nemen aan de aardgas vrije transitie in Rotterdam?

- En wat zijn de belangrijkste motivaties voor bewoners om niet deel te nemen?
- Waarom? Heeft u een voorbeeld uit de praktijk?

Vraag 4: Hoe hebben jullie specifiek ingespeeld op de hierboven benoemde motivaties?

Vraag 5: Welke obstakels kwam u tegen bij het betrekken van bewoners bij de aardgas vrije transitie?

Vraag 6: Denkt u dat het inkomen, leeftijd en/of educatie van invloed hebben op de keuze van de bewoners?

- Zo ja, in welk opzicht?
- Hebben jullie hier ook rekening mee gehouden in het participatie traject?

Vraag 7: Uit de literatuur blijkt dat er 4 verschillende persoonlijke waardes zijn die beïnvloeden of bewoners mee gaan doen. Dat zijn deze waarden:

- Hedonic values: gefocust op eigen plezier en comfort
- Egoistic values: gefocust op het beschermen en bevorderen van persoonlijke middelen (bijv. geld en status)
- Alturistic values: gefocust zijn het welzijn van andere mensen en de samenleving
- Biospheric values: maken zich veel zorgen over het milieu en de gevolgen hiervan

Heeft u dit ook gemerkt in de praktijk? En hebben jullie rekening gehouden dat het mogelijk is dat mensen voor verschillende redenen mee gaan doen?

- Hoe hebben jullie hier rekening mee gehouden?

Interventies van gemeente

Vraag 4: Ik heb begrepen dat er 12 interventies zijn ingezet om bewoners te helpen bij het maken van hun keuze. Kunt u in steek woorden de voornaamste doel(en) per interventie?

Bijvoorbeeld informeren, enthousiasmeren, bewustwording, persoonlijke aandacht, samenhorigheid vergroten, etc. Je mag een of meerdere antwoorden geven per interventie.

A. Rode kunstobjecten

.....

B. Warme wandeling

.....

C. Informatie bijeenkomst in het energiehuis meerdere

.....

D. Warm winter Reyeroord

.....

E. Aanbod-doos

.....

F. Informatie video's

.....

G. Buurtpraatjes

.....

H. Buitenbioscoop

.....

I. Gemeente langs de deuren

.....

J. Nieuwsbrief van de gemeente

.....

K. Stellingen op straat

.....

L. Energiehuis

.....

Vraag 5: Waren er ook nog andere middelen/ interventies die jullie hebben ingezet?

Vraag 6: Welke middelen hebben volgens u het beste gewerkt? Waarom? Kunt u een voorbeeld geven uit de praktijk?

- En welke middelen het slechtste? Waarom? Kunt u een voorbeeld geven uit de praktijk? → door vragen

Vraag 7: Is er ook gebruik gemaakt van subsidies of andere financiële prikkels om bewoners te stimuleren om hun huizen aardgas vrij te maken?

- Hoe effectief waren deze?
- Waarom?
- Kunt u eventueel een voorbeeld geven?

Vraag 8: Wat denkt u dat het meeste impact heeft gehad om bewoners te betrekken: waren dit subsidies, het geven van informatie of de manier hoe bewoners worden geïnformeerd?

- Of moet er een combinatie zijn?
- P.S. maatregelen waar de gemeente invloed op had

Afsluitende vragen

Vraag 16: Wat zijn de grootste uitdagingen voor de lokale overheid bij het stimuleren van bewoners in de overstap naar aardgasvrij wonen te maken en hoe kunnen deze worden aangepakt?

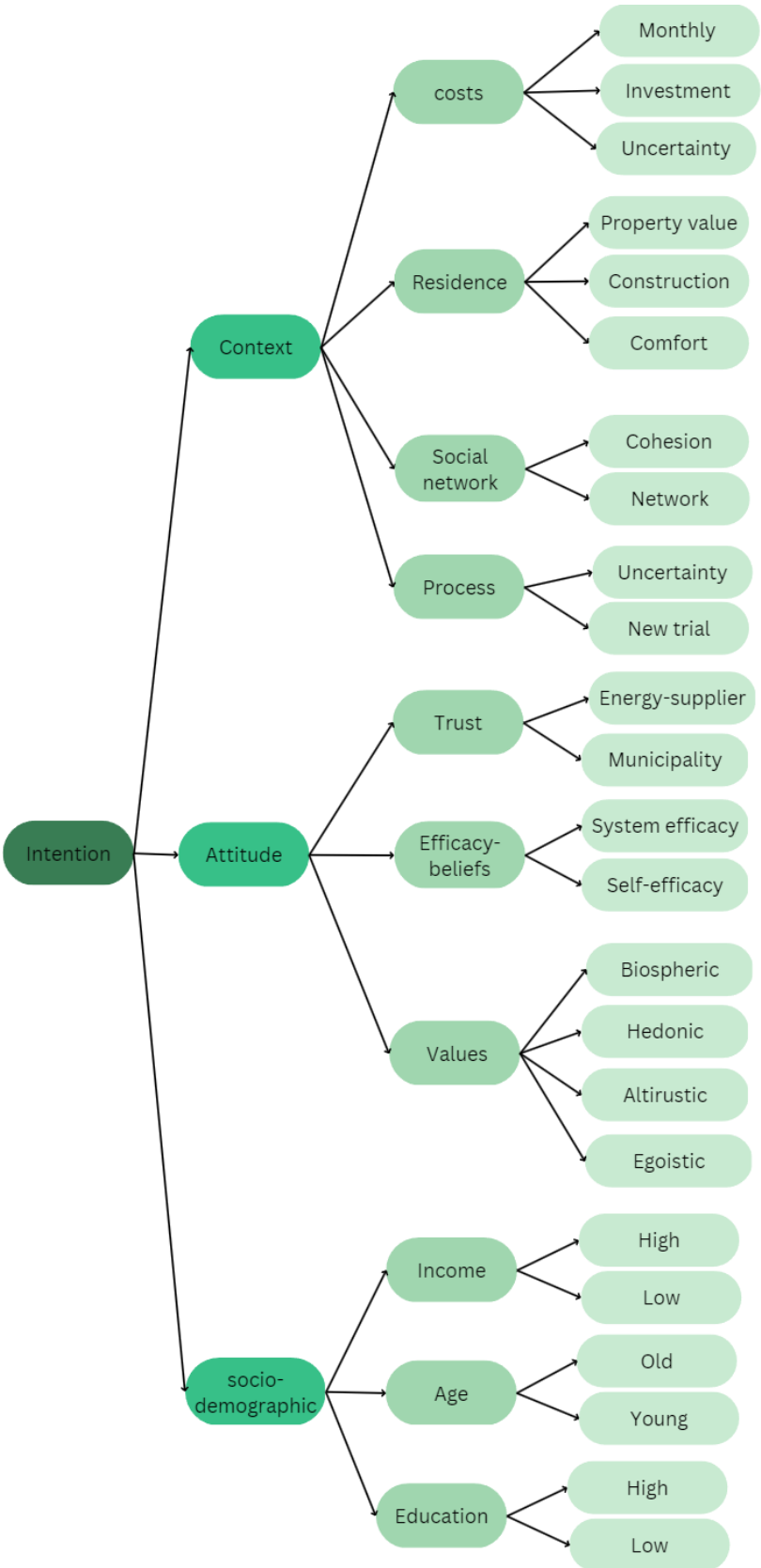
Vraag 17: Wat zijn volgens u de belangrijkste lessen die u hebt geleerd heeft of aanbevelingen die u heeft bij het betrekken van bewoners bij de energietransitie?

Vraag 19: Wilt u nog iets kwijt, en/of heeft u nog vragen voor mij?

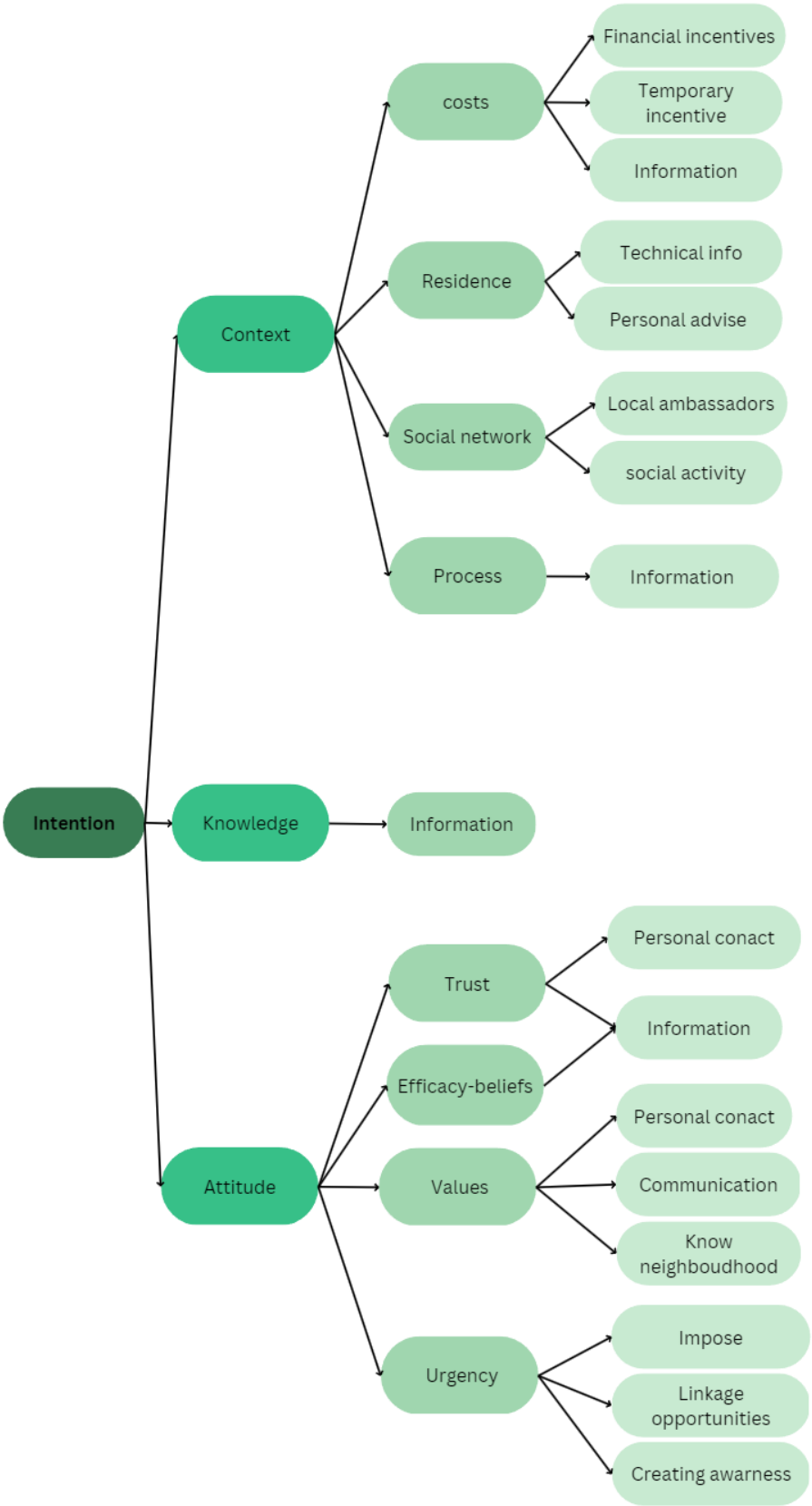
Dat waren mijn vragen, heel erg bedankt voor het meewerken. Als u nog vragen of opmerkingen heeft kunt u mij altijd contacten!

Appendix C: Coding tree's

1. Coding tree influential factors on homeowner



2. Coding tree potential municipal interventions



Appendix D: Explanation of informative interventions in Reyeroord

Red art objects

Three art objects were placed within the informed part of the neighbourhood. The reasoning behind the placement of these art objects was to increase homeowners awareness about the project. The art objects were a stove, shower, and radiator. To establish a connection with the Rotterdam port, anchors were fastened to the art objects. Furthermore, various information panels were attached to the art objects.

Warm winter Reyeroord

The warm winter Reyeroord intervention is made up of three distinct components that work as a whole to give the neighbourhood a Christmas atmosphere. The first component was the delivery of a greeting card to each resident's house. Homeowners were encouraged to write their wishes for the neighbourhood on this card and attach them to the neighbourhood Christmas tree. The final component of this intervention was a neighbourhood Christmas walk. During the walk, residents were invited to deliver Christmas cards to their neighbours.

Warm walk

With the warm walk, residents in Reyeroord were invited to walk across all previously implemented interventions in the neighbourhood. Furthermore, additional panels with information and statements were located in the neighbourhood. The purpose of this walk was to interact with the residents of Reyeroord, offer personalised advice, and raise awareness among other locals who saw the warm walk.

Statements on the street

Several panels with triggering statements were shown in the streets of Reyeroord. Homeowners were able to agree or disagree per statement by voting with large balls in tubes. There was no good or false answer for the statements because the purpose of the statements was to start the conversation between the residents of Reyeroord and the project team. During the conversation, tailor made information about the heat transition was given to the residents.

Outdoor cinema

The outdoor cinema was organised as a good deed for the neighbourhood. Throughout the day, movies were shown on a big screen located in the neighbourhood. The movies varied greatly in order to provide entertainment for all homeowners. In addition to the movies, an information market was established to answer

homeowners' questions about the heat transition. Finally, homeowners were able to receive an energy box containing energy-saving products.

Neighbourhood talks

The neighbourhood talks took place within the streets of Reyeroord. The project team had personal conversations with the homeowners during the neighbourhood talks in order to provide tailored advice. Therefore, a large team of experts was present during this intervention. By having the neighbourhood talks in the streets of Reyeroord it was possible to inform homeowners who would otherwise not be contacted. During the summer periods pancakes were baked on induction hobs to provide a cosy atmosphere.

Information meetings

The information meetings took place in the Energy House. This is a physical location in the neighbourhood where residents can go to ask questions about the heat transition. This location is central to the neighbourhood and was therefore a good place to have the information meetings. The informational meetings were open, drop-in events. During an information meeting, different information panels were located, clustered by theme. As a result, information about every facet of the project could be provided.

Offer package

All homeowners in the informed part of the neighbourhood received the offer to disconnect their homes from natural gas and connect it to DHS. Within this offer package, the homeowners received a calculator, an interest card, three information flyers, the financial incentive, and a dummy of the technique. To increase awareness of the offer box, the municipality went door to door to offer every house an offer box.

Offer video's

To help homeowners understand the offer box and create additional awareness of the project, videos were recorded and displayed on the website Duurzaam010/Reyeroord.nl. It was hoped that by displaying the same information as the offer box in a different format, more homeowners, such as those who speak less Dutch, would be reached. In total three video's were recorded.

Newsletters natural gas-free

To keep the residents in Reyeroord informed of the developments in the process, announce new interventions, and show everything that is happening around the heat transition, news letters were sent. The letters were sent once every two months, online and in person. It was chosen to send the newsletter to all residents of Reyeroord or a part of the neighbourhood, depending on the information in the newsletter. Within the other interventions, it was asked what the residents of Reyeroord preferred to read in the newsletter. With this feedback, it was possible to deliver the right information in the newsletters.

Door-to-door

The last intervention implemented was the door to door approach. The project team went to all the homes of the homeowners who had not submitted their interest cards yet. The goal of this intervention was to encourage homeowners to submit their interest cards and therefore show their intention to connect to DHS. During the implementation of this intervention, homeowners were offered additional information to help them make a decision.