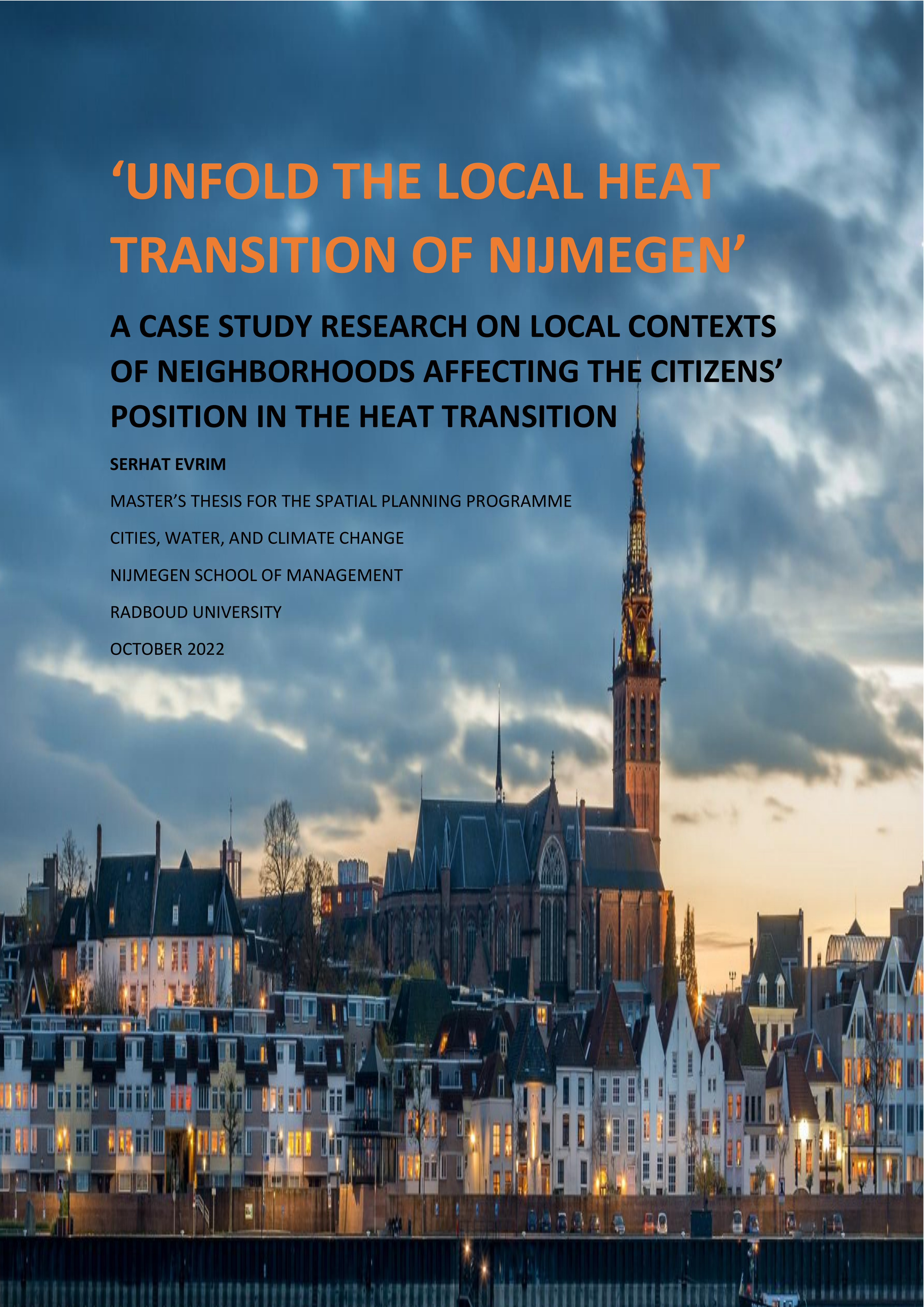

‘UNFOLD THE LOCAL HEAT TRANSITION OF NIJMEGEN’

A CASE STUDY RESEARCH ON LOCAL CONTEXTS OF NEIGHBORHOODS AFFECTING THE CITIZENS’ POSITION IN THE HEAT TRANSITION

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MASTER’S THESIS FOR THE SPATIAL PLANNING PROGRAMME

CITIES, WATER, AND CLIMATE CHANGE

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SUMMARY

In most places in the Netherlands, the heat transition takes place based on area or district-oriented approaches as the heat transition inherently takes the local conditions into account to deliver the best solution (SER, 2019). The growing attention to the heat transition and the pressure on neighborhoods has started the era where energy politics and practices that are driven by a deficit view of the public do not function as sufficiently as expected anymore (Koning et al., 2020; Mah et al., 2012). Thus, local-level implementation of the heat transition by neighborhood approach necessitates citizens to be at the center of the process (Beauchampet & Walsh, 2021). However, there are local contexts that separate each neighborhood: The first is the social characteristics of the residents living in a neighborhood, and the other is the physical context of the neighborhood (van den Wijngaart et al., 2017). To be able to obtain a thorough understanding of different local contexts of neighborhoods, several theories are combined with the latest ideas of scholars on the heat transition. Neighborhood capacities consist of organizational, infrastructural, personal, and social-cultural capacity (1), transformative activities (2), which are activities that increase or decrease the capacities of neighborhoods in heat transition through residents, and goals and outcomes (3), which represents the social acceptance of the transition by the public, were combined. In light of these considerations, the main research question in this thesis is formulated as follows:

How do the physical and social characteristics of neighborhoods in Nijmegen have an influence on the residents' attitudes and role in the heat transition, and what are considered barriers and opportunities to accelerate the heat transition in Nijmegen?

To formulate an answer to this question, five case neighborhoods from the Nijmegen have been selected. A field survey was conducted in these five neighborhoods to measure the residents' willingness to participate/support/contribute to the local heat transition of the neighborhoods with different social and physical contexts. In addition, two experts on the local heat transition of Nijmegen were approached for the interview. Analysis of the collected data has been done with the help of Atlas.ti for the interviews and Microsoft Excel for the field survey.

It is concluded that the social and physical characteristics of the neighborhoods have an influence on not only the willingness of residents in participating/support/contribute to the local heat transition but also the neighborhood's capacity to realize the heat transition at the neighborhood level. In detail, the research findings concluded that neighborhoods with higher average income levels are more willing to realize the heat transition compared to lower-income neighborhoods. Moreover, it is found that neighborhoods with a higher proportion of homeowners show higher participation, support, and contribution to heat transition compared to tenants. Also, the age of residents is determinative in one's participation in social learning events themed heat transition, which explicitly affects the capacity of a neighborhood to achieve the heat transition. On the other hand, when the house type from the physical characteristics is examined, it is concluded that the residents whose house type is detached are more willing to participate, support, and contribute to the process than the residents who reside in either terraced or flat houses. Finally, as the house/building age increases, it is concluded that although the participation of residents in social activities increases, their expectations with national and local governments decrease. In this context, the barriers impeding the transition process and the opportunities of the process were determined according to the interview analysis and survey results. As a result, although further research is required due to the limitation of this thesis, it is found that considering the different social and physical characteristics of the neighborhoods can be effective in accelerating the heat transition of Nijmegen.

PREFACE

I am delighted to submit my master's thesis to Radboud University Nijmegen's ‘Spatial Planning program’, with the specialization ‘Cities, Water and Climate Change'. I have been busy reading literature, comprehending theories, conducting interviews with experts and questionnaires with residents of Nijmegen, and analyzing qualitative and quantitative data to accomplish this master thesis. There have been ups and downs in the research process. Even though finding the correct topic and idea to be explored was difficult for me, the writing part was easier and more enjoyable after finding the subject representing my field of interest.

I now proudly present my master's thesis, "Unfold the local heat transition of Nijmegen" after 7 months of work. However, without the assistance and support of numerous people, this thesis would not have been able to be completed. Firstly, this master's thesis was maintained and completed with the support of the Republic of Türkiye. In this context, I would like to express my gratitude to the staff members of the Republic of Türkiye Ministry of National Education General Directorate Abroad, the Turkish Education Attaché of Hague, Associate Professor Doctor Miyase Koyuncu Kaya, and my advisor, Dr. Veysel Selimoğlu on behalf of Republic of Türkiye Ministry of Environment, Urbanization and Climate Change. In addition, I want to thank Dr. Linda Carton, my university supervisor, for her patient attitude and helpful criticism throughout the research process. I also want to express my gratitude to all of the interviewees for their cooperation in this study. Likewise, this thesis could not have been completed without the contribution of ninety-five Nijmegen residents who participated in the survey. Finally, I want to express my gratitude to my mother, sisters, and friends for their encouragement and support throughout this journey. Without them, I would not have been able to accomplish this thesis.

I hope that this research will make societal contribution to the peaceful city Nijmegen where I lived for two years. After twenty-one years of education, I look forward to what life will bring to me in business.

Serhat Evrim

October 2022

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1. Introduction

1.1. Research problem statement

Dutch National Climate Agreement (Klimaatakkoord in Dutch) which was in line with Paris Agreement (UNFCCC, 2015) was published in 2018 to declare the Dutch plan on reducing greenhouse gas emission to reach climate goals. In addition, The Dutch Climate Mitigation Act (Klimaatwet in Dutch) introduces several national measures aiming to achieve 49% CO2 emission reduction by 2030 and 95% by 2050, compared to 1990 CO2 emission levels. An energy report published by Ministry of Economic Affairs and Climate Policy (2013) emphasizes five sectors that emit most of greenhouse gasses in the Netherlands: The built environment, mobility, industry, agricultural land-use and electricity. The built environment is one of great importance in reaching climate target because it contributes 30% of total energy consumption in the Netherlands (Government of the Netherlands, 2012). 7 million houses and 1 million buildings which have a low level of insulation and are heated by natural gas are the locus point of the energy transition toward climate neutrality. The national target is to make 50,000 households gas-free per year from 2021 onwards, and 200,000 households annually by 2030, with a goal of making the built environment 100% decarbonised by 2050 (SER, 2019).

To achieve these goals, three important policy steps are taken regarding the heat transition process in the Netherlands. First, a new law (the 'Wet Voortgang Energietransitie' in Dutch) interdicts new buildings to have a natural gas grid connection after 2018 (SER, 2019). Second, a neighborhood-oriented approach is chosen as the main strategy by the Netherlands to switch natural gas to alternative low-carbon heating sources in the built environment (International Energy Agency, 2020). Third, all Dutch municipalities is tasked by the national government to compose a heat transition vision (transitievisie warmte in Dutch) until 2021 that declares when, how and in what order the heat transition of neighborhoods will be taken place (Ministerie van Binnenlandse Zaken en Koninkrijkrelaties, 2019). Even though the local-level implementation of the heat transition makes individuals and communities a key component of the process, the local contexts of the neighborhoods are so unique that each neighborhood requires a different approach to achieve a gas-free built environment. Oorschot (2020) argues that each generation of neighborhoods in the Netherlands has its own specific characteristics due to changes such as legislation and subsidies made in accordance with the needs and conditions of each neighborhood. Basically, the local contexts of the neighborhoods can change depending on the socio-economic status of residents living in a neighborhood (social characteristics) and the infrastructural features of the neighborhood (physical characteristics) (van den Wijngaart et al., 2017). Correspondingly, the transition toward sustainable heat entails socio-technical challenges at the local level as it requires infrastructural changes and transformation of building stocks, and it leads up to patterns of path dependence consisting of socioeconomic elements such as income and poverty (Sovacool & Martiskainen, 2020).

Considering the importance of different social and physical characteristics of neighborhoods and the increasing role of citizens in the neighborhood approach, the question arises of how context-specificness of neighborhoods influences the citizens' attitude and role in the heat transition.

1.2. Research aim and Research question

As it is aforementioned, achieving the national target that makes the built environment 100% decarbonized by 2050 explicitly depends on the success of the neighborhood-oriented approach, which places citizens and communities at the center of the heat transition process. Therefore, this research aims to discover to what extent context-specificness of neighborhoods influences the citizens' attitude and role in the heat transition. By doing so, the heat transition process can be accelerated to reach the national targets by eliminating the barriers emerging from the local contexts of neighborhoods and taking advantage of the opportunities that exist in the process. The research questions of this research are formulated to reflect the aim of this research as follows:

How do the physical and social characteristics of neighborhoods in Nijmegen have an influence on the residents' attitudes and role in the heat transition, and what are considered barriers and opportunities to accelerate the heat transition in Nijmegen?

This main research question is subdivided into several sub-questions, each of which provides answers related to the main research question. The sub-questions are:

1. How does the social and physical environment of a neighborhood affect the citizens' attitudes and behaviors in participating/supporting/contributing/etc., to the heat transition in Nijmegen?
2. How do different characteristics of the neighborhoods have an impact on the neighborhood's community capacity for the realization of the heat transition in Nijmegen?
3. What are the existing barriers and opportunities of the heat transition in Nijmegen?

1.3. Societal relevance

Applications of research findings in real-world settings are referred to as societal relevance (Hessels et al., 2009). This research attempts to offer insight for practitioners who are in charge of policies on the topic of the local heat transition by examining the effect of local context on citizens' behaviors and attitudes. In real world-setting, this refers to municipalities that are in charge of planning and implementing sustainable heat in neighborhoods.

As it is aforementioned, achieving climate targets set by the Paris agreement and The Dutch National Climate Agreement (Klimaatakkoord in Dutch) is dependent on whether national and local policy instruments on the subject of the energy transition are sufficiently effective and efficient in practice (Vringer et al., 2021). A transition toward sustainable heat has a great potential for reducing greenhouse gas emissions. However, phasing out natural gas in residential houses brings social and technical challenges (Jansma et al., 2020). These challenges can be overcome by delving into the effect of context-specificness of neighborhoods on residents' behaviors and attitudes toward sustainable heating. Therefore, this research aims to contribute to the societal issue of global climate change and the national heat transition of the Netherlands.

On the other hand, zooming into the different social and physical characteristics of case studies will provide insight into the factors that either increase or decrease the willingness of residents to participate/support/contribute to the heat transition of Nijmegen. Choosing the five neighborhoods of Nijmegen as a case study is expected to shed light on the practices that work best for the realization of heat transition at the neighborhood level. This means that the results drawn from various case studies can be applied to other neighborhoods by Dutch municipalities. In that sense, this research aims to touch upon societal issue of local heat transition process.

1.4. Scientific Relevance

The scientific relevance of research expresses the value research can add to a specific scientific field (Hessels et al., 2009). The findings of this research would be relevant to the discussion of energy transition and, more specifically, the neighborhood-level heat transition.

Since neighborhood-oriented approaches have only recently been implemented in the heat transition in the Netherlands, there has not been much research done on how residents are affected by different local contexts of neighborhoods. Nevertheless, several research is conducted in this regard. First, some publications focus on the role of citizens in the energy transition process within the discussion of democratization of energy use such as (DellaValle & Czako, 2022), which aims to explore the journey from passive consumerism to active energy citizenship among the energy poor. Also literature focuses on the role of municipalities in the heat transition. For example, the research conducted by (Beauchampet & Walsh, 2021) try to reveal the theory and practice of citizens engagement in the heat transition from the perspective of the Dutch municipalities. Correspondingly, the research on governing capacity of Dutch municipalities in achieving gas-free neighborhoods is executed by (Vringer et al., 2021). Second, several articles published on the topic household perception of the heat transition. For example, while (Broers et al., 2019) explore Dutch home owners' decision-making process for energy-saving measures, (Sovacool et al., 2021) investigates the public attitudes of household in the heat transition of five European countries. In addition, the literature also focuses on the social acceptability of sustainable heating systems and energy efficiency measures. One of the publications is (Ebrahimigharehbaghi et al., 2019), which delve into Dutch homeowners' behaviour towards energy efficiency renovations and another research is (de Wildt et al., 2021) on social acceptance of sustainable heating systems. The literature also contains research related to the financial part of the heat transition. For example, the research of (Nava-Guerrero et al., 2021) focus on how choices made by individuals and groups in the heat transition would affect the amount of natural gas used for heating and the cost in an illustrative neighborhood in the Netherlands. Also, (Scheepers et al., 2022) aims to explore a climate-neutral energy system and their overall cost optimization in the Netherlands. Lastly, a rare publication is available on how different local contexts effects the citizens' behaviours and attitutedes toward the local heat transition. One of the research conducted in this domain is (Jansma et al., 2020), which aims to explore how the perception of homeowners and tenants differs in accordance with local context of neighborhood in the Netherlands, the research also clarifies the differences between how residents of subsidized and unsubsidized neighborhoods perceive the heat transition.

However, there is a knowledge gap in the literature on how social and physical characteristics such as citizens' age, income, home ownership status, house type, and house age affect residents' participation/support/contribution to the local heat transition. Therefore, this research aims to contribute the literature in two ways. First, strengthening the scientific discussion of the factors affecting the role of the citizen in the neighborhood-oriented heat transition by executing five neighborhoods as case studies. Second, revealing if knowing the effects of local context on residents is a useful insight to steer the local heat transition.

2. Theoretical Framework

In this chapter, an outline of the used theories and concepts will be given. Several theories and concepts serve as a guide and will be used to simplify the research. At first, the theory of transition management is introduced as the overarching framework in paragraph 2.1. Then, in paragraph 2.2, the assessment of co-creation theory is discussed to determine the factors affecting citizens' role in the heat transition process. Paragraph 2.3 will then address the genius loci of the neighborhoods concept which describes the different social and physical characteristics of neighborhoods. Subsequently, in paragraph 2.4, the theory of community capacity building is explained which will be used to understand the effect of the different social and physical characteristics of neighborhoods on the capacity of a neighborhood to achieve decarbonized built environment. Finally, in paragraph 2.5, the conceptual model is presented. This model combines the previous concepts and theories and serves as a theoretical basis for this research.

2.1. Transition Management Theory

To understand how the policy domain is structured with regard to the energy transition, it is important to know the context wherein the energy transition is placed (Stuiver, 2020). Energy systems can be classified as a socio-technical systems, which inherently contains persistent and structural problems (Kern & Smith, 2008). To deal with these challenges and to better understand changing local contexts, ideas, and developments in local heat transition, the theory of transition management by (Kemp et al., 2007) is judicious.

Transition management is a way to provide identification to 'systematic change' by aiming to influence structural change in socio-technical systems through a set of coherent policy initiatives (Kern & Smith, 2008; Shove & Walker, 2007). Kemp et al., (2007) state that any transition constitutes an evolutionary cycle that includes changes in needs, aspirations, institutions, and practices, and is part of progressive social change. Therefore, each transition requires radical changes not only in government policy but also in the functioning of the current system of governance such as society and patterns of interaction over transitions.

Multi-phase and multi-level are two models of transition management theory (Kemp et al., 2007). The multi-phase model has four stages as it can be seen in Figure 1.

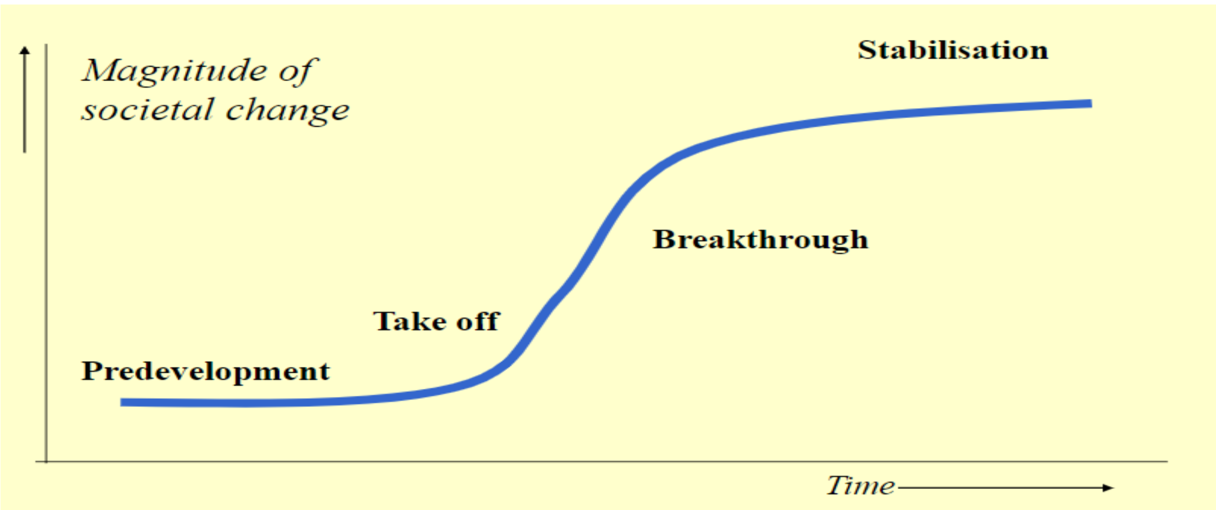


Figure 1.Transition phases of the multi-phase model (Rotmans, Kemp, van Asselt, 2001)

In this research, only the multi-phase model will be introduced as it provides the basis of the overarching concept for the heat transition. First, the predevelopment phase means minor and invisible changes in the existing system. Then, the take-off phase refers to the process where a change in the system starts to build up. Subsequently, the breakthrough or the acceleration phase is a process where rapid, visible, and structural changes occur at all levels in the existing system. Lastly, the stabilization phase refers to a new dynamic balance system reaches (Kemp et al., 2007). When we look at the heat transition from this model, the transition is in the take-off phase as it has yet to become common practice for achieving the 2050 target of the Netherlands. Therefore, it is crucial to explore how local contexts of neighborhoods affect citizens' role in the heat transition through which barriers that impede the heat transition from upgrading to the acceleration phase and the opportunities that may ease the decarbonization of the built environment can be found.

2.2. Assessment of Co-creation

As it is aforementioned, the heat transition is a highly complex societal process. Therefore, it requires intensive collaboration among the stakeholders from the state, market, and civil society (Sillak et al., 2021). Furthermore, Rutherford & Coutard, (2014) discuss that cities are not secondary entities that cannot be expected to solely contribute to one unique national or global energy transition rather cities are political arenas through which transition is invented, and implemented, enacted, and experienced in always different and specific ways. One solution to unfold the complexity of heat transition is the concept of 'co-creation' proposed by Sillak et al. (2021), through which the economic, social, psychological, technical, and political challenges of heat transition can be analyzed (Itten et al., 2021). As this research aims to focus on heat transition at the neighborhood scale, it is purposeful to use a co-creation assessment framework as a starting point wherein the factors that have an impact on the citizen's role toward sustainable heat can be detected.

The co-creation assessment framework consists of three phases: initiation, design, and implementation. In addition, the participation of 'stakeholders' and the 'activities' are evaluated to come up with 'goals and outcomes' (See figure 2).

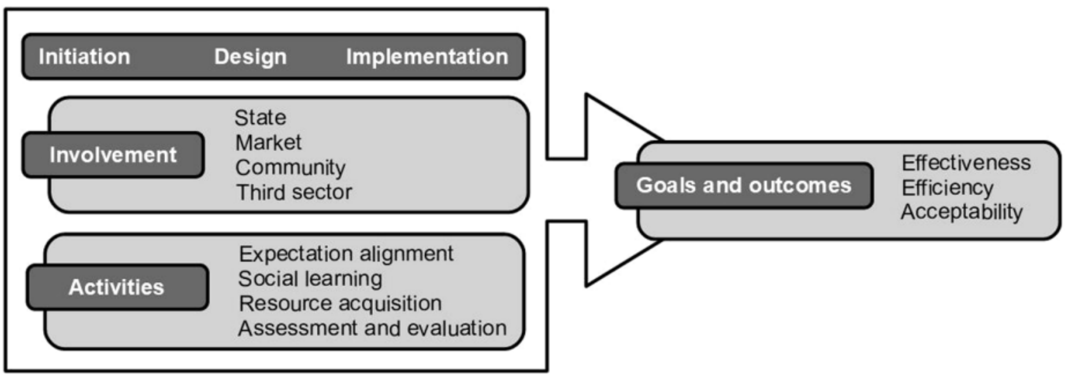


Figure 2.Framework for assessing co-creation in strategic planning for energy transitions. (Sillak et al., 2021)

2.2.1. Classification of Phases

While academic literature suggests varied classification for the phases of co-creation, this research is based on the phases introduced and classified by Sillak et al. (2021). The initiation phase refers to the basis of transition where different actors and innovative solutions come together in order to solve an unsustainable problem in the urban environment. Subsequently, the design phase is a process where different stakeholders make a vision of a plan to be implemented. Finally, the implementation phase refers to the implementation of solutions developed in the design phase (Sillak et al., 2021).

2.2.2. Actors, roles, and power relations

Co-creation is based on the concept of polycentric governance systems in which multiple, semi-autonomous stakeholders are in an effort to overcome urban challenges in a collaborative way (Carlisle & Gruby, 2019; Parks et al., n.d.). Similarly, while the governance of heat transition in the built environment progressively becomes more polycentric, government shares its responsibilities with varied stakeholders such as municipalities, homeowner associations, energy companies, and grid operators (Rodhouse et al., 2021). However, the classification of actors and their relations is as complex as the boundaries which are generally overlapped by different actors (Sillak et al., 2021). To deal with this problem, Sillak et al. (2021) use a triangled 'multi-actor perspective' proposed by (Avelino & Wittmayer, 2016). Figure 3 shows the multi-actor diagram and also demonstrates the expected actors of an energy transition, which is coherent with the heat transition.

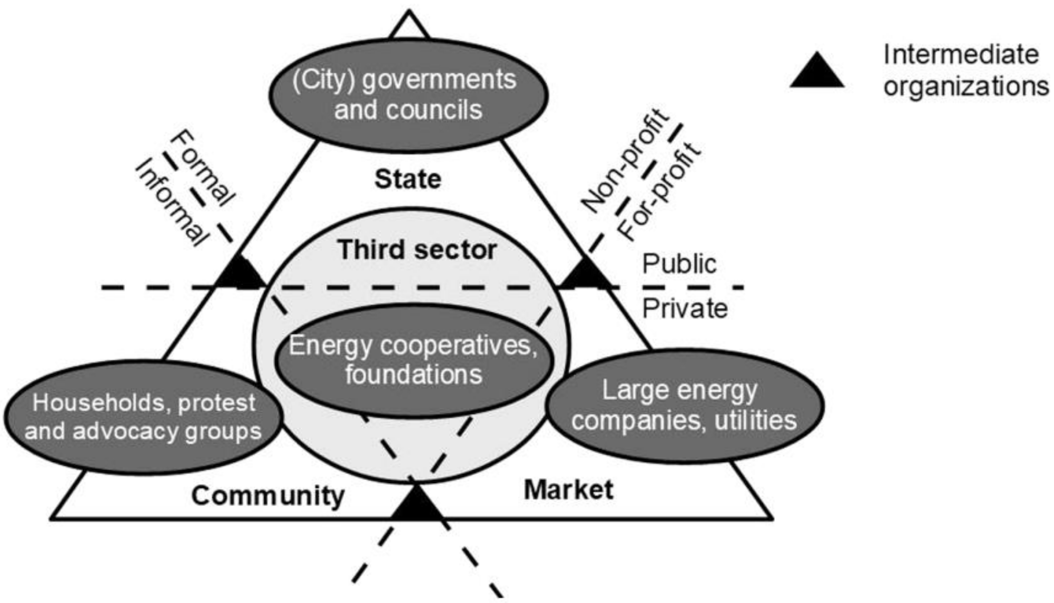


Figure 3.The classification of actor groups in co-creation and examples from the energy sector at the organizational level

Based on this classification, Sillak et al. (2021) describe four basic actor categories: 1) the state (formal, non-profit, and public); 2) the market (formal, for-profit, and private); 3) the community (informal, non-profit, and private); and 4) the third sector (formal, non-profit, and private). In addition, a variety of combined organizational forms such as public-private partnerships and state-owned companies involving state and market actors exist in the multi-level actor perspective (Sillak et al., 2021). Furthermore, Voorberg et al. (2014) discuss the concept of co-creation as a new 'social contract' where roles and powers among actors involved in a transition are likely to be interchangeable. For instance, public officials may take over civic roles and 'ordinary' citizens (community) may take over public tasks. As distinct, actors may take a role given by the other actors or purposefully bear a role and use them as a tool to steer transition in line with their own goals (Sillak et al., 2021). However, as this research focuses on the role of the residents in the local heat transition, the actors, roles, and power relation concept will only be used where the actors have an effect on the role of residents.

2.2.3. Activities that foster transformative power

The heat transition is *disruptive, contested, and non-linear* like other sociotechnical transitions (Geels et al., 2017). For example, implementing an innovative idea such as district heating entails major changes for the local market and related systems so that a resistance to change is highly likely to occur in any transition (Geels et al., 2017; Itten et al., 2021). Therefore, the co-creation process stresses the importance of transformative power that can be obtained by specific activities or preconditions to overcome the resistances composed by the changes in the system (Sillak et al., 2021). To increase the transformative power of the transition process, Sillak et al. (2021) compiles various methods and lists those which are most related. First, the expectation alignment refers to a vision shared by different stakeholders to realize change. Second, social learning is about the dissemination of information through discourses, narratives, training programs, etc., and the highly technical side of energy transition requires vigorous efforts to be understood by all stakeholders. Third, resource acquisition refers to any kind of resources such as finance and knowledge that increase transformation capacity to realize long-term goals. Lastly, the assessment and evaluation of a transition in the short and long term are needed to increase the motivation of stakeholders which, in turn, increases the transformation capacity of stakeholders (Sillak et al., 2021). How the transformative activities are applied to this research will be scrutinized in the next paragraphs. Nevertheless, transformative activities that encourage citizens' participation, support, and contribution to the process are essential for this research as these activities have a potential to affect the perception of residents toward sustainable heating within the existing conditions characterized by the local contexts.

2.2.3.1. Expectation Alignment

The heat transition as a part of the energy transition is a type of political process as it is prone to involve significant changes in technology, economy, and indeed society (Brisbois, 2019). However, communities have been marginalized within the economic paradigm that attributes citizens as ‘consumers’, ‘users’, or ‘customers’ in energy systems while they have been perceived as having limited knowledge and interest. (Beauchampet & Walsh, 2021; Coy et al., 2021). Therefore, only the voices of elite groups and those who held power have been heard rather than communities to date in energy policy domain (Sovacool & Brisbois, 2019). Despite that, politics have evolved from 'government' to 'governance' since the late 1980s in sustainable energy and environmental policies due to many reasons such as the complexity of problems and government’s limited capacity to deal with these problems (Raman, 2003; Roy et al., 2007). This transformation has led to arising of the questions of ‘humanizing’ the energy transition through looking for new ways of thinking about community participation and engagement that brings new approaches beyond traditional governance (Wahlund & Palm, 2022). As the heat transition is implemented at neighborhood level, community’s acceptance and engagement becomes more important for its success. Moreover, the household’s choice of domestic heating systems and their usage behavior makes citizens one of the key actors in the heat transition (Curtis et al., 2018). Therefore, authorities have the aim of harmonizing actors’ expectations through increasing synergy and minimizing conflicts across scales, sectors, and time to encourage diverse actors toward shared, integrated, and long-term goals. (Hölscher et al., 2019). As this research focuses on the residents’ role in the local heat transition, it is important to uncover to what extent residents’ expectations with regard to heat transition are aligned with that of other actors, and to what extent the expectation alignment is shaped through by the local context.

2.2.3.2. Social Learning

The concept of social learning refers to all activities either encouraged by the state or other actors with an aim of both fostering engagement of residents and empowering the resident's capacity to achieve sustainable heating through different kinds of activities such as neighborhood meetings, informative messages disseminated either online or in person, etc. Future decarbonization efforts may face opposition due to misinformation and myths. Therefore, it is quite important to stimulate information campaigns and increase public engagement throughout the process, which is essential to achieve the decarbonization of the built environment (Noel et al., 2019; Sovacool et al., 2021).

Activities and events in themed of the heat transition strengthen the relationship between residents and other actors because learning is experiential and supported by a range of formats and techniques that include all significant players as well as intermediaries (Bai et al., 2010). Events and activities are thus beneficial in providing a context about where residents stand with regard to the heat transition in the neighborhoods (Doggen, 2021). Correspondingly, Michelsen & Madlener (2010) argue that the knowledge of residents about energy efficiency is the main factor in determining the person's decision to switch fossil fuel-based heating systems to low carbon alternatives. Therefore, the concept of 'social learning', which has the potential to increase the willingness of the citizen to participate/support/contribute to the local heat transition process, is essential for this research since residents' participation in information sharing and the heat transition events is explicitly dependent on the local contexts that citizens live in.

2.2.3.3. Resource Acquisation

As it is aforementioned, resource acquisition refers to all resources including financial, technical knowledge, and time spent that are available for actors to realize the heat transition in practice. Financial resources are mostly decided by the national government; these resources may be the provision of funds to municipalities for heat transition, and the provision of easily accessible loans for residents for domestic energy efficiency measures (Jansma et al., 2020; Vringer et al., 2016). Jansma et al. (2020) argue that the national subsidies that some municipalities received to realize the heat transition do not only provide financial support but also flourish expectations among communities, promote professional input and increase the transformative capacity. In addition, financial resources make field experimentation possible in the neighborhoods, which provides proper conditions for developing and testing innovations (Hölscher et al., 2019). Apart from material resources (funding, space, tools), knowledge, skills, and social networks are also important types of resources that help, especially, civil society actors in accessing resources available and in equipping them to meet their expectations in the process (Wolfram, 2018). Since this research examines the effects of different social and physical characteristics that neighborhoods hold on the residents' role in the process, it is highly likely that the resources available shape citizens' role in the local heat transition process. Therefore, the concept of 'resource acquisition' is found necessary for this research.

2.2.4. Goals and Outcomes of Co-creation

As it is aforementioned before, the co-creation approach is promising in the sense that it can unlock the sustainable heating transition by providing space for local issues to be overcome (Itten et al., 2021). To do so, there are criteria identified by various academic research to measure the successes and failures of co-creation. Figure 4 shows the criteria used by Sillak et al. (2021), which are based on the earlier works of (Trencher et al., 2014), (Voorberg et al., 2014) and (Puerari et al., 2018). According to (Sillak et al., 2021), goals and outcomes of co-creative process can be classified under four main pillars: Effectiveness, efficiency, acceptability and involvement. While, effectiveness focus on the intended goals that are expected to be reflected the target results, efficiency is about whether steps to overcome challenges are taken properly. Next, acceptability refers to the degree to which the process is accepted by the community. Finally, involvement refers to all parties that have a more or less impact on the process (Sillak et al., 2021). These criteria that are employed for this research will be scrutizied in following sections.

Figure 4.The classification of the goals and outcomes of co-creation (Sillak et al., 2021)

2.2.4.1. Effectiveness

Effectiveness in co-creation concept means reflecting the intended goals into target results (Sillak et al., 2021). The co-creation is promising to contribute the society by means of delivering sustainable heating solutions in a timely and efficient way, empowering the sense of active citizenship in energy-related issues as well as helping to build trust among state, market, and civil society (Itten et al., 2020). Yet co-creation is not a remedy for all problems: Nor is it tension-free (Späth & Rohracher, 2015). Therefore, Itten et al. (2021) further suggested a set of critical considerations for a co-creation process to be more effective through which the challenges existed in either supply or demand-side of sustainable heat can be solved. As this research aims to accelerate the local heat transition by revealing the effects of local contexts on residents' role in the process, the 'effectiveness' concept is found important for this research.

2.2.4.2. Efficiency

Efficiency at the basic level refers to the fact that the steps for delivering a socio-technical challenge have been taken in the right way. In other words, the efficiency concept is mostly intertwined with an optimal solution that delivers the fastest or least expensive way possible. However, it should not be forgotten that citizen satisfaction and social acceptability are important criteria in the context of the energy transition (Sillak et al., 2021).

The success of local heat transition at the neighborhood level is explicitly dependent on the efficiency of the provisions and services delivered to neighborhoods. Mallaband & Lipson (2020) and Sovacool & Martiskainen (2020) state that people attribute strong importance to physical and financial feasibility with regard to heating choices rather than the types of heat (e.g. low carbon or fossil-based) that are delivered to their homes. This is compatible with the earlier findings that put forward people are unlikely to change their heating systems unless the more feasible option in terms of cost-efficiency appears (DECC, 2013). In detail, efficiency concepts are dealt with under two concepts in co-creation assessment theory. First, the energy efficiency measures at the neighborhood level is accepted as one of the effective instruments in achieving decarbonization of the existing building stock (Kazmi et al., 2022). Furthermore, UN (2017) stresses that the energy efficiency of old and new buildings is a very important tool for the implementation of new energy and climate policy. Second, time efficiency refers to whether the investment made in energy-related challenges such as energy-saving measures or installing sustainable heating systems will pay off within a time frame that creates maximum satisfaction among citizens. Therefore, it is essential for this research to address the feasibility and/or efficiency of heat services and provisions that are delivered to neighborhoods, which have an impact on citizens' behaviors toward sustainable heating within the local context.

2.2.4.3. Social acceptability

Acceptability in co-creation is a dynamic process of balancing and negotiating a variety of technological and social options (Fournis & Fortin, 2017). Since the neighborhood approach has been preferred in sustainable heat transition, individual and community acceptance are important for its success (Jansma et al., 2020) because citizens have the last word in their heating systems (Van Der Schoor et al., 2016). Moreover, Stern (2014) argues that citizens can implicitly influence governments and other organizations in the energy-related policy field through acceptance, acquiescence, or resistance to changes in the energy system. The heating systems as a whole can be considered as a subset of the heat transition, which constitutes a socio-technical process on its own. Therefore, this research deals with social acceptability in two phases: Social acceptance of heat transition and more particularly social acceptance of sustainable heating technologies. Furthermore, as this research focuses on the neighborhood level, it is found more logical to concentrate on micro-social acceptability rather than meso-political and macro-economic.

The social acceptance of the heat transition

Wimbadi & Djalante (2020) state that despite the urgency of heat transition to reach climate goals, the decarbonization of residential areas is one of the hardest to transform. Therefore, the community acceptance of the heat transition that takes place at the neighborhood level is of great importance for the decarbonization of households (Jansma et al., 2020). Furthermore, Sovacool et al. (2021) argue that the social acceptability of the heat transition is a key condition for a well-articulated and smooth transition. There are many factors either implicitly or explicitly that have an impact on the social acceptance level of the heat transition among residents (Jansma et al., 2020; Sovacool et al., 2021). Van der Waal et al. (2020) suggest that the contextual factors such as guidance and expertise provided by authorities can be driving factors in acceptance of the local heat transition. Similarly, the national and local subsidies are the contextual factors that might affect the level of acceptance of the heat transition. It is important to note that the subsidies not only facilitate the acceptability of the heat transition through financial motivation but also raise the expectations, concretize responsibilities, and increase the faith to transition among people (Jansma et al., 2020).

Jansma et al. (2020) separate the factors affecting the social acceptability of the heat transition into five categories: Financial aspects, knowledge and information, process-related factors, environmental concerns, and socio-demographic characteristics. First, the financial aspects are generally related to the availability of subsidies, energy-efficient measures applied to homes, and the replacement cost of heat sources. In other words, the homeowners are interested in whether their investment will pay off whereas tenants are more passionate about the energy-efficient measures to reduce energy costs. The second factor is knowledge and information that an individual's competency on energy-related issues such as policy, regulation, or the energy efficient-measures. Broers et al. (2019) argue that the positive information obtained through networks results in the more deployment of energy-efficient measures in households. The third category is about the transition-related factors including policymaking, trust in agents, and complexity of the process. Miedema et al. (2018) discuss that the lack of mandatory policy agreements between the state and other actors constitutes a significant obstacle to the social acceptability level of the heat transition. The fourth factor addresses to what extent environmental concerns of citizens are important in the social acceptability of the heat transition. Despite the public was being mostly characterized as self-interested and financially motivated concerning heat-related problems (Cherry et al., 2017), it is found that environmental concerns are significant drivers in triggering interest in energy-efficient measures (Ebrahimigharehbaghi et al., 2019). The fifth factor is about the citizen's background including age, education, gender, etc., and how these preconditions determine to what extent the heat transition is accepted among citizens. For example, older people might be more reluctant to change their heating systems due to the uncertainty about if the adoption of heat transition will pay off within the rest of their lifetime (Jansma et al., 2020; Kastner & Stern, 2015).

The social acceptance of the sustainable heating systems

There are multiple sustainable heating systems are available for residents to replace their natural gas heating. Hydrogen networks, combinations of photovoltaics, batteries, heat pumps, and, district heating are the most popular options among others (de Wildt et al., 2021). However, the acceptability of these options is strongly related to homeowners' perception of comfort, control, and personal security (Cherry et al., 2017). In addition, Hers et al. (2018) argue that another important factor related to the social acceptance of these options is the financial burden of most sustainable heating systems on households. For example, it is expected to add an average of 1000 € heating cost per year per household in the Netherlands case of replacing natural gas with sustainable heating systems. Furthermore, de Wildt et al. (2021) state that sustainable heating systems may have significant disadvantages such as the high installment cost and insufficient heat and humidity problems for households, which may result in a lack of social acceptance. Ultimately, these drawbacks may lead to social tension, energy poverty, and unfairness in energy access in society (Hast et al., 2018; Reames, 2016).

According to (de Wildt et al., 2021), two reasons stand for why social acceptance is difficult to predict when it comes to sustainable heating systems. First, the impact of a new heat system on the household is far from being certain because the suitability of a new system varies from place to place, in turn, the acceptability strongly dependent on the local characteristics of each neighborhood in terms of housing, geographic location, and existing infrastructure (Millar et al., 2019; Reames, 2016; Schilling et al., 2019; Werner, 2017). Similarly, von Wirth et al. (2018) emphasize that the spatial scale of implementation (e.g., household, neighborhood, or city level) is an important factor in the acceptance of new heating technologies because of its effect on both the local economy and the local environment. Second, it is not easy to predict household perception even though the possible impact of a certain heating system is forecasted. Consequently, inconsistency in terms of social acceptability arises between the planning and operation phases of energy systems (Eltham et al., 2008; Wolsink, 2007)

2.3. The Genius Loci of The Neighborhood

The genius loci of the neighborhood represent a physical and social aspect of a neighborhood with related to series of a practices that form the context of the transition process (Norberg-Schulz, 1979). Norberg-Schulz (1979) states that the genius loci of the neighborhood provides deep insight into the identity of the neigborhood, and thus helps to identify the capacity of a community living at the same spatial configuration. As this research takes into consideration that citizens' willingness to participate/support/contribute to the local heat transition is affected by the social and physical characteristics of the neighborhood, it is necessary to use this concept as an initial point for further analyzing the community capacities, which will be further explained in the following section. Furthermore, this research does not only concentrate on the physical aspects such as the location, configuration and articulation of the neighborhood as Norberg-Schulz (1979) suggests, but also it focuses on social aspects since the place where a person feels belong is crucial in terms of determining the place where a same person places himself/herself culturally and socially (McIntosh et al., 2004). In a nuthsell, the combination of the physical and social factors ascertains the identity of a place, which helps to understand the context of a neighborhood (Robertson et al., 2010) . In the next section, the physical and social aspects will be explained in detail.

2.3.1. Physical Aspect

In this research, several parameters are employed to examine the neighborhoods from a physical point of view. These are the house age and house type.

First, age of the houses are one of the important parameters in identifying the local contexts of a neighborhood. Oorschot (2020) argues that the quality and age of the built structures are important because these are determinative of the energy demand of households. In addition, the age of the house is an important factor in the insulation and indoor environmental quality of the house (Li et al., 2021). On the other hand, the house's age could well be an impetus for renovation because older homes frequently need renovations to increase energy efficiency and comfort levels in line with modern standards (Broers et al., 2019). Therefore, the age of built structures is necessary to better understand the local context of a neighborhood.

The housing typology is employed for this research as a second physical aspect. The type of houses in a neighborhood can vary; Detached, terraced, or flat are some of them and it is one of the factors that determine the neighborhood's physical characteristics. The housing typology influences how a house should be transformed before a new heating system is installed (van den Wijngaart et al., 2017). Besides, Oorschot (2020) states that each neighborhood has similar urban design elements and housing typology. Therefore, housing typology is found essential physical factor to understand the local context of a neighborhood.

2.3.2. Social Aspects

Social aspects basically refer to the residents sharing a common living space in the neighborhood as well as their background and the ability of these residents to act together (Doggen, 2021). Furthermore, the way residents organize and the willingness of residents to be active citizen in the heat transition are strongly determined by the social aspects of the neighborhood. Three parameters are chosen to research the social aspects of the neighborhoods. These three parameters are the age, income level and legal ownership status of the residents.

First, the energy uses and practices in residental sector are driven by various factors such as financial and economic reasons, and also by behavioural and psychological factors such as attitudes, motivations, expectations and trust (Aravena et al., 2016). However, the socio-demographic characteristics of citizens such as the age of a person are determinative in energy use and practices of households (Curtis et al., 2018). For example, Özcan et al. (2013) state that the residents over 50 are predisposed to choose natural gas, oil and electricity rather than coal and other types of solid energy sources with the motivation of comfort and health. As the age of residents are determinative in both whether a neighborhood to adopt the heat transition measures and how early transition takes place in the neighboorhood, the age of residents is found essential social factor affecting citizen’s behavior and attitudes in the heat transition.

Second, the income level of a resident is one of the important factors defining the local context of a neighborhood as the effects of economic conditions on people's behavior patterns are great. Previous researches show that the lowest income groups are less likely to make investments in any kind of energy-efficient technology (Schleich, 2019) since low-income individuals and families might lack the resources to prioritize investments with regard to energy (Beauchampet & Walsh, 2021). In addition, low-income households are more likely to live in affordable, unrenovated homes with high fuel costs (Grösche, 2010), which causes the risk of energy poverty among low-income families.

Besides, participation of lower-income people/families in the energy transition tend to be socioeconomically exclusive (Beauchampet & Walsh, 2021; Radtke, 2014). On the contrary, Lennon et al. (2019) argue that people from lower socioeconomic status have historically benefited more from commercial forms of community energy because they are more connected. In parallel, Hansen et al. (2014) state that low-income neighborhoods have strong social capital, as well as a network of ties between family and friends. Hence, the income level of residents is found crucial for this research as it is determinative of the social context of a neighborhood in the heat transition process.

Third, the legal ownership can be in three version: Owner-occupants, a tenant from private landlord and the tenant from housing corporation. van den Wijngaart et al. (2017) discuss that the type of legal ownership influences the way to what extent residents have complete power over the changes in the house. Furthermore, owner-occupant residents are expected to take action and invest money for the transition by themselves whereas tenants have less power and rely on their housing corporation or landlord/lady to take action. (Jansma et al., 2020). Although the tenant may seem like the least powerful stakeholder in the transition, the housing company or the landlord/lady must have the approval of at least 70% of the residents to renovate their property in the Netherlands (Rijksoverheid (Dutch National Government), 2008). For these reasons, the legal ownership status of residents is found important to understand the social context of a neighborhood.

2.4. Community Capacity Building

To better understand the role of individuals and communities in neighborhood-oriented local heat transition, the theory of 'community capacity building' is needed. Before explaining this theory, a critical note is required about its usefulness for this research. The theory of community capacity building is designed to study grassroot initiatives and their ability to act on sustainability related issues (Middlemiss & Parrish, 2010). Rather, this research focuses on the capacities that enable neighborhoods to realize the heat transition. The neighborhood level does not solely refer to community initiatives, rather refers to political arena's where infrastructural, technological, and economic heat solutions could establish a form of democratic legitimacy by enabling trust, transparency, and accountability (Hendricks 2008; Rodhouse et al., 2021) Since the theory of community building capacity is geared toward the capacities of grassroot initiative, it does not precisely fit this research. However, this theory is used in this research because of two reasons. At first, this theory is based on two premises that the capacity to change depends on the nature of the social context and that of the agent (individual or community), which in turn will result in different capacities for each agent in matters of sustainability (Middlemiss & Parrish, 2010). Similarly, the heat transition of the built environment has a low capacity to change due to the fact that the structure of household heat consumption is often embodied in both existing long-lived infrastructures and social practices (A. R. Hansen, 2016, 2018). Therefore, having depth knowledge of community capacities in a neighborhood, which are highly dependent on the social context of place and that of the agent in the case of local heat transition could help to better understand the influence of local contexts on residents' attitudes and roles in the heat transition. Second, the framework provided by Middlemiss & Parrish (2010) is very useful for identifying local community capacities, which makes it suitable for the neighborhood level where the real transformation takes place and where communities play important role in the transition.

Middlemiss & Parrish (2010) shed light on the interaction between grassroot action and community capacity by providing a framework offering four different community capacities acting as either enabling or impeding factors in the process that grassroot initiatives take a role to enhance sustainable development at the local level. The community's responsibility for its ecological footprint is located at the center of the theory as it can be seen in figure 5 and is interlinked to the personal, cultural, organizational and, infrastructural capacities of the community. The stronger the capacities are in a community, the ability of a community to fulfill responsibility for the ecological footprint becomes greater whereas another way around is also possible (Middlemiss & Parrish, 2010). In the following sub-paragraphs, the four capacities introduced by Middlemiss & Parrish (2010) will be explained and enriched by various concepts related with each capacity to make the framework more compatible with this research.

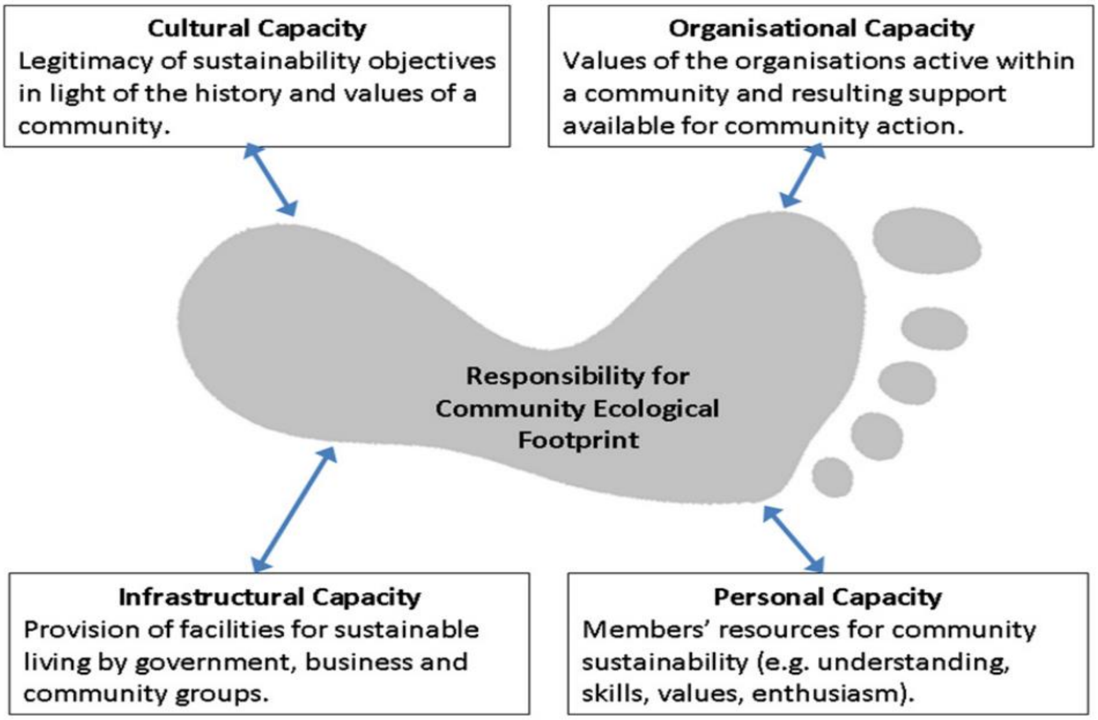


Figure 5.Theoretical framework for understanding the role of community capacity in enabling responsibility for community ecological footprint (Middlemiss & Parrish, 2010)

2.4.1. Personal Capacity

According to Middlemiss & Parrish (2010), personal capacity indicates the resources held by individuals taking an active role in sustainability issues. These resources range from the individual's understanding of sustainability issues to enthusiasm and values as well as the skills that enable the community to act on sustainability-related problems. These personal resources are highly dependent on the socio-economic situation of citizens and that are determined by the factors such as income, gender education, and professional position (Van Eijk & Steen, 2015; Voorberg et al., 2014) For example, individuals whose income level is higher are more likely to invest in sustainability related problems. In addition, the level of education is also important driver for citizens to be able to act on sustainable issue because the higher educated citizens are more likely to be aware of their needs and of collective problems (Jager, 2006). Paradoxically, energy politics and practice commonly do not attach sufficient importance to the public and its capacity. Furthermore, citizens are perceived as having limited knowledge or interest despite the fact that they have both the capacity and the willingness to participate in the energy transition according to literature (Devine-Wright, 2007; Mah et al., 2012). Therefore, it is crucial for this research to identify personal capacities of residents in the heat transition of Nijmegen and to explore how different socio-economic backgrounds of neighborhoods entails diverse personal capacities in each neighborhood.

2.4.2. Infrastructural Capacity

According to Middlemiss & Parrish (2010), infrastructural capacity refers to existing facilities available in the community that either enables or hinders the potential of the community for sustainable living. Existing housing stock, transportation, energy services, or communications are examples of such infrastructures. The move to alternative heat sources and infrastructures in the built environment is currently known as the heat transition (Scholte et al., 2020). However, the heat transition is path-dependent on the current use of gas and the existing energy infrastructure, which makes it more challenging for new technologies to succeed since the previous decision to use a gas network continues to shape the system for a very long period (Correljé, 2011). Moreover, there are many factors that have an impact on the determination of the heat system and therefore its infrastructure in the neighborhoods. Beauchampet & Walsh (2021) list factors in their research as follows; the number of newly built buildings, the density of high-rise buildings, the number of social/corporation houses in the neighborhood, the homogeneity of the houses in the neighborhood, etc. Correspondingly, Curtis et al. (2018) found that the proximity to the energy resource and the availability of alternative heating systems play a significant role in determining the fuel choice in the heat transition. To summarize, the infrastructural capacity of a neighborhood is an essential part that determines neighborhood's success toward sustainable heating. Thus, infrastructure capacity was deemed essential for this research as it has potential to reflect neighborhoods' physical characteristics.

2.4.3. Organizational Capacity

The organizational capacity of a community means to the values that hold by (in)formal organizations that are active in the community. It is matter to what extent values are aligned with the sustainability objectives of the community and the degree to which communities are supported by these (in)formal organizations to stimulate change (Middlemiss & Parrish, 2010). The community-based organizations are in overall control of resident recruitment, neighborhood education regarding potential heat-related action, identification of municipal and community partners for participation in workshops, selection of the workshop locations, input and approval of workshop agendas, and the beginning of demonstration projects (Guardaro et al., 2020). However, residents in some neighborhoods are unable to act collectively and promote energy efficiency measures because there is less trust and fewer networks among neighbors (bonding social capital) and less meaningful contact with decision makers (bridging social capital) (Harlan et al., 2007). The importance of social capital in neighborhoods were emphasized by Putnam (2000) in his book 'Bowling alone: The collapse and revival of American community'. He stated that the ability to bridge and connect social capital increases the capacity of neighborhoods by positioning them to take collective action toward sustainability challenges. The organizational capacities of the neighborhoods differ according to the physical and social characteristics of each neighborhood. For example, according to Hansen et al. (2014), an extensive family and friend network, or substantial social capital, can be found in low-income and immigrant neighborhoods. Correspondingly, Uyterlinde & Gastkemper (2018) state that while there are many volunteers willing to help out with one-time events in specific neighborhoods, there are very few residents who are able to plan events or assume responsibility over an extended period of time. It was noted that a person's social network, which is frequently exposed in particular neighborhoods, is also a source of strength for that person to participate in collective action (Uyterlinde & Gastkemper, 2018). Therefore, in this study, it was found important to measure the organizational capacities of neighborhoods, as it is one of the factors that can determine the course of the ongoing heat transition in the neighborhoods.

2.4.4. Social-Cultural Capacity

The cultural capacity of a community is a kind of objective of a community that makes sustainability legitimate based on a community's history and values. The way how a community perceives sustainability and which ways sustainability is framed within a culture is the focus of cultural capacity (Middlemiss & Parrish, 2010). A key determinant of the energy transition's success is how communities typically perceive and handle the problems brought on by the energy transition (Johnson & Hall, 2014). Thus, energy-related problems including the heat transition should be taken into consideration more comprehensively and comparative as it is embedded in our culture (Korjonen-Kuusipuro et al., 2017). Furthermore, according to (Kalkbrenner & Roosen, 2016), it has been discovered that willingness to take part in community energy projects is closely correlated with social norms, trust, and environmental concerns. On the other hand, Rodhouse et al. (2021) discuss that people's opinions on natural gas are not particularly based on pro-environmental behaviors and communities are so accustomed to natural gas, in other words, natural gas is so thoroughly ingrained in our culture. Correspondingly, recent research has highlighted the significance of social networks, fashion, habitual behaviors, and cultural norms in domestic energy use for residents because people's options and choices are shaped and limited by the physical, social, cultural, and institutional settings (Owens & Driffill, 2008). Furthermore, (Dabrowska & Fiegenbaum, 2014) emphasize that cultures play a role in establishing patterns when it comes to novelty and knowledge transfer and point out that culture impacts preferences, expectations, and behaviors, such as those related to risk and trust. As this research looks for different patterns and motives that neighborhoods develop to respond to sustainability challenges, detecting the cultural capacity of neighborhoods may help to better understand the background of social characteristics of neighborhoods.

2.5. Conceptual Framework

The theories and concepts that will be used in this research were explained and specified in the previous section. The visual representation of the conceptual framework (see figure 6) consists of the theory of transition management, the co-creation assessment, and the theory of community capacity building in order to generate a workable overview for this research.

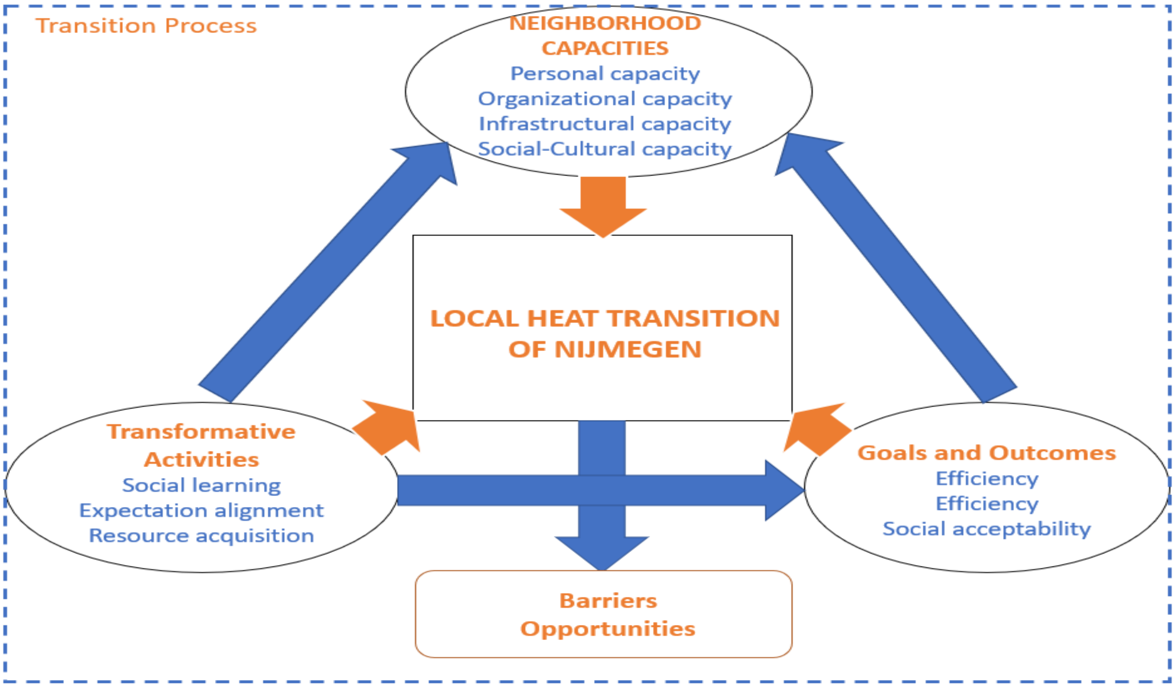


Figure 6.Conceptual model

The theory of transition management represents the entire process where other approaches and theories are placed. It is inevitable for the system to adopt the changes arising from the neighborhood capacities, transformative activities, and goal-outcomes factors in the heat transition process of Nijmegen. Thus, the dotted box labeled "transition process" in the conceptual model for transition management simply demonstrates how the other theories and concepts are the variables that can impede or accelerate Nijmegen's heat transition. Since the further application of the transition management theory would fall outside the scope of this study, the use of the theory is thus limited in this research and conceptual framework.

The central concept of this study is the effect of the social and physical characteristics of neighborhoods on the heat transition process of Nijmegen. As it is aforementioned, the heat transition of Nijmegen is dependent on various factors. Three pillars that determine the success of the local heat transition are derived from the theories mentioned in the previous chapter and are operationalized by being evaluated based on the different physical and social characteristics of neighborhoods. These three pillars are the capacities of neighborhoods, transformative activities, and goals and outcomes.

First, the neighborhood capacities focus on the ability of the neighborhood to perform heat transition in accordance with its physical and social characteristics. Four different types of sub-capacity are identified in this research: Organizational capacity, infrastructural capacity, personal capacity, and social-cultural capacity. Each of these sub-capacities represents what a neighborhood needs for the realization of heat transition and is open to change based on the change of the other two factors.

Second, the transformative activities, represents the activities, reforms, or political steps that have the potential to change the attitudes and behaviors of citizens in heat transition, and therefore can increase or decrease the capacity of neighborhoods with their presence or absence, while also directing the goals and outcomes of the heat transition process in Nijmegen. Three key indicators representing transformative activities were used in this research: Social learning, expectation alignment, and resource acquisation.

Third, the goals and outcomes represent why, how, and under what conditions the citizens put the transition process into practice and consist of three sub-topics: Effectiveness, efficiency, and social acceptability. Although the third pillar can directly affect the capacity of neighborhoods in heat transition, it changes depending on the transformative activities that exist in the process.

Lastly, the barriers and opportunities that can slow down or accelerate the Nijmegen heat transition that arises due to all three pillars are placed at the bottom of the model. In summary, the conceptual model formed in this research will help to address how the local contexts of neighborhoods influence residents' attitudes and roles in the heat transition process, as well as the existing barriers and opportunities the process embodies. On the other hand, it is worthwhile to note that actors, roles, and relationships were not included in the model as the other actors are independent of the different social and physical characteristics of the neighborhoods.

3. Methodology

The methodology employed to conduct this research is described in the following chapter. First, the research paradigm is explained in paragraph 3.1. Then, the research design is addressed in paragraph 3.2. Subsequently, the research methods are elaborated in paragraph 3.3. In paragraph 3.4, the case selection criteria are described, and the selected cases are introduced. Paragraph 3.5 clarify how the data is collected. Then, how data is analyzed elaborated in paragraph 3.6. Lastly, the validity and reliability of research are represented.

3.1. Research Paradigm

The research paradigm and the research design are the two pillars on which the research strategy is built (Guba & Lincoln, 1994) First, a research paradigm can be described as “a set of basic beliefs (or metaphysics) that deals with ultimates or first principles. It represents a worldview that defines, for its holder, the nature of the world.” (Guba & Lincoln, 1994, pp.107). A research paradigm can be distinguished based on several philosophical perspective listed as ontological, epistemological, and methodological. Ontology and epistemology form the cornerstone of multiple research paradigms (Brymen, 2012). In ontology, the researcher explores the nature and forms of reality, whereas, in epistemology, they look at how knowledge is acquired, and how it spreads among people (Rehman & Alharthi, 2016). Given that both dimensions are interconnected, a theory of what can be known about reality already tends to lead to a particular relationship between researcher and reality. As this research aims to explore how different social and physical characteristics of neighborhoods have an impact on the heat transition process from the perspective of residents, the constructivist approach is employed. Constructivism is built upon the relativist ontology, which argues that there are various realities, each of which is depending on how particular people and groups uniquely perceive it (Guba & Lincoln, 1994). In addition, constructivist research is person-centered, uncovering people’s values, ideas, and knowledge that shape how they perceive the world (Brown, 2003; Kolkman et al., 2007) Therefore, personal characteristics such as emotions, cultural background, social norms, and experience are given greater importance in constructivist methods (Moon & Blackman, 2014). In light of this, the research is framed by many constructed notions of reality that the researcher interprets within his own framework (Guba & Lincoln, 1994).

Constructivism is compatible with this study due to several reasons. First, residents living in different neighborhoods develop different social constructs on heat transition due to the diverse social and physical characteristics of each neighborhood, which allows multiple observable realities to occur in the heat transition process. Second, The Dutch heat transition program is implemented on the neighborhood/district level, necessitating the use of various strategies for each neighborhood. For this reason, residents living in each neighborhood are supposed to create particular social constructs about the heat transition. Lastly, because the information to be obtained from the multiple case study comes to the researcher gradually and is shaped by the researcher’s framework, it aligns with the constructivist method.

3.2. Research Design

Explorative case study approach has been chosen for this research. Explorative research investigates a topic where little or no knowledge is available (Thiel, 2014). How the physical and social characteristics of neighborhoods affect residents' experiences, feelings, and thoughts about heat transition is an area where little or no information is available for this research. To fill this information gap, a procedure of “mixing” both quantitative and qualitative research design has been chosen. To elaborate, this research answers the research question by employing multiple case studies, which will be discussed in detail in the next section. The case study research is mostly accepted as qualitative inquiry (Huberman & Miles, 2002) as it bases on interpretation by definition (Gaber & Gaber, 2007). However, this research also uses quantitative methods in the sense that it does not only rely on the understanding, interpretation, and observation, but also on statistics or numbers (Ghauri et al., 1995) to better understand various pathways behind the different characteristics of the neighborhoods. Hence, this research is qualitative research that utilizes quantitative research instruments to supplement the research.

On the other hand, as it is aforementioned, multiple cases are chosen to demonstrate the diverse physical and social characteristics of each neighborhood. The same standards found in theories and articles as described above are applied to the analysis of every case. The cases will be defined, examined and analyzed in accordance with the predefined aspects of the conceptual model. In that way, researcher ensures that the practical application of a concept is equivalent to empirical research in which it is explored. In this context, this research is a deductive study as it hypothesizes that different physical and social characteristics of different neighborhoods affect the resident's and neighborhoods' capacities in the realization of the heat transition and aims to test it with an operationalized conceptual model. Compared to an inductive approach, a deductive research structure offers more guidance. In a deductive study, all of the procedures that will be conducted during the course of the research are predetermined. The purpose of the research—namely, to test a theoretical explanation—is also obvious from the outset. This is why a deductive study is frequently regarded as the more practical choice. Such assurances are not provided by inductive research (Thiel, 2014)

The research strategy is split into six phases (see figure 7). In the first phase, the literature and policy documents related to the neighborhood approach used in the heat transition as well as the heat transition itself were examined. The desk research has served as the scientific background to establish the hypothesis to be tested in the research. In the second phase, the theoretical framework that makes it possible to test the hypothesis was developed to establish a conceptual framework. In the third phase, multiple cases have been chosen to enable the hypothesis to be tested in the field. Then, a survey was carried out in the fourth phase and the accuracy of the research data was further increased by conducting interviews with experts. Next, the hypothesis was tested in the fifth stage through the analysis of the survey and interview data. Finally, the analyzed data are presented in the result section, the validity of the hypothesis is discussed in the conclusion section, and the discussion section compares the outcomes with conclusions drawn from the academic literature in the sixth phase.

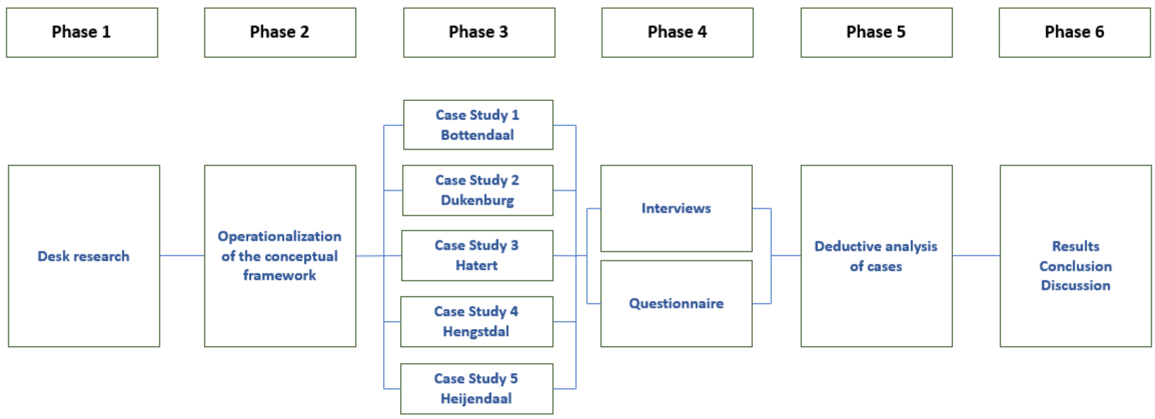


Figure 7.Research design

3.3. Research Method

The primary method of this research is a case study analysis. A case study analysis is a technique that can be used to investigate actual conditions through collecting comprehensive data (Creswell, 2013). In addition, a case-studies are mostly preferred when the aim of the research is to get an insight into how something is and why it is that way (Creswell, 2013). Thus, the case study research design is often employed in explorative studies (Saunders et al., 2009), as in this research. On the other hand, Yin (2009) states that a case study can consist of either a single study or multiple studies. As this research aims to explore different local contexts of neighborhoods, it is logical to pick multiple case studies for this research. In addition, Baxter & Jack (2010) assert that the evidence produced by a multiple case study is solid and trustworthy. As it is aforementioned, the main aim of the case study research is to conduct an in-depth analysis of the problem, and to understand the problem from the perspective of participants (Harrison et al., 2017). The multiple case study is found necessary to answer the main research question of this research.

3.4. Case Selection

In this research, multiple cases have been chosen heterogeneously to make possible to compare different pysical and social characteristics of neighborhoods. In a heterogeneous design, the researcher can compare multiple cases to attempt and determine the impact of the variation in some key variables. The researcher should ideally be aware of the appropriate independent variables in advance in order to choose contrasting cases that are sufficiently different from one another (Thiel, 2014) In addition, the cases that are employed for academic research should not be selected randomly but based on their characteristics (Creswell, 2013). Therefore, each neighborhood was selected on the basis of several criteria for this research as it is listed below,

-The ages of buildings,

-Landlord and tenant ratio of residences

-House number and typology (family housing, student housing, public buildings, etc.,)

-Income level

-Availability of data

To identify cases by criteria, several areas of Nijmegen are particularly selected in order to further demarcate the research. In should not be forgotten that newly constructed neighborhoods in Nijmegen, Waalsprong, and Waalfront, did not involve in the selection as new buildings constructed after 2018 are prohibited to have a gas connection. In addition, the municipality of Nijmegen has taken a “neighborhood-approach,” whereby each neighborhood will eventually take off the gas (Stuiver, 2020). Five neighborhoods in Nijmegen were selected as frontrunners in order to get this process in motion; Bottendaal, Dukenburg, Hatert, Hengstal and Station Heijendaal (Gemeente Nijmegen, 2018). The map below depicts these neighborhoods (see figure 8). The existing and projected heat networks are also depicted on this map as a black line and a dot, respectively.

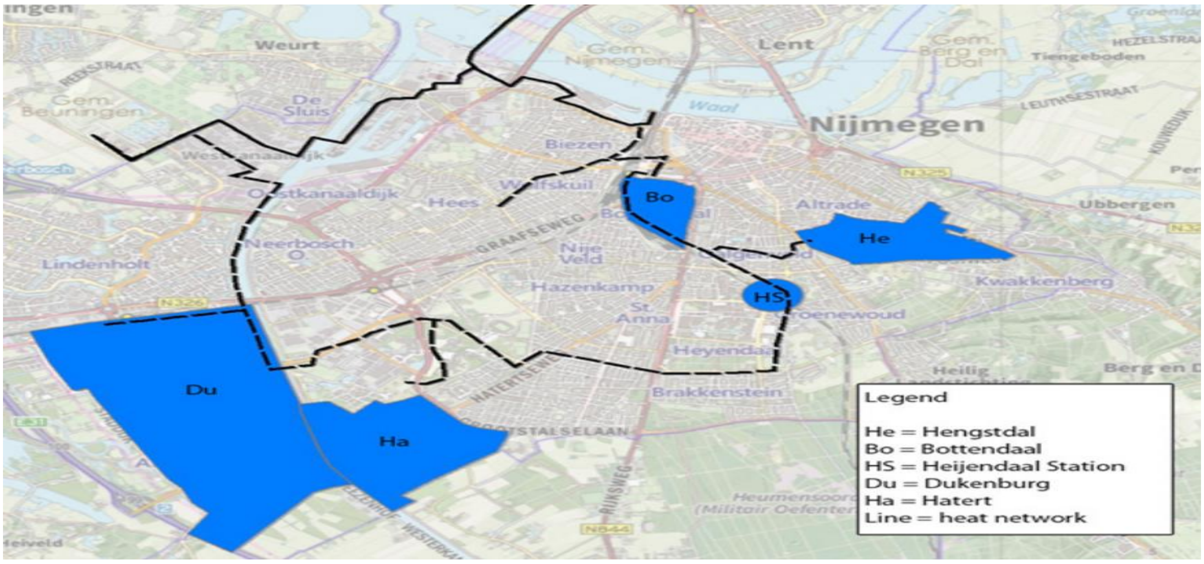


Figure 8.Selection of the case studies based on (Gemeente Nijmegen, 2018; Stuiver, 2020)

Considering one of the selection criteria above, the availability of data, it would be appropriate to exclude neighborhoods other than the five neighborhoods where heat transition has already started. Furthermore, according to heat vision of the municipality of Nijmegen heat vision (Warmtevisie in Dutch), these five neighborhoods are expected to be gas-free by 2035 (Gemeente Nijmegen, 2018). Thus, the parameters of five neighborhoods are listed in accordance with the aforementioned selection criteria (see table 1). However, further exploration of the five neighborhoods is necessary for this research to conceptualize each neighborhood's physical and social characteristics.

Neighborhood	Building age	The number of house and housing type	Homeowner-tenant ratio	Income level (avarage)
Dukenburg	Varied building age, mostly 1960-1970s	-2400 houses -Various, mostly, high-rise buildings	34% homeowner 8% tenant of private property 57% tenant of housing assoc.	€22000 /per year
Hengstdal	Various, mostly prewar	-3500 houses -Various, mostly high-rise and family buildings	35% homeowner 9% tanant of private property 56% tenant of housing assoc.	€26900 /per year
Bottendaal	Various, mostly prewar	-2194 houses -Various house type	36% homeowner 30% tenant of private property 34% tenant of housing assoc.	€26500 /per year
Hatert	Prowar, mostly 1950-1970s	-4900 houses -various, dense populated (%52)	23% homeowner 18% tenant of private property 59% tenant of housing assoc.	€20100 /per year
Heijendaal	Mostly 1990-2005	-1200 houses -mostly student houses	29% homeowner 14% tenant of private property 57% tenant of housing assoc.	€27700/per year

Table 1.Selected cases and the features of neighborhoods based on selection criteria (AlleCijfers, 2022a; Gemeente Nijmegen, 2018)

3.4.1. Bottendaal

Bottendaal is one of two neighborhoods that has an action plan on heat transition (the other is Hengstdal) (Gemeente Nijmegen, 2018). The residents, Talis Housing Association, Liander Network Manager, and Nijmegen Municipality all collaborated in the emergence of this action plan. In addition to this, the expert agency is tasked by the municipality to provide energy advice in accordance with the housing type of residents in the neighborhood (Gemeente Nijmegen, 2022). Various housing types can be found in Bottendaal, and because they were constructed over a long period of time, the neighborhood is familiar with both high-rise structures and family houses (Stuiver, 2020). More spesifically, most of the houses in the district date from the late 19th and early 20th centuries (see figure 9)(Gemeente Nijmegen, 2018), which necessitates an enormous insulation task for houses before any solution is implemented.

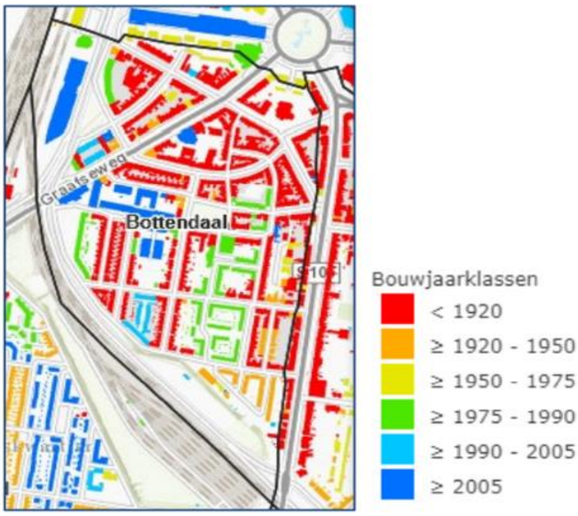


Figure 9.Building ages in Bottendaal (Gemeente Nijmegen, 2018)

Considering the variety of house type and age, various approaches are needed for the realization of the heat transition in the neighborhood. The heat network is proposed by the municipality as a solution for part of the neighborhood since the proposed heat network is pass through the neighborhood. However, small-scale scale solutions are not suitable due to the fact that Bottendaal has a protected landscape (Gemeente Nijmegen, 2018). Hence, The Bottendaal district heating plan prepared by Bottendaal project group Natural gas-free (projectgroep Bottendaal Aardgasvrij in Dutch) was approved by the municipality on 19 May, 2021 (Gemeente Nijmegen, 2022).

On the other hand, the social characteristics of Bottendaal should also be examined. Bottendaal residents are engaged in improving the sustainability of their homes and streets by taking an active role in neighborhood associations (Gemeente Nijmegen, 2018). One of the active neighborhood organizations in Bottendaal is 'Residents Organization Bottendaal' (Bewoners Organisatie Bottendaal in Dutch), whose main focus can be described as to improve the quality of life in Bottendaal.(kaynak BOB) More specifically, 'Green Bottendaal (BottendaalGroen in Dutch) is a group of residents interested in sustainability and the energy transition. This group organizes information meetings on topics such as energy saving and home isolation, where Bottendaal residents can have direct personal contact with the representatives of other important stakeholders of the heat transition (Nieuwsbrief nr.12, 2022). Another service they provide on the heat transition is that they offer Bottendaal residents the opportunity to detect heat leaks in their homes with thermal heat cameras.

Putting all that aside, the municipality of Nijmegen is the main executive institution in the heat transition of Bottendaal as it carry out many different tasks to achieve gas-free Bottendaal by 2035. Some of the important roles the municipality takes for the heat transition of Bottendaal are being investor, collaborator, mediator, facilitator, plan-maker, implementer., etc. Furthermore, the municipality of Nijmegen aims to keep residents informed about the heat transition by publishing the Newsletter Bottendaal Natural Gas Free (Nieuwsbrief Bottendaal Aardgasvrij in Dutch) digitally at most once every 2 months (Gemeente Nijmegen, 2022). According to the newsletters, the municipality provides the following services to realize heat transition in Bottendaal;

-Neighborhood workshop, where residents share their ideas and opinions. (1st Newsletter)

-Energy scan in houses (1st Newsletter)

-Consultation service about energy saving and insulation (2st Newsletter)

-Joint purchaising campaign for solar panels and the insulation of walls and floors (3st Newsletter)

-Digital meeting with residents to discuss the district heating plan (4st Newsletter)

-Online district safari to observe the heat stress in the neighborhood (6st Newsletter)

-Energy saving reports (7st Newsletter)

-Information evenings fabout insulation and saving energy (8st Newsletter)

-Information evening for tenants about insuation and saving energy (9st Newsletter)

-Energy coach services for ones to need help with energy saving (11st Newsletter)

-Energy allowance to support low income families (13st Newsletter)

3.4.2. Dukenburg

The Dukenburg district consists of the districts of Zwanenveld, Tolhuis, Lankforst, Meijhorst, Aldenhof, Malvert and Weezenhof, making the heat transition of Dukenburg the biggest project in Nijmegen. The Dutch government has chosen Dukenburg as one of the 27 experimental neighborhoods that will receive assistance from the government to take off the gas (Stuiver, 2020). Along with the other 26 neighborhoods, Dukenburg serves as a neighborhood where a variety of sustainable solutions can be tested in order to later be scaled up to other neighborhoods in the Netherlands (Ministry of the Interior and Kingdom Relations of the Netherlands, 2019). Since the most of the buildings in Dukenburg were built between the 1950s-1960, majority of the houses' overall insulation scores fall into the B and C, making them unsufficient in terms of insulation level (see figure 10). Studies have revealed that due to the presence of compact and high-rise buildings in Dukeburg, the neighborhood needs a collective heating solution such as a heat network. (Gemeente Nijmegen, 2018). It should be noted that only draft district heating plans for the Zwanenveld and Lankforst districts have been approved so far. No information was found about the rest of the districts in Dukenburg.

Figure 10.Building ages in Dukenburg and Hatert (Gemeente Nijmegen, 2018)

On social aspect, Dukenburg ranks one of the lowest in terms of average annual gross personal income compared to other neighborhoods in Nijmegen. In addition, more than half of citizens (56%) are tenants of housing corporations (AllCharts.info, 2022). For this reasons, Dukenburg's heat transition is required unique strategy that not only the infrastructural but also social problems like loneliness, poverty and an unhealthy lifestyle should be dealt with (Gemeente Nijmegen, 2018). On the other hand, no local groups engaged in addressing energy-related issues were discovered. In this context, the municipality of Nijmegen, as it does in Bottendaal, publishes a bimonthly magazine with the theme of heat transition and provides residents with information & inspiration through the Sustainable Living Center (Duurzaam Wonen Centrum in Dutch) (Winkelcentrum Dukenburg, 2022).

3.4.3. Hatert

As Nijmegen's most populous neighborhood, Hatert is primarily made up of homogeneous houses that date back to the 1960s (see figure 10). Since the houses are often stacked and homogenous and the neighborhood is close to the Goffert industrial area, a heat network would be promising in the heat transition of Hatert (Gemeente Nijmegen, 2018). However, It is unknown if the heat network expansion will connect to Hatert. Therefore, another option is to set up a local heat network (Stuiver, 2020). As it is stated in the heat vision document, there is surface water adjacent to every district in Dukenburg, Hatert, Goffert, and Neerbosch-Oost, which can be a source for a heat network in these neighborhoods (Gemeente Nijmegen, 2018). However, According to the study named ‘’A warm Nijmegen’’ (‘’Een warm Nijmegen’’ in Dutch) conducted by (CE Delft, 2016), the most suitable heat plan that fits Hatert is possible with all-electric solution.

From a social aspect, Hatert has one of the lowest average annual gross personal incomes (€20.800) among the neighborhoods of Nijmegen. In addition, almost five out of three residents are tenants from housing corporations (AlleCijfers, 2022). Hatert encounters some of the same social problems as Dukenburg. When enhancing the built environment's sustainability, the municipality plans to tackle these issues as well (Stuiver, 2020). Beside, there is an active neighborhood association in Hatert named Sustainable Hees (Duurzaam Hees in Dutch) whose aim is make Hatert more sustainable in terms of energy and energy saving. To achieve this, Sustainable Hees cooperates with actors such as Vereniging Dorpsbelang Hees, the municipality of Nijmegen, Power2Nijmegen and Buurkracht, while providing information meetings, campaigns for house isolation and solar panels, and digital application services for energy saving (Duurzaam Hees, 2022). Apart from SmartLiving App (SlimWonen App in Dutch), informative application on energy saving, no other services provided by the municipality for the heat transition of Hatert could be found.

3.4.4. Hengstdal

Hengstdal is part of the “Green Deal natural gas-free neighbourhoods” (“Green Deal aardgasvrije wijken” in Dutch) at national level and “District of the future” (“Wijk van de toekomst” in Dutch) program of the Gelders Energy Agreement (GEA) at regional level. In addition, Hengstdal, together with Zwanenveld and Bottendaal, has been selected as a pilot neighborhood by the municipality of Nijmegen to gather knowledge about house types and suitable heat solutions (Gemeente Nijmegen, 2018). While the ages of the buildings vary in Hengstdal, the energy labels of the houses provided by (Energie Atlas, 2018) can be seen in figure 11. According to (WoonConnect, 2017), the average energy label in Hengstdal is E, which requires an enormous insulation task for Hengstdal before any heat solution is implemented.

Figure 11. The energy label of houses in Hengstdal (Energie Atlas, 2018; Pak, 2018)

Correspondingly, In Hengstdal, the availability of a wide range of housing types allows for both the designation of eligible regions (spanned) for small-scale low-temperature heat networks as well as all-electric heating solutions (Gemeente Nijmegen, 2018). In this context, the Neighborhood Energy System (Buurt Energiesysteem (BES) in Dutch) project as a part of the prepared district heating plan for Hengstdal has received a government grant from the Ministry of the Interior and Kingdom Affairs(Gemeente Nijmegen, 2022). The Neighborhood Energy System is a collective, novel approach being used in the Netherlands to make existing neighborhoods gas-free without causing far-reaching interventions on the homes (Duurzaam Hengstdal, 2022b).

On social aspect, Hengstdal's average income per capita (€27,400) is slightly above the avarage of Nijmegen. In addition, tenants from housing corporations accommodate in fifty-six percent of the houses in the neighborhood (AlleCijfers, 2022b). Beside, a local group called Duurzaam Hengstdal is an active neighborhood organization taking care of Hengstdal's problems with regard to sustainability and energy. The projects and services provided by Duurzaam Hengstal concerning on the heat transition of Hengstal are listed below (Duurzaam Hengstdal, 2022a) ;

- Investigation of Neighborhood Energy System with the municipality of Nijmegen, housing corporation Woongaat and Alliander.

- Information evenings about insulation and energy saving

- Heat scan control

- Blower door test

- Campaign for central boiler (CV) optimization

- Publishing newsletter

The municipality of Nijmegen is also active in the transtion ongoing in Hengstdal. The municipality informs residents with its energy advice service and a digital newsletter published every month (Gemeente Nijmegen, 2022).

3.4.5. Heijendaal

Heijendaal is a neighborhood with few residences and home to Radboud and Han universities. The municipality of Nijmegen included Heijendaal Station (Stationsgebeid Heijendaal) in its natural gas-free program due to the Radboud Medical Centre's need for too much energy, which is unsustainable. As it can be seen at the figure 12, Heijendaal has great potential for a collective heat network due to its proximity to the intended heat network of the municipality (Gemeente Nijmegen, 2018).

Figure 12.Potential heat network in Heijendaal(Gemeente Nijmegen, 2018)

As it is aforementioned, there are fewer houses in Heijendaal compared to other neighborhoods in Nijmegen and most of these houses were built in 1980 and later. The fact that the buildings are relatively young may provide an advantage in terms of requiring less insulation for houses in the heat transition of Heijendaal.

From the social perspective, Heijendaal's average per capita income is above Nijmegen's average and the majority of its residents (65%) are between the ages of 15-45. No active neighborhood association involve in energy-related problems was found. In parallel, no current advancement of the heat transition of Station Heijendaal was found in municipal sources.

3.5. Data Collection

As it is aforementioned, the data required for this research is obtained to clarify the research purposes. To do so, the case study is chosen as a main strategy to conduct this research. A case study explores one or more actual cases as part of a typical qualitative research strategy(s). In a case study, social phenomena are investigated in their natural setting using the triangulation data collection technique, which aims to fully comprehend the phenomenon by addressing multiple data sources. More importantly, case study research consistently produces extensive and richly detailed descriptions of the phenomenon being studied. The researcher can also attempt to arrive at an explanation of the research subject within the particular context of the relevant case. The most typical sources are relevant documents, key actor interviews, and participant observation. Besides, case studies are suitable for both deductive and inductive research, but they typically provide few options for statistical testing of hypotheses (Swanborn, 1996; Thiel, 2014)

For this research, relevant policy documents, journal articles and concerning institutional webpages are examined to better understand the local heat transition. Then, the survey instrument is employed in five neighborhoods of Nijmegen to discover how effective is it to know the effects of the physical and social characteristics of neighborhoods on residents' role to achieve a sustainable built environment in Nijmegen. Lastly, interviews are conducted for both finding missing parts of desk research and revealing the unearthed barriers and opportunities of the local heat transition of Nijmegen. In the following paragraphs, the data collection methods used in this research will be further explained.

3.5.1. Desk research

The first used data collection method in this research is a literature analysis. A literature analysis can be quantitative or qualitative (Thiel, 2014). In this study, qualitative literature analysis was preferred in accordance with the purpose of the research as it provides a room to gain knowledge about the heat transition. More spesifically, the articles, policy documents, institutional web pages that are likely to provide information on different characteristics of neighborhoods, the neighborhood potentials and its importance in the realization of the heat transition as well as the impeding and the facililator factors of the heat the transition is tried to be collected. The data obtained from literature is used throughout the research to create academically coherent story.

3.5.2. Questionnaire

Questionnaires are one of the most popular methods for gathering data from or about people to characterize, compare, explain, or forecast their knowledge, attitudes, or behaviors on certain issue (Fink, 2003). In other words, it is a format that makes it possible to collect homogeneous, structured data on each of a vast number of cases. In all types of social research, from small-scale student and community projects to large-scale worldwide surveys, questionnaires are now often utilized. The survey is particularly well suited for theory-driven or deductive forms of research because it necessitates standardizing measurements and designing a scale or set of answer categories in advance (Thiel, 2014). The formulation of a series of questions and responses that will often enable the researcher to answer the research question or test the hypothesis is the main characteristic shared by surveys (Matthews & Ross, 2010).

The survey used for this research was designed to take 10-15 minutes to complete, and it consisted of 23 questions across four sections. The first section explored the socioeconomic-demographic and housing type of attributes of respondents. The second section investigated heating knowledge and expectation alignment of residences. The third section analyzed social learning and neighborhood potential. The fourth section examined resource acquisition and business models. For most questions, a 5-point Likert scale was used, although some questions were multiple choices, and the last question was open-ended. The online survey that was conducted in this study is further described in Appendix 1.

The survey was presented in Dutch, English, and Turkish in five districts of the city of Nijmegen, the Netherlands (Dukenburg, Hengstdal, Bottendaal, Heijendaal, and Hatert). The survey was prepared by a software program, Qualtrics, and was distributed on social media and in the field with QR code printed business cards (see figure 13). Those who answered the survey were not determined beforehand but randomly selected to increase the diversity among participants. The sampling frame consisted of adults in each of the five neighborhoods who had to be over the age of at least 18 years old. The survey was piloted in mid-May 2022 and the final data collection took place until early-July 2022. Roughly 4000 thousand business cards are delivered to the mail slot of houses in five neighborhoods and 98 residents completed the survey.

Figure 13.The business card printed for the distribution of the research questionnaire

3.5.3. Interview

The term "interview" refers to a conversation between two or more people during which the "interviewer" is the one asking questions in order to obtain specific information from the respondent (the interviewee[s]) (Phillips et al., 2013). According to Saldana et al. (2011), interviewing is an efficient method for gathering data about people's perspectives, feelings, opinions, values, attitudes, and beliefs regarding their personal live and social environments.

Marrelli (2010) asserts that interviewers should create an interview methodology to make sure all necessary information is gathered and that data collection is consistent when approaching multiple interviewers. In general, there are three types of interviews: Semi-structured, unstructured, and structured (Gubrium & Holstein, 2001). To conclude, the interview may be highly organized, meaning that a series of planned and specific questions will be asked of each participant in a certain order, or it may be unstructured, meaning that there will only be a basic list of themes for discussion (Saldana et al., 2011). For this study, the decision is made to conduct semi-structured interviews due to the fact that a semi-structured interview leaves room for improvisation and dialogue between the interviewer and interviewee. Within a semi-structured interview, an interview guides were prepared, where a list of subjects and questions that the interviewer would want to cover were presented (see appendix 2). All interviews were performed online through the use of Microsoft Team.

Different stakeholders were approached with a request to interview about the heat transition taking place in Nijmegen for this research. However, Woonwarts and Portaal, an active housing company in Nijmegen, as well as Duurzaam Hengstal, which focuses on the energy-related issues in the Hengstal neighborhood, did not approve the interview request. General information about the interviews held for this research is given in Table 2. The interview was prearranged and held at the time agreed upon. Although all questions were asked during the interviews, there were changes in the ranking of questions due to the answers given.

Case	Interviewee	Profession	Interview date
Heat transition of Nijmegen	Juul Doggen	Urban planner-Private sector	01.07.2022
Heat transition of Nijmegen	Erik Maessen	Energy transition advisor-Municipality of Nijmegen	06.07.2022

Table 2: Overview of the conducted interviews

3.6. Data Analysis

After data is collected, the data were analyzed to obtain an academically useful conclusion. The qualitative data, the interviews for this research, are analyzed based on conceptualization whereas the quantitative data, the survey for this research, is analyzed through the use of statistics and diagrams. This section will scrutinize the methods of analyzing the data collected in the next paragraphs.

3.6.1. Desk Research

Scientific articles, policy documents, and institutional websites with regard to the heat transition are reviewed. The data gathered from various kinds of literature was then combined in this thesis to create a clear and coherent narrative.

3.6.2. Questionnaire

The data obtained from the questionnaire can be divided into two parts as verbal and numerical for this research. First, verbal data is derived from the specific questions asking participant's opinions and preferences (e.g., How would you describe your perspective with regards to the heat transition in your neighborhood in your own words?). For this reason, the verbal data obtained from the questionnaire were analyzed according to the qualitative analysis methods. To do so, the data is listed and documented before proceeding to Atlas.ti. The data is then processed with the same coding procedure as the interview analysis (see Appendix 3.2). The overarching concepts refined from the data are used to strengthen the thesis' argumentation where necessary. In addition, the analyzed results of survey participants are used to reveal unearthed barriers and convenience of the heat transition of Nijmegen with the results refined from the interviews.

Secondly, numerical data obtained from the questionnaire is used to show the correlation-if any-between the social and physical characteristics of the neighborhoods and the potential of neighborhoods to realize the heat transition. The numerical data is analyzed through Microsoft Excel. Computer programs offer the researcher a number of benefits, including a variety of statistical techniques, the ability to handle sizable datasets with numerous respondents, and ample user assistance (Thiel, 2014). In this context, numerical data were first tested for proficiency with the help of Microsoft Excel program. The results which are completed less than seventy percent of the questionnaire were not considered sufficient and were not included in the analysis (e.g. three respondents' answer were not met the threshold of seventy percent). Then, the data were used to create meaningful correlation between descriptive survey answers (respondent's age and income, and house'type and age) with the other parameters measuring, for example , the respondent's willingness to change heat source. In accordance with the conceptual framework, the correlations obtained from the data are shared in the result section to reach a conclusion answering the research question. Lastly, a codebook and data matrix were prepared in order to ensure that the survey data would reach the same results when analyzed by other researchers.

3.6.3. Interview

Interviews are recorded with the consent of the interviewees and transcribed fully to make it possible to analyze for this research. The transcriptions are organized and analyzed via Atlas.ti software program through which qualitative data can be digitally stored, organized and analyzed (Thiel, 2014). To analyze data, first, the interview transcripts are coded by labeling specific words, passages, or paragraphs with overarching concepts based on the conceptual framework of this research. In this way, patterns, and connections between and within data are tried to be revealed.

Coding basically consists of three steps: Open coding, axial coding, and selective coding. The first step, known as open coding, entails reading the transcripts and labeling similar groups of data without yet referring to the theory. The contents of the transcript can eventually be organized into different codes (Friese, 2012). During the axial coding, the focus is on identifying patterns in the codes that have been assigned to the data. While performing the axial coding, in addition to ensuring that the codes used in the analysis are comparable and that theoretically intriguing relationships are found, the ordering of the codes is necessary to keep the analysis succinct (Thiel, 2014). The final stage, the selective coding aims to combine axial codes into one overarching idea that connects to the essence of participants' responses (Friese, 2012). An overview of the selective codes obtained from the interviews can be found in Appendix 3.1.

3.7. Validity and Realiability of Research

The validity and realiability of a study is a crucial factor for a study to be academically legitimate.First, the validity of the research can be divided into internal and external validity and can be improved by a number of factors. Second, reliability is concerned with the question if the results of the research are generalizable (Bryman, 2016). In this section, the validity and reliability of this research as well as ethics will be discussed in detail.

3.7.1. Internal Validity

Internal validity of research refers to whether the predefined questions are answered (Becker et al., 2012; Thiel, 2014; Yin, 2009). In other words, Bryman (2016) states that the internal validity is about whether the research focuses on what is intended. In this research, several steps taken to make sure that high internal validity is reached. First, the data triangulation method which allows using multiple and different sources, methods, investigators, and theories to provide corroborating evidence in reaching an answer to the research question (Creswell, 2013) was employed to obtain high internal validity for this research. Second, the semi-structured interview method was chosen to allow respondents to express themselves. In addition, additional questions were also prompted during the interviews to understand better the interviewees' responses. Furthermore, the interviews were recorded with the consent of respondent to make sure that the responses are thoroughly transcripted. Third, the survey instrument was used among residents to answer the main research questions. As this research is designed in a way that theory-driven analysis fits well, statistical analysis of patterns based on survey data protects the research from having low internal validity. Fourth, to prevent the study from deviating from its main objective, the geographical scope was kept as small as possible; only five Nijmegen neighborhoods were chosen as case studies. On the other hand, some individuals and institutions, both of which could have made significant contributions to the research, have declined requests for an interview, which affected the internal validity of this research negatively.

3.7.2. External Validity

The external validity of research refers to the generalisability of the research (Becker et al., 2012; Thiel, 2014; Yin, 2009). Since a case-study has been chosen as the research-design, the external validity, unlike the internal validity, will not be very high (Verschuren & Doorewaard, 2010). Nevertheless, the outcome of this research was aimed to have a high external validity by following several steps. First, neighborhoods chosen as a case studies were tried to reflect as large as possible different social and physical characteristics to enable research’s outcome to be generalized. According to Guba & Lincoln (1994), including a thorough and in-depth description of the characteristics of a research site is recommended to increase the external validity of the research. Therefore, the neighborhoods chosen as case studies were explained as extensively as possible in paragraph 3.4. Second, the survey conducted for this research was tried to reach as many participants as possible in five selected case location. Even though the steps taken to increase external validity of this research, the generalizability of this research is limited because of several reasons. First, since the neighborhood level was chosen as the case study, there is a very wide scale of the physical and social characteristics that neighborhoods may have in the rest of the World, which makes it impossible to reflect all these local contexts in five samples. Second, low participation in the survey conducted for the research is another factor that reduces the generalizability of this research.

3.7.3. Reliability

Reliability of the research basically refers to if the results of the research can be repeatable (Bryman, 2016). In addition, repeatability is about ensuring that the research steps are used correctly and are well-documented so that someone else can conduct the same study and obtain the same findings as this study (Becker et al., 2012; Thiel, 2014; Yin, 2009). In order to increase the reliability of this research, several factors were taken into consideration. First, operationalization of the conceptual framework is tried to be expressed as clearly as possible. Second, the interview guides, the analyses of the interviews, and the survey, as well as its results, are aimed to be as precise and extensive as possible. It should be noted that because the researcher assigns the codes based on its own assessment, coding can be a subjective process. Therefore, Creswell (2013) suggests using "intercoder agreement," in which multiple researchers independently code transcripts and then compare the results, to reduce the risk of subjective coding. However, the intercoder agreement was not employed for the data analysis of this research as this research is expected to be individual and completed within the limited time frame. Nevertheless, the codebook and data matrix were formed to allow other researchers to reach the same findings, which helps to obtain higher reliability in this thesis.

3.7.4. Ethics

The ethics of this research is accepted as an important criterion within the validity and reliability of this research. According to (Becker et al., 2012), it's crucial that participants' privacy is respected and safeguarded throughout the research process. In order to achieve this, several steps were taken in this research. First, the respondents of the field survey were informed well about the research, and they were asked for consent before the beginning survey to make sure that the data gathering conditions are approved for each participant. Secondly, the names of the participants in the survey study were not requested to protect their privacy. Lastly, the interviewees were informed about the research, the research goals, and how the interviews are planned to be used in this research. Thus, the research was tried to be ethically safe for all parties concerned.

4. Results

In this chapter, the analysis that is conducted to answer the research questions is represented. First, section 4.1 scrutinizes the descriptive statistical data of the survey participants according to the social and physical criteria used in the research and the statistical formulation that is used to come up with the result section is shown. Section 4.2 shows the estimated neighborhood capacities in selected cases based on the different physical and social characteristics of neighborhoods. Next, section 4.3 demonstrates the results of how the transformative activities have the potential to affect the residents' participation/support/contribution to the heat transition. Subsequently, section 4.4 contains the results of the analysis of the goals and outcomes that focus on the effectiveness, efficiency, and social acceptability of the heat transition. Finally, section 4.5 elaborates on the barriers and opportunities identified in the Nijmegen heat transition process.

4.1. Introduction to the survey results

As it is aforementioned, this thesis is designed as case study research, where multiple neighborhoods that have different local contexts in Nijmegen were chosen. To be able to understand the residents' role in the heat transition in Nijmegen, the field survey was carried out in the five neighborhoods of Nijmegen. Table 3 shows the number of residents who participated in the field survey.

Bottendaal	**Dukenburg**	**Hatert**	**Hengstdal**	**Heijendaal**
18	19	25	19	14

Table 3.The number of respondents by neighborhoods

As the number of participants distributed uneven over the five neighborhoods, the results needed to be interpreted with caution. For example, the result obtained by the Heijendaal neighborhood is at risk of being unrepresentative in some survey questions due to a relatively low participation ratio in that neighborhood. Besides, the table 4 demonstrates the distribution of participant by income groups based on the survey question 4, which is one of the social characteristics that is likely to have an impact on the role of residents in the heat transition of Nijmegen.

Under 20.000 Euros per year	**Between 20.000-35.000 Euros per year**	**Above 35.000 Euros per year**	**Prefer not to answer**
20	23	44	8

Table 4.The number of respondents by income groups

As can be clearly seen from table 4, the survey samples are not fairly distributed among income groups, which may pose risk for some categories to not precisely represent in the research findings. Also, the options available in the 4th question of the field survey, '20.000-25.000', '25.000-30.000', and '30.000-35.000' were combined under the more inclusive option of '20.000-35.000' in the coding process to enable these groups to be presented more properly in terms of statistics. One of the other social characteristics measured in the survey was the age of participants. Table 5 represents the distribution of participants by the age groups of respondents.

Under 35	**35-44**	**45-54**	**55-64**	**65 and over**	**Prefer not to answer**
16	10	11	22	35	1

Table 5.The number of respondents by the age ranges

2nd question of the field survey used to classify the age groups of respondents. However, the option of '18-24' and '25-34' age groups were combined under the more inclusive group of 'Under 35' as only four respondents were available aged between 18 and 24. By doing so, the age group 18-24 was tried to be prevented from being unrepresentative in the survey results. Nevertheless, the fact that the age distribution among the participants is predominantly in the age group 65 and over necessitates more caution when evaluating the results related to the age of respondents and the correlation established with that social characteristic. Another social characteristic used in this research was the legal ownership status. The table 6 represents the distribution of the survey respondents by the legal ownership status.

Tenant from private landlord	Tenant from housing corporation	Homeowner
15	35	45

Table 6.The number of respondents by legal ownership status

The legal ownership status of respondents is measured with the help of 3rd question of the field survey. Participants were not offered the option of 'prefer not to answer'. Even though the total number of survey participants is relatively low (95), the distribution of respondents by legal ownership status is in line with the real-world setting (see table 1).

This research also employed several physical characteristics. First, table 7 represents the distribution of the survey's participants by house types based on the 6th question of the field survey.

Flat/Apartment	Terraced	Detached	Prefer not to answer
35	44	12	2

Table 7.The number of respondents by house type

As can be seen from table 7, a higher number of respondents of the field survey reside in terraced and flat types of housing. In addition, a small proportion of respondents live in the detached type of houses. Also, it should be noted that the 'semi-detached' and 'detached' options were combined as these groups consist of eight and four respondents respectively. These groups were combined under the 'detached house' group to increase the representation of the respondents that fit one of those groups. Another important point is that even though the option of 'student dormitory or care homes' were available in the questionnaire, only two respondents fit into this option. Therefore, the results and preferences of this group were not included in the analysis process of the variances based on the house type.

The last physical characteristic employed in this research was the age of houses. The table 8 shows the distribution of respondents by the age of houses based on the survey question 5.

0-10 years	10-20 years	20-30 years	Over 30 years	Prefer not to answer
13	7	17	57	1

Table 8.The number of respondents by the house's age range

As can be seen from the table 8, the survey respondents are distributed unevenly by their age of houses, which is reasonable when comparing the survey data with real world setting in Nijmegen (see Table 1). While a large proportion of the respondents indicated that their house is 30 years or older, only 4 households were 10-20 years old. The uneven distribution of respondents limits the generalizability of correlation found between residents' participation/support/contribution to the heat transition and the resident's house age. Also, the options '30-40' and 'over 40' were combined under the more inclusive group of 'Over 30 years' as the only four persons chosen '30-40' as the house age group in the survey result. By doing so, the danger of this group being underrepresented in the survey results was tried to be prevented.

To conclude, the aforementioned questions were asked to the participants of the field survey to differentiate the social and physical characteristics of selected case neighborhoods. Even though the number of respondents and their classification over variances in the survey limits this research in an academic sense, the research findings are still promising to shed light on the effects of the different local contexts of neighborhoods on residents' attitudes and roles in the heat transition process.

After providing the descriptive numerical data about the survey results, it is necessary to explain how the results are reached. To do so, the graphics presented in the result section will be grouped to show the analytical background of the calculation made during the analysis process of the survey data. First, how the 5 scale-question were calculated will be explained. These group of questions in the questionnaire made possible to analyze the sections: 4.2.1 Organizational capacity, 4.2.2 Personal capacity, 4.2.3 Infrastructural capacity, and 4.4.3 Social acceptability. For the analyzes of 5-scale questions, the following steps were followed,

The number of respondents selected ‘1’ = X

The number of respondents selected ‘2’ = Y

The number of respondents selected ‘3’ = Z

The number of respondents selected ‘4’ = T

The number of respondents selected ‘5’ = W

$$Mean\ value: \frac{X*1+Y*2+Z*3+T*4+W*5}{X+Y+Z+T+W}$$

Also, the result chapter 4.3.2 Expectation alignment was measured based on 10^{th} of the field survey, which option consist of ‘Yes’, ‘Partially’, ‘No’, ‘No idea’ and ‘Prefer not to answer’. In order for the results of this section to be more mathematically compatible with other data, the following steps were followed to reach the mean values of preferences,

The number of respondents selected ‘No’ = X

The number of respondents selected ‘Partially’ = Y

The number of respondents selected ‘Yes’ = Z

$$Mean\ value: \frac{X*1+Y*3+Z*5}{X+Y+Z}$$

On the other hand, the questionnaire contains questions that helps to measure the willingness of residents to participate in and contribute to the heat transition of Nijmegen. By doing so, the following result chapters are analyzed: 4.2.4 Social-Cultural capacity, 4.3.1 Social learning, 4.3.3 Resource acquisition, 4.4.1 Effectiveness and 4.4.2 Efficiency. The steps below were followed to design presented graphics in mentioned chapters,

Total number of respondents in a group 1: a

Total number of respondents in a group 2: b

Total number of respondents in a group X: c

N: The frequency of the dependent variable

$$The\ mean\ percentage\ of\ group\ 1: N/a$$

$$The\ mean\ percentage\ of\ group\ 2: N/b$$

$$The\ mean\ percentage\ of\ group\ X: N/c$$

4.2. Neighborhood capacities

4.2.1. Organizational capacity

In this section, the results of the variations in the neighborhood capacity to organize about sustainability and especially the heat transition are demonstrated by the different social and physical aspects. To do so, the responses to the field survey question 20 were used.

First figure 14 shows the correlation between the estimated neighborhood capacities according to the age groups of participants. What figure 14 demonstrates is that while the participants up to the age of 44 voted that their neighborhood's organizational capacity in the heat transition is around 3 out of 5, this rate reaches the lowest level at 2.36 out of 5 in the 45-54 age group. Finally, the ratio increases exponentially to the highest level of 3.62 out of 5 among those aged over 65.

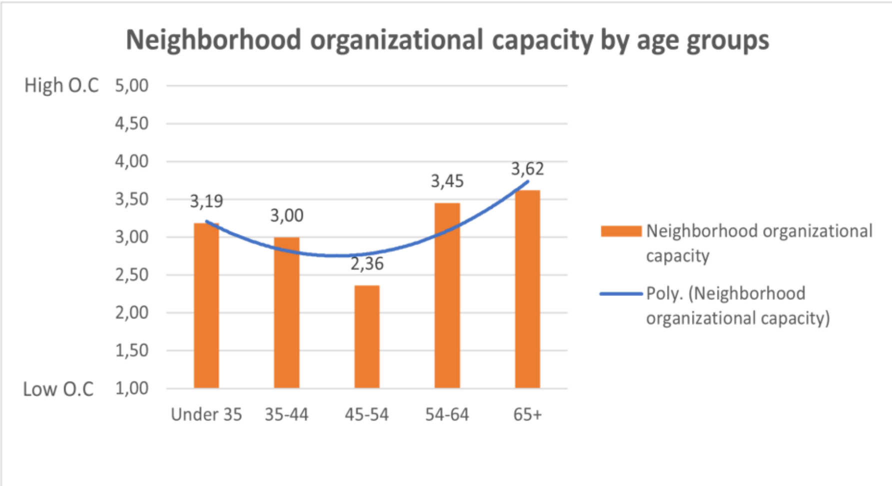


Figure 14.Neighborhood organizational capacity by age groups

Second, figure 15 demonstrates the correlation between the estimated neighborhood capacities according to the legal ownership status of participants. As can be seen from figure 15, the linear trendline of neighborhood capacity level increases from tenants of the private landlords to tenants from the housing corporations and reaches the highest level among homeowners.

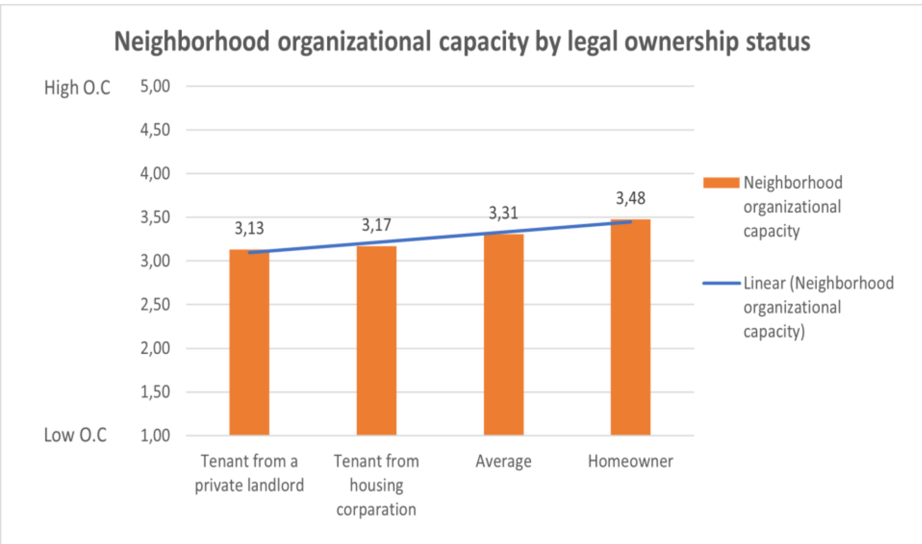


Figure 15.Neighborhood organizational capacity by legal ownership status

Third, figure 16 indicates the correlation between the estimate neighborhood capacity by house types. According to figure 16, apartment/flat residents rate the organizational capacity in their neighborhood as 3.17 out of 5, which is 3.22 among those living in terraced houses and reaches the highest level, 4.09 for those residing in detached houses.

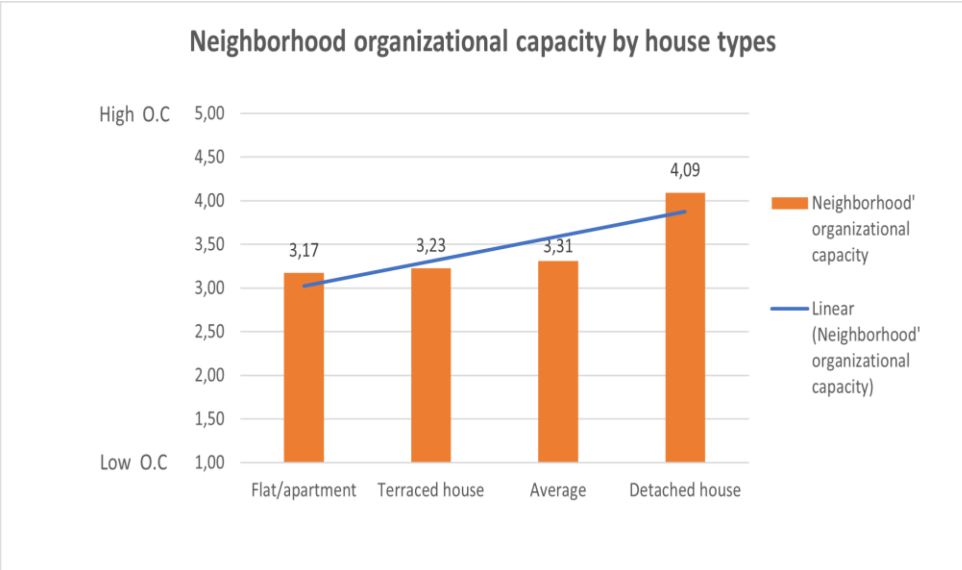


Figure 16.Neighborhood organizational capacity by house types

The factors that is likely to affect the organization capacity of a neighborhood in the heat transition were mentioned. However, it should be noted that no correlation was obtained between the organizational capacity of a neighborhood and the age of the houses in the same neighborhood.

After examining the estimated organizational capacity by several physical and social characteristics, it is also important to delve into the five selected cases in terms of organizational capacity. In this research, it was considered that the ability of the residents to organize is important for the realization of heat transition in the neighborhoods. The research findings give reasons to support the hypothesis that neighborhoods' organizational capacity is a determinative factor in the local heat transition in Nijmegen. Residents living in the five case neighborhoods assessed the estimated capacity of their neighborhood to be organized in heat transition-driven problems. At the same time, the participants whose main heating source is either gas or oil were asked in the 8th question of the field survey to rank their willingness to change the existing heating systems.

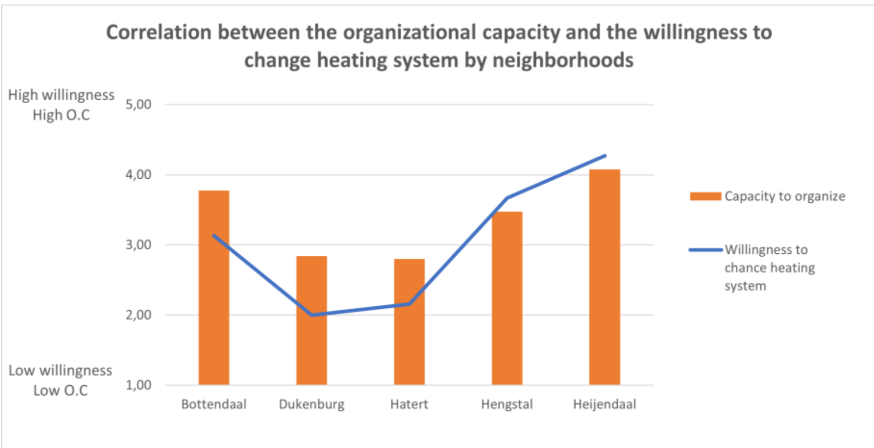


Figure 17.Correlation between the organizational capacity and the willingness to change heating system by neighborhoods

According to figure 17, the neighborhoods that are estimated to be more organized host residents who are more willing to change their heating systems. In detail, the Heijendaal neighborhood, where the highest estimated organizational capacity is indicated, consists of the residents with the highest annual income among others, while the residents living in Hatert have the lowest average income. In addition, Bottendaal and Heijendaal have the highest percentages of homeowners, while Dukenburg and Hatert can be seen to have an overwhelming majority of tenants. Besides, although the income level of the Hengstal is relatively low according to the survey results, it can be assumed that the high organizational capacity in the neighborhood may be due to Duurzaam Hengstal, which is an active neighborhood organization tackling energy-related problems and helps to increase awareness of residents. In parallel, it is sensible for residents of Dukenburg to state to have a relatively low organizational capacity as most of the residents live in flats/apartments and have relatively lower income level compared to that of other neighborhoods. To conclude, organizational capacity can be affected different physical and social factors that exist in the neighborhood such as income level of residents, common house type of neighborhood and as well as the existence of active neighborhood organization. All these factors determine to what extend the residents will be adaptive in taking off the natural gas in the neighborhood since it is stated by J. Doggen (personal communication, July 1, 2022) that neighborhoods where residents are more connected may be more advantageous for a smooth transition.

4.2.2. Personal Capacity

In this section, the relationship between the personal capacity of residents toward the heat transition and the income group of the participants, legal ownership status, and house types are shown based on the survey results. To obtain the necessary data to be analyzed, the survey participants were asked to what kinds of contribution as they are willing to make individually in the question 19 of the field survey. Besides, the personal capacity by neighborhoods were assessed based on the survey question 10, 14 and 15 to reach a more comprehensive conclusion.

First, figure 18 was prepared based on the question 19 of the field survey that asks participants to what kind of individual contribution would you make to the heat transition process. Results of the question are reflected in figure 18, showing the proportion of ones who are willing to contribute to the process by income groups. While only 65% of the residents whose annual income is below 20,000 Euros want to make an individual contribution to the process, this rate rises to 83%, with a considerable increase among residents whose annual income is between 20,000-35,000 Euros. Finally, the rate of those who say that they will make an individual contribution to the process among the residents whose annual income is above 35,000 Euros sees a peak at 87%.

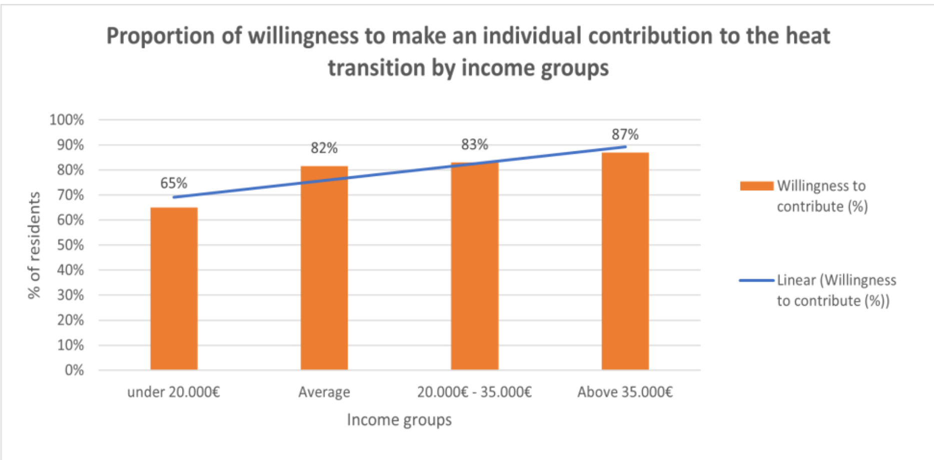


Figure 18.Willingness to make an individual contribution to the heat transition by income groups

Second, figure 19 shows how the willingness of participants to contribute to the heat transition is changed by legal ownership status. According to figure 19, the proportion of those who may contribute to the process among tenants from private landlords and housing corporations is around 72%, which is below the average of 81%. Lastly, the proportion of those who say that they will contribute to the process reaches the highest level among homeowners with 93%.

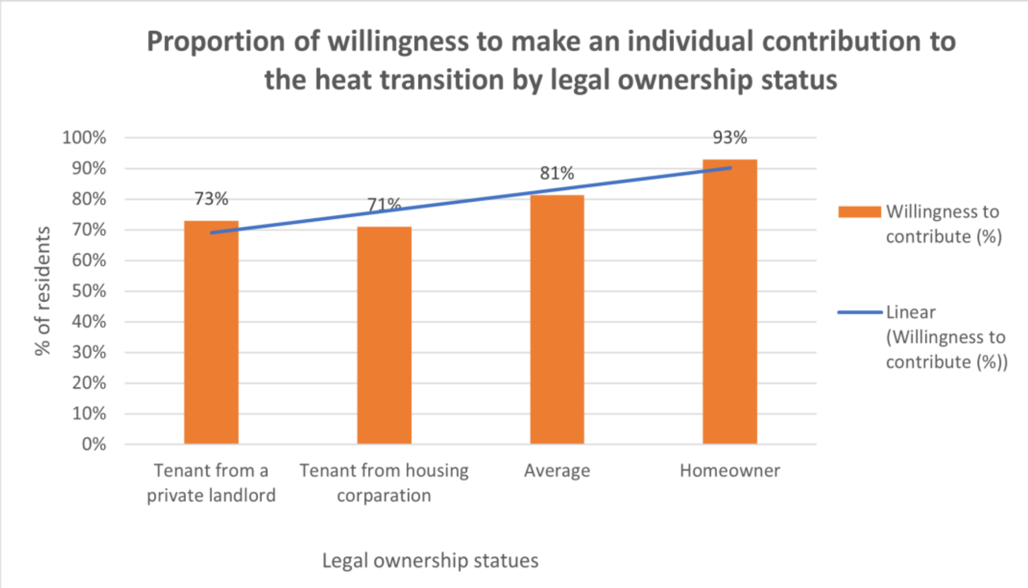


Figure 19.Willingness to make an individual contribution to the heat transition by legal ownership status

Third, figure 20 represents the correlation between willingness to provide individual contribution to the process and the house types. Based on figure 20, while 71% of the participants living in a flat/apartment stated that they could contribute to the process, this rate was below the average of 82%. Moreover, the rate of those living in terraced houses who say they can contribute to the heat transition reaches to 88%, and then the rate experiences its peak at 91% in those living in detached houses.

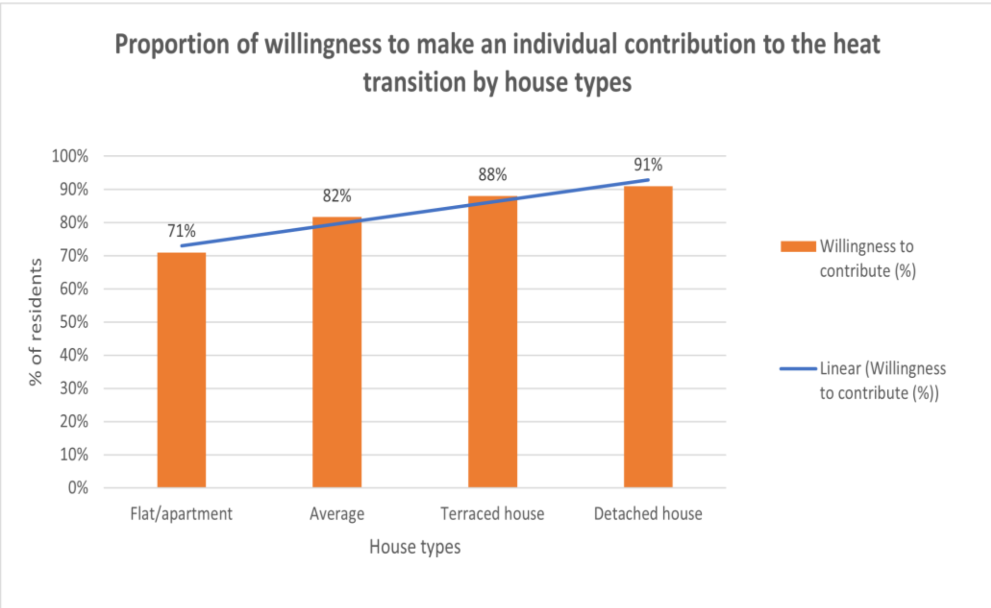


Figure 20.Willingness to make an individual contribution to the heat transition by house types

On the other hand, no meaningful correlation was found between the personal capacity and both the age of the house and the age of residents. After examining the willingness to make an individual contribution to the heat transition by different physical and social characteristics of the citizens, it is useful to look at the willingness to make an individual contribution to the process in the five selected cases. The willingness of residents to contribute to the process may vary according to many factors. According to J. Doggen (personal communication, July 1, 2022), both character of a person and whether that person has intrinsic values toward transition are important factors for one's decision to contribute heat transition. She continues by emphasizing the willingness of citizens, and states that the level of desire to contribute process, is explicitly correlated with to what extend residents are informed about transition. According to survey results, the municipality's efforts to raise awareness of the heat transition are found to be positively associated with neighborhood residents' desire to participate in the social events about the heat transition (see figure 21). More than 50% of Bottendaal and Hengstdal residents stated that they were informed by the municipality, while a considerable number of Hengstdal residents (9 out of 19) also stated that they were informed about the heat transition process by the neighborhood organization Duurzaam Hengstdal. As it can be clearly seen from the figure 21, participation in at least one informative event about the heat transition is relatively higher in Hengstdal compared to other districts, while it is at the lowest at around 10% in Hatert. However, no correlation was found between the willingness to contribute to the process and either the level of being informed or attending to informative event about the transition. Furthermore, only around 10% of Hatert residents stated that they were informed about the heat transition by the municipality, which is the lowest rate among other neighborhoods. Parallel to this, E. Maessen (personal communication, July 6, 2022) states that the municipality of Nijmegen has made no efforts to inform Hatert inhabitants about the heat transition process thus far. As a result, just over 10% of Hatert residents attended either digital or in-person events themed on heat transition. However, the residents of Hatert have the highest willingness to make an individual contribution to the process among case neighborhoods at approximately 95%.

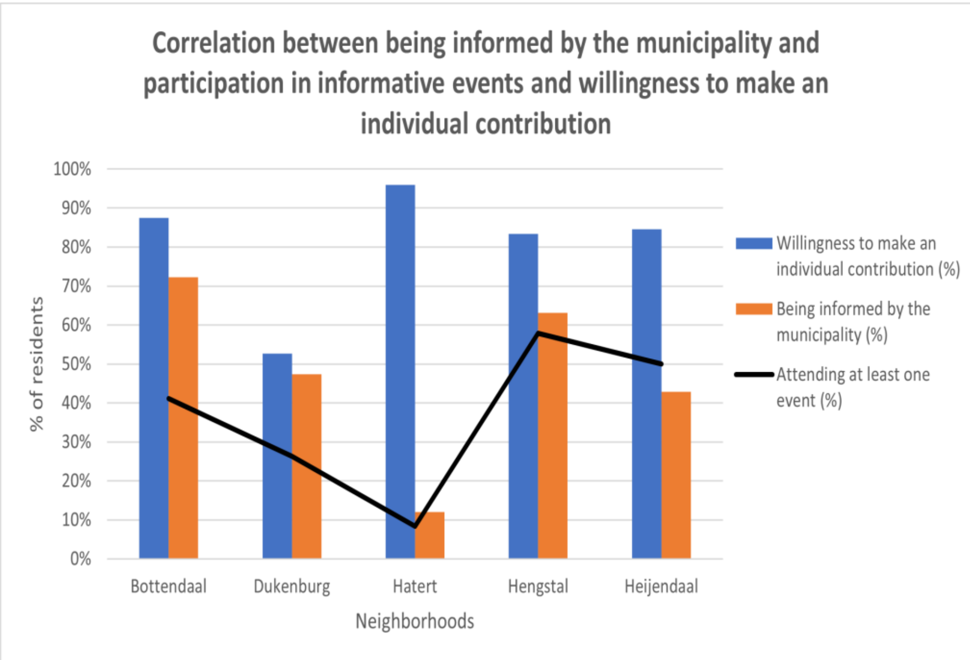


Figure 21.Correlation between social learning-participation

4.2.3. Infrastructural Capacity

In this section, the estimated infrastructural capacity of the neighborhoods is examined based on the several physical and social characteristics: The age groups, income levels, and house types of residents. To find this link, survey participants were asked in question 17 of the field survey to score the estimated infrastructural capacity of the neighborhoods

First, figure 22 represents the estimated infrastructural potentials that vary based on age groups of the survey participants. As it can be seen from figure 22, while the participants under the age of 35 score the infrastructural potential of their neighborhoods as 3.25 out of 5, this ratio sees the bottom with 2.7 among the 35-44 age group. Then, the score rose up to 2.91 among citizens aged 45-54. Next, an expansionary increase can be seen in the trendline, with which the score rose up to 3.50 in the 55-64 age group. Participants over the age of 65 estimated the highest infrastructural capacity by rating 4 out of 5.

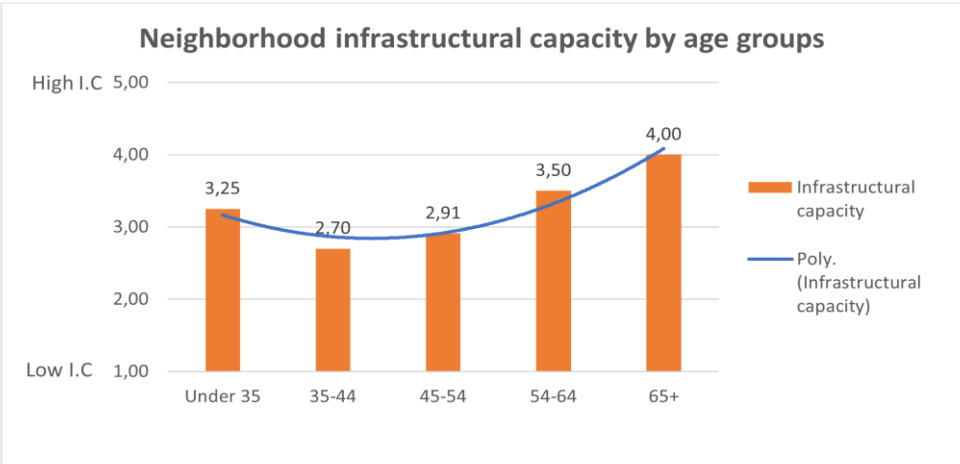


Figure 22.Infrastructural capacity by age groups

Second, figure 23 displays the estimated infrastructural potentials that vary based on income groups. As can be seen from figure 23, residents with an annual income of fewer than 20,000 Euros estimated the infrastructural potential of their neighborhood as 3.5 out of 5 whereas this score is 3.61 for those whose annual income is between 20,000-35,000 Euros. Finally, residents whose annual income is above 35,000 and above estimated the highest infrastructural capacity in their neighborhood as 3.66 out of 5.

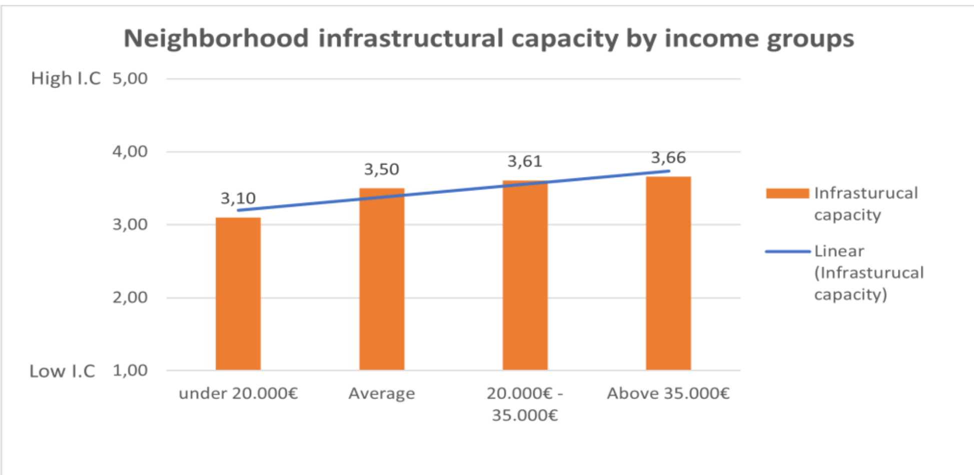


Figure 23.Infrastructural capacity by income groups

Third, figure 24 represents the estimated neighborhood infrastructural capacity by house types. What can be understood from figure 24 is that residents living in either flat/apartment or terraced houses rated the neighborhood's infrastructural potential as approximately 3.50 out of 5,00. Furthermore, this rate exceeded the average of 3.53 among detached house residents where the estimated infrastructural capacity rose to the highest level (4 out of 5).

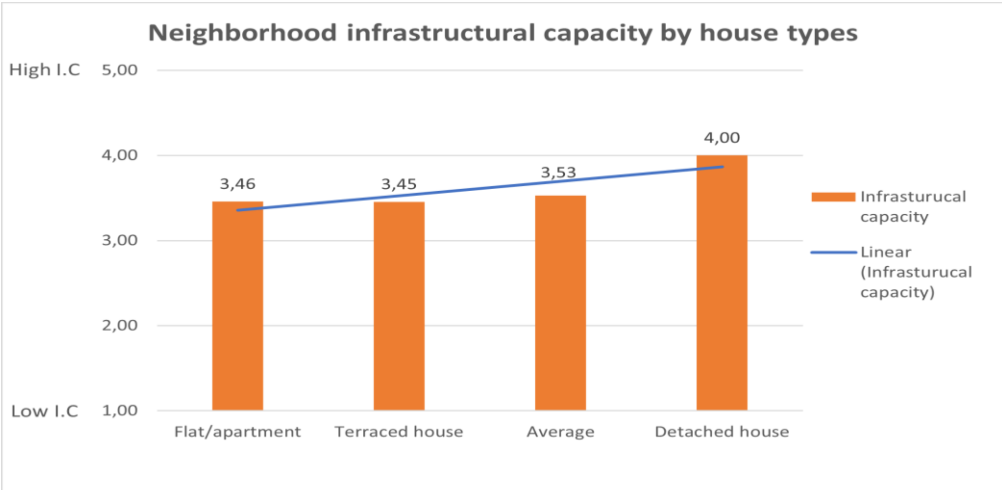


Figure 24.Infrastructural capacity by house types

On the other hand, it should be noted that no meaningful correlation was found between the infrastructural capacity and the legal ownership status of residents, and the age of the houses. After delving into the variations of infrastructural capacity by different social and physical characteristics, it is necessary to look into case studies. J. Doggen (personal communication, July 1, 2022) states that the infrastructure exists in the neighborhood can be described as situation, which have an impact on neighborhood's transition process and more importantly cannot be changed. Thus, the survey participants are asked to measure the estimated infrastructural capacity of their own neighborhood. According to survey results, there is a correlation between the estimated infrastructural capacity and the desire to change the heating system in the neighborhoods, with the exception of Dukenburg (see figure 25). One of the reasons for why Dukenburg set apart from the general trend is that 38.89% of survey participants of Dukenburg are 65 years or older and the general tendency in this age group is to make an overestimation in terms of infrastructural capacity (see figure 23). On the other hand, while residents of Heijendaal estimated the highest infrastructural capacity, the lowest infrastructural capacity is estimated by residents of Hatert. The difference is likely to be occurred due to the distinct social and physical characteristics of these neighborhoods. Heijendaal has a relatively high-income level, a high homeowner/tenant ratio, and a younger average house age, while the Hatert district has a lower income level, a low homeowner/ tenant ratio, and an older average house age (see table 1).

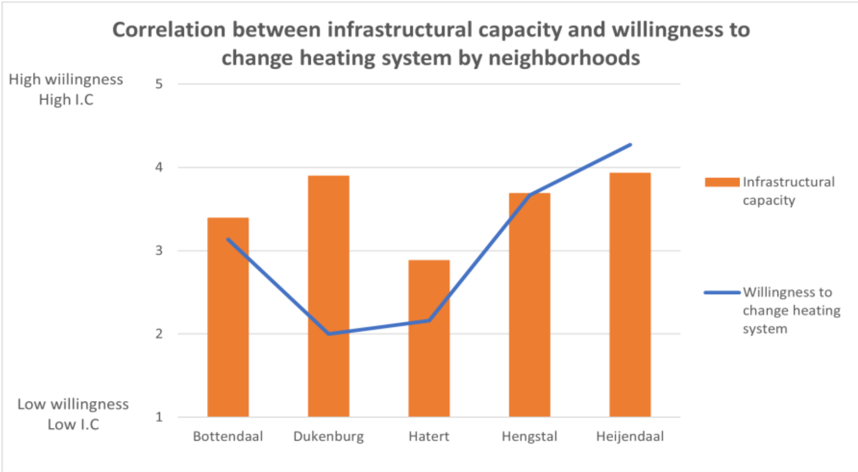


Figure 25.Correlation between infrastructural capacity and willingness to change heating system by neighborhoods

4.2.4. Social-Cultural Capacity

In this section, the social-cultural capacity of neighborhoods is examined based on the several physical and social characteristics: The income level and the age of the residents. Other physical and social aspects will be used as a tool to better understand the social-cultural capacity of five neighborhoods. To do so, survey participants were asked in the question 11 of the field survey to choose their main driver(s) in decision-making about the heat transition. Several options were offered to participants such as environmental concerns, societal purposes, and etc.

First, figure 26 shows how important the environmental concerns in decision-making about heat transition by income groups of participants. As it can be seen from figure 26, residents whose income is fewer than 20,000 Euros per year, environmental concerns are at the lowest level in decision-making on heat conversion at 63%, which is 4% less than the average. While this rate is 68% for residents whose income is between 20,000-35,000 Euros per year, the rate of those who say environmental concerns are a factor in my decision-making process with regard to the heat transition peaks at 70% for residents whose income is above 35,000 Euros per year. To summarize, environmental concerns become more of a driving force in decision-making when residents' income increases.

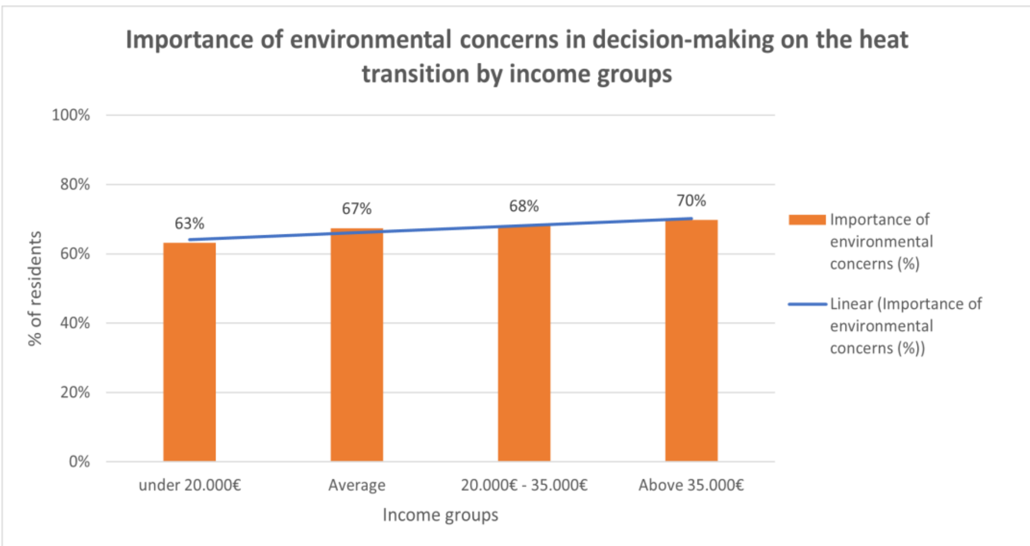


Figure 26.Importance of environmental concerns in decision-making on the heat transition by income groups

Second, figure 27 represents the variation of the environmental concerns in decision making related to the heat transition by age groups of participants. According to figure 27, an upward trend of environmental concerns is observed as the residents' age increases. While residents under the age of 35 state that environmental concerns occupy the lowest place in decision-making, this rate is 56% in the 35-44 age group, with a steady increase. Then, it becomes 73% for the 45-54 age group with a sharp increase of 16%. The importance of environmental concerns in decision-making related to the heat transition is 67% in the 55-64 age group which is slightly lower than that in the 45-54 age group, while it peaks at 82% for residents over 65.

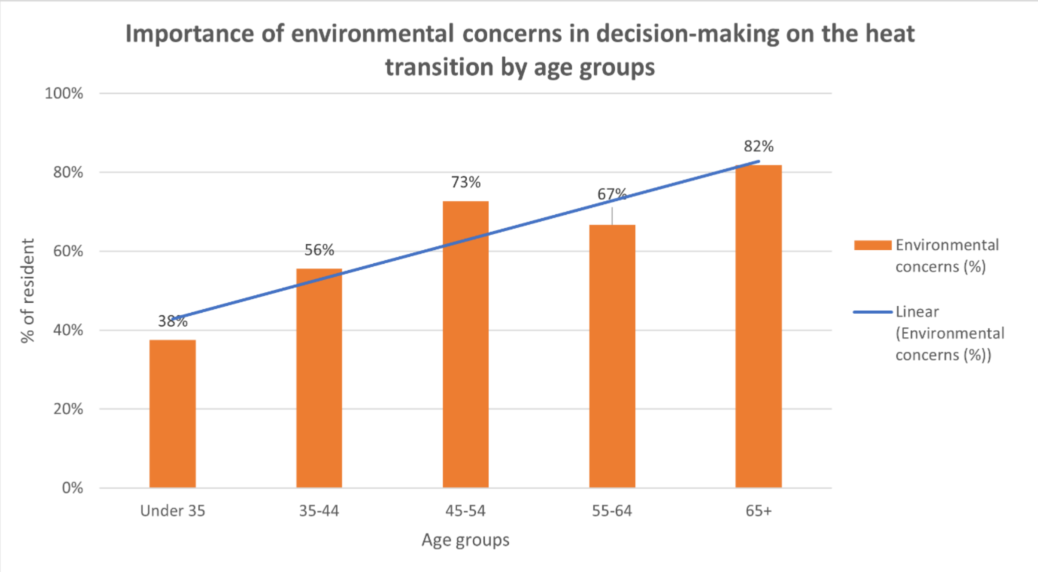


Figure 27.Importance of environmental concerns in decision-making on the heat transition by age groups

Third, figure 28 demonstrates how many percentages of the residents consider societal purposes in their decision-making in the heat transition process. As can be seen from the figure 28, as the income level increases, societal reasons, in other words, willingness to contribute to the wider community decreases. In detail, while the highest rate of contributing to wider society in decision-making related to the heat transition is at 26% in the group with the lowest income level (under 20,000 Euros/per year), the lowest ratio of societal purposes in decision-making was detected among those whose annual income level is above 35.000 Euros at 19%.

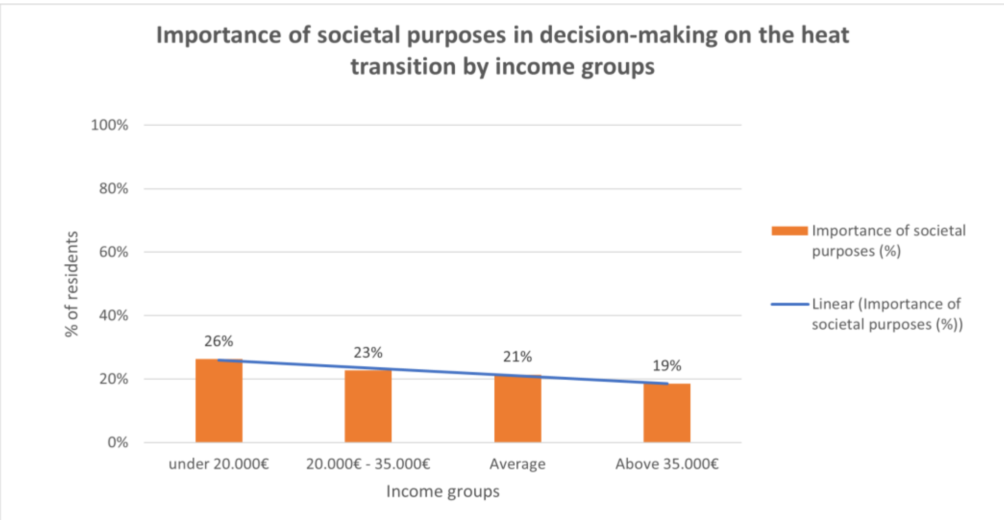


Figure 28.Importance of societal purposes in decision making on the heat transition by income groups

It is also crucial to look at social and cultural capacity of neighborhoods. Although, J. Doggen (personal communication, July 1, 2022) expresses that even though the existence of common cultural background in a neighborhood does not play big role in transition process, existence of strong feeling of community matters for a neighborhood to face common challenges. What can be understood from the figure 29 is that environmental concerns are a primary factor when making decisions about the heat transition for residents in the neighborhoods where the average income is relatively higher whereas cost-efficiency is the primary criterion when deciding on heat transition for residents in neighborhoods where the average income is relatively lower.

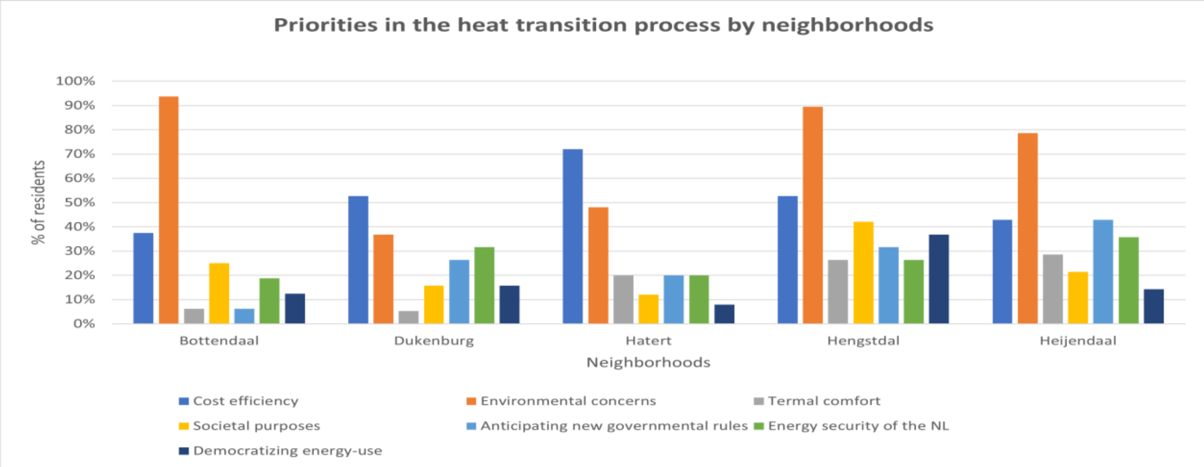


Figure 29.Priorities in the heat transition process by neighborhoods

Besides, another noteworthy point is that the residents of the Hengstdal neighborhood cited social goals (to benefit the wider community) and democratization of energy use among decision-making factors to a greater extent than residents of other neighborhoods. One of the reasons behind this is that Sustainable Hengstdal (Duurzaam Hengstdal in Dutch), an active neighborhood organization themed on energy and energy transition in Hengstdal, is able to explain the heat transition in the Hengstdal not only the transition's financial and technical dimensions but also its social aspects. This is not surprising as the highest rate of participation in informative activities and events by neighborhoods taken place among the residents of the Hengstdal (see figure 21).

4.3. Transformative activities

4.3.1. Social Learning

In this section, the results of the survey demonstrating the variation of the residents' participation in an informative event by the resident income group, residents' legal ownership, house type, and house age are shared. The necessary data used in this section was obtained through 15th question of the field survey that asks respondents to what kind of events themed on the heat transition they attended.

First, figure 30 shows the distribution of participants who attended at least one event about the heat transition by income groups. According to figure 30, the participation of residents in informative event increases in line with their income level. While only 11% of residents whose annual income is less than 20,000 Euros participate in one or more of the events/activities on heat transition, this proportion reaches 45% for residents whose annual income is above 35,000 Euros.

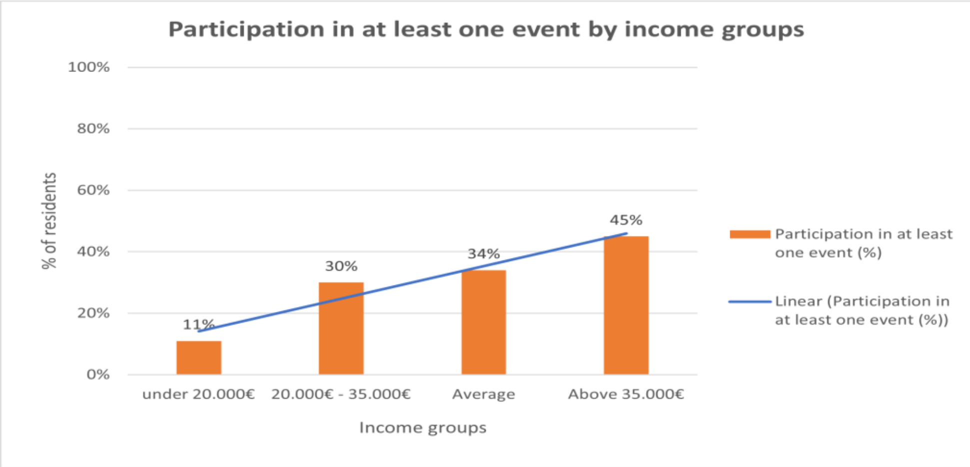


Figure 30.Participation in at least one event by income groups

Second, figure 31 shows the distribution of participants who attended at least one event about the heat transition by types of legal ownership. As can be seen from figure 31, the ownership status of the houses in which the residents live affect the residents' passion for participating in an event about the heat transition. According to the survey results, while participation in heat transition-related event is at the lowest by 7% among tenants from private landlords, it is at 21% among tenants from housing corporations and reaches its peak at 53% among homeowners.

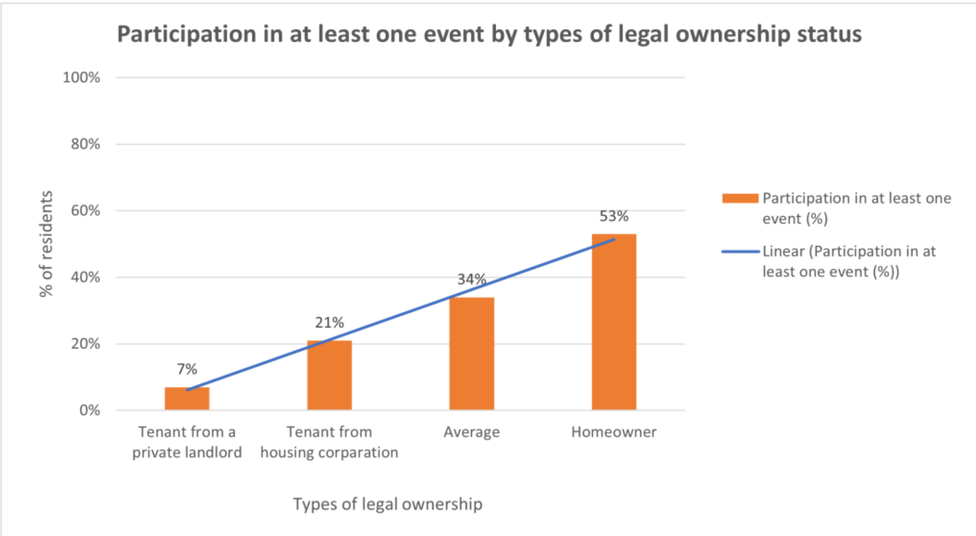


Figure 31.Participation in at least one event by types of legal ownership status

Third, figure 32 demonstrates the distribution of participants who attended at least one event about the heat transition by house type. As can be seen from figure 32, while only 21% of the residents accommodating in flats/apartments participated in one or more events about the heat transition, this rate is twice as high for those living in terraced houses. The participation rate of attending at least one event related to the heat transition experiences its peak at 50% among residents who accommodate in detached houses.

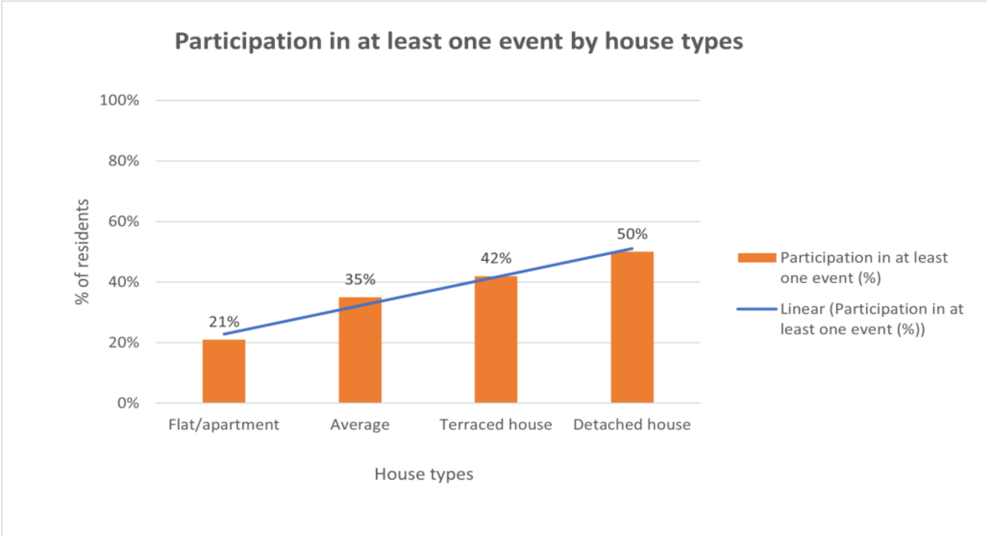


Figure 32.Participation in at least one event by house types

Fourth, figure 33 shows the distribution of residents who attended at least one event themed on heat transition by the age of houses. Figure 33 shows that residents living in houses aged between 0 and 10 do not participate in any activity on heat transition, while this rate is 29% for those residing in houses aged between 10 and 20, and 41% among residents residing in houses aged 20-30 and 30 plus years.

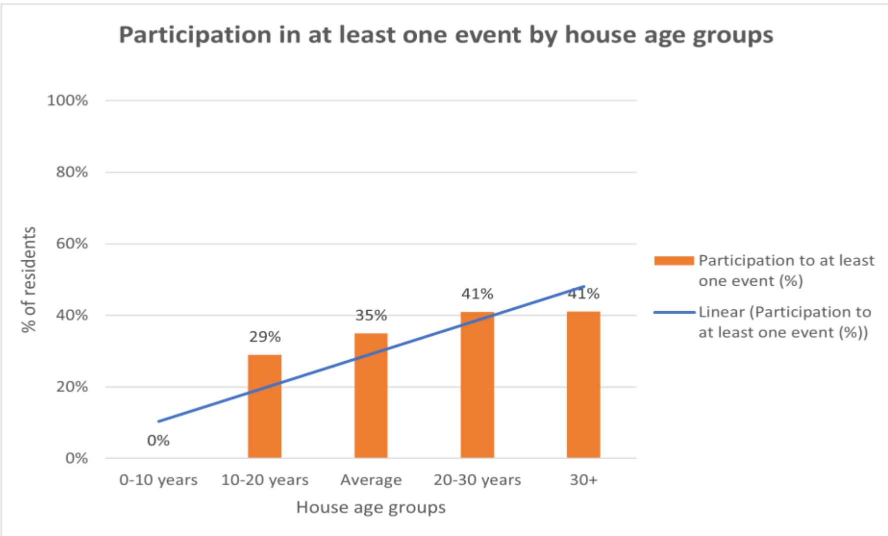


Figure 33.Participation in at least one event by age groups

Finally, figure 34 demonstrates the proportions of residents participating in at least one informative event related to heat transition by the age groups of residents. What can be seen from figure 34 is that only around 10 percent of residents aged 45-54 attended an event, which is the lowest among others. The rate of participation in at least one event is around 23% for the younger age groups (under 35 and 35-44), while this rate is 50% among residents aged 54-65 and 40% among residents aged over 65.

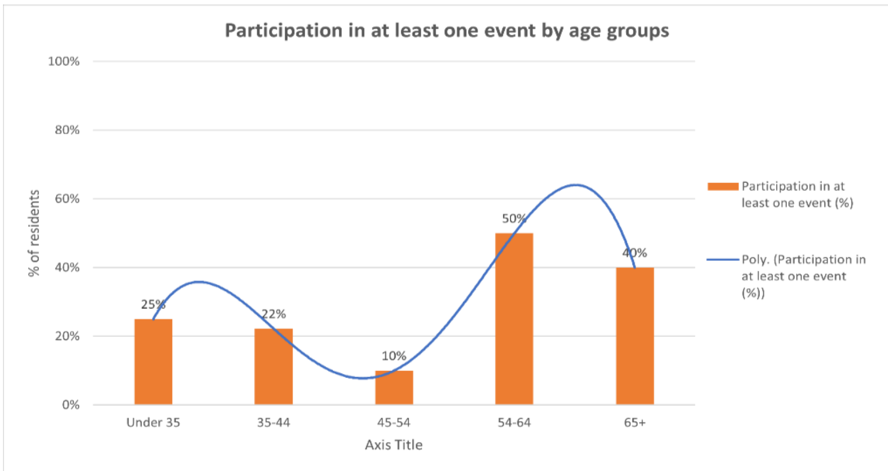


Figure 34.Participation in at least one event by age groups

On the other hand, it should be emphasized that no correlation was found between the residents' participation in an informative event themed the heat transition and the age of residents.

4.3.2. Expectation Alignment

In this section, the extent to which the expectations of the citizens on the heat transition align with local and national governments will be examined in accordance with participants' income level, legal ownership status, house types, and the house age groups. The necessary data for this section was obtained via question 10 of the field survey.

First, figure 35 demonstrates how the level of expectation alignment is changed by different income groups. As can be seen from figure 35, the lowest expectation alignment occurred in the lowest income group (under 20.000 Euros per year), while the increase in income level resulted in greater alignment in expectation between residents and the national and local authorities.

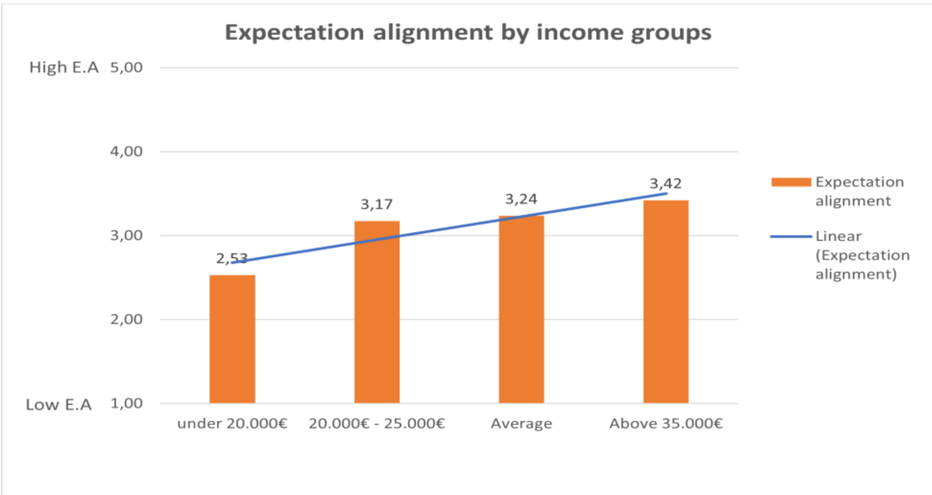


Figure 35.Expectation alignment by income groups

Second, figure 36 represents how the level of expectation alignment is changed by legal ownership status. According to figure 36, the rate of alignment between the expectations of residents, who are tenants from private landlords, with local and national governments on heat transition is the lowest with 3.0 out of 5. While this ratio is 3.2 among those who are tenants of housing corporations, it rose up to its peak at 3.24 out of 5 among homeowners.

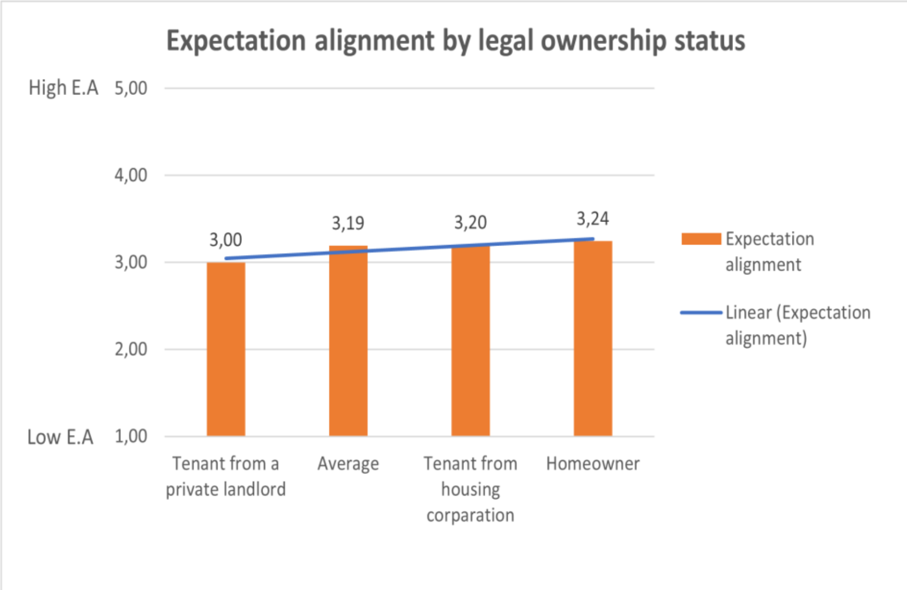


Figure 36.Expectation alignment by legal ownership status

Third, figure 37 shows the variations of the participant's expectation alignment with the local and national authorities in accordance with the house types of the survey participants. While those living in flats/apartments rated the lowest expectation alignment by 3 out of 5, this ratio exceeded the average of 3,19 among those living in terraced houses by 3.31. Next, it reaches the highest level among those residing in detached houses by 3.55.

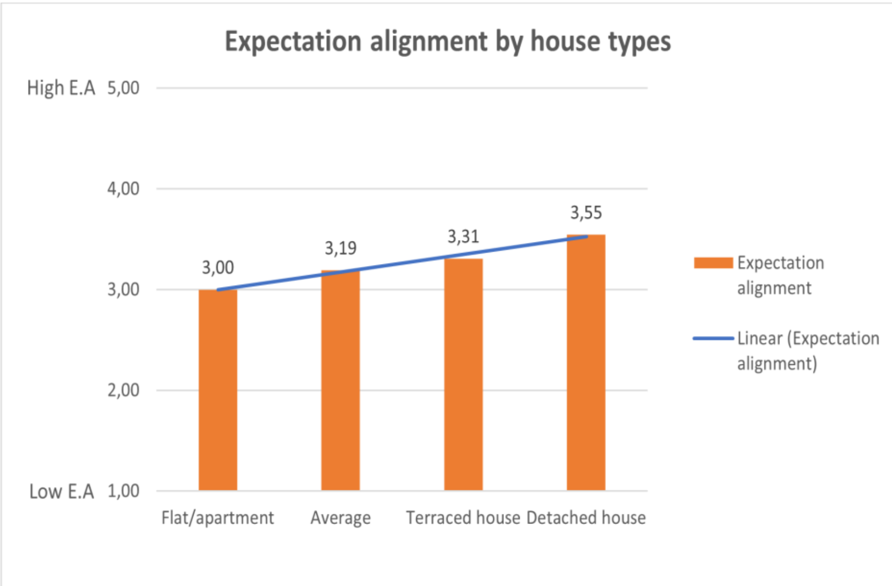


Figure 37.Expectation alignment by house types

Fourth, figure 38 shows how the expectation alignment of residents varied based on the different house age groups. According to figure 38, expectation alignment peaked at 3.67 over 5 among residents living in houses aged 0-10. Then the ratio experienced a steady decline and decreased to 3.33 for those living in homes aged 10-20, and 3.13 for those living in homes aged 20-30. Finally, the ratio saw its lowest at 3,04 among those who live in houses aged 30 and over.

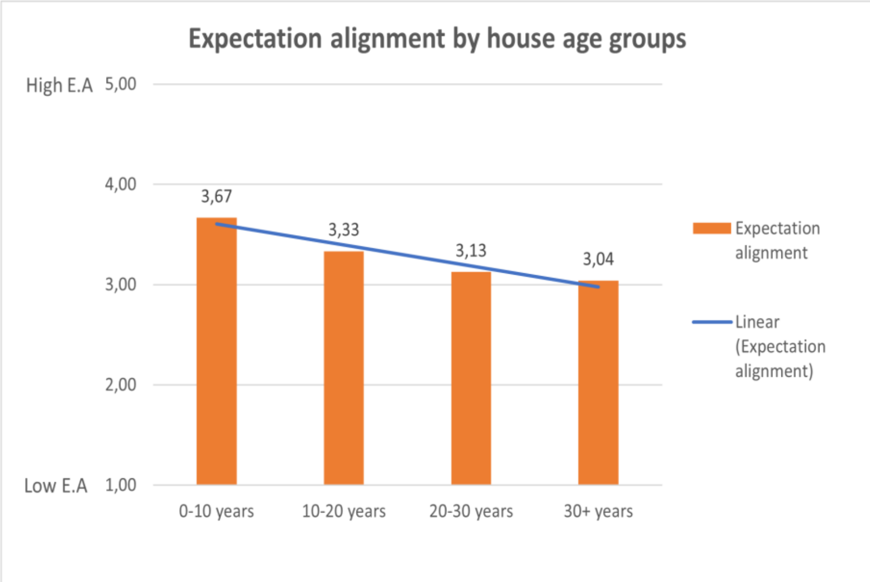


Figure 38.Expectation alignment by the age of houses

On the other hands it is important to note that no meaningful correlation was reached between the expectation alignment and the age of residents.

4.3.3. Resource Acquisition

In this section, the survey results on what share of the cost of the heat transition should be met by the local and national authorities will be examined by looking at several factors: Residents' age groups, income level groups and legal ownership status. The data used in this section were obtained through the 21st question asked in the field survey.

First figure 39 shows the proportional distribution of what percentage of the cost of heat transition should be met by the local and national authorities in accordance with the age groups of participants. As can be seen from figure 39, residents aged 35 and younger indicate that local and national governments should bear about 45% of the costs incurred in the heat transition. While this rate is approximately 49% in the 35-44 age group by a slight increase, it reaches its peak at about 63% among the 45-54 age group. Then, a downtrend begins, and the ratio drops to about %55 among the 55-64 age group. Finally, it reaches approximately 48% among those who are 65 and over.

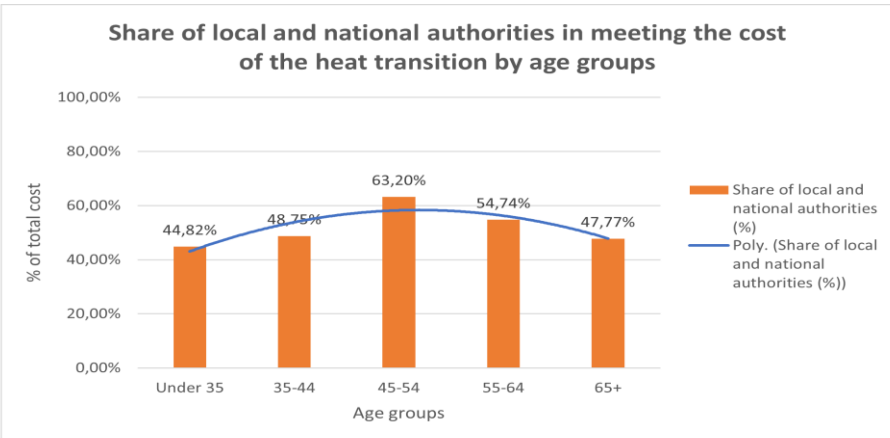


Figure 39.Resource acquisition by age groups

Second, figure 40 represents the relation between the participant's scores on to what extent the local and the national government should bear the cost of the heat transition and the income level groups of the survey participants. According to figure 40, residents earning less than 20,000 Euros per year indicate that about 54% of the cost should be covered by local and national governments. This ratio drops to approximately 40% for those whose annual income is between 20,000-35,000 Euros. Then, the proportion reaches about 51% with an increase of approximately 11% in those who earn 35.000 Euro and over annually.

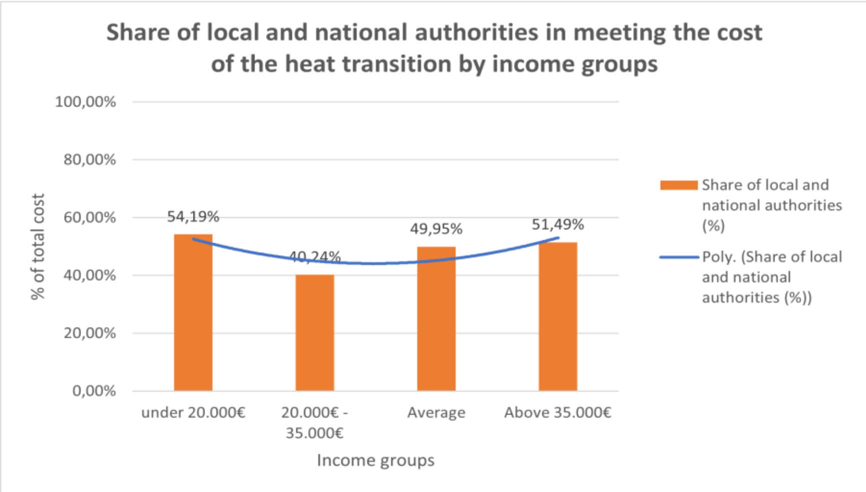


Figure 40.Resource acquisition by income groups

Third, figure 41 shows the distribution of the share of local and national governments in covering the cost of heat transition by legal ownership status. What figure 41 demonstrates is that residents who are tenants from private landlords gave the lowest share to local and national governments in covering the cost of the heat transition at 42.5%, while the shares found suitable by tenants from home companies and the homeowners to the local and national authorities are 51.65% and 52.42% respectively.

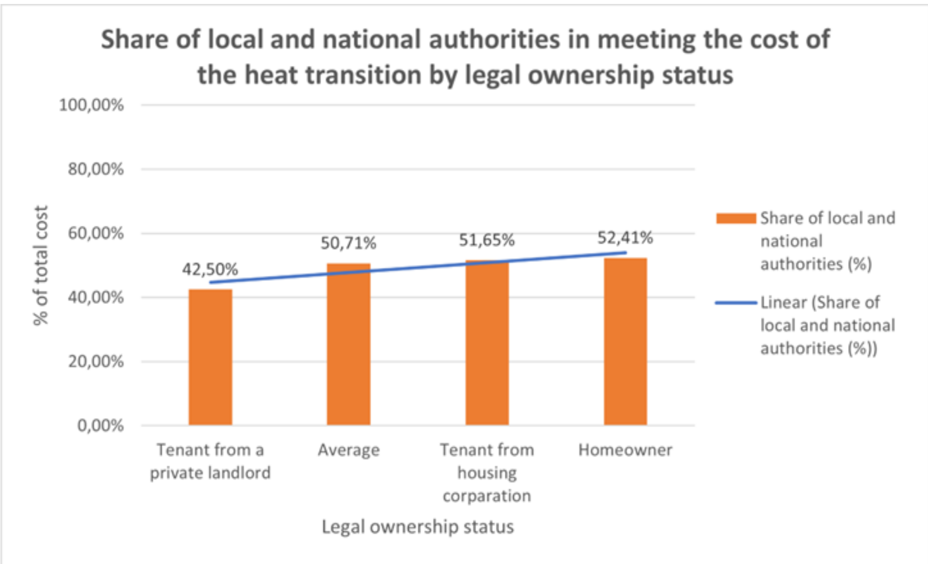


Figure 41.Resource acquisition by legal ownership status

On the other hand, it should be indicated that no correlation was found between the resource acquisition and the type of house and age.

4.4. Goal and outcomes

4.4.1. Effectiveness

This section examines the results of the survey based on question 16th at which stage of the heat transition the participation of residents would make the process more effective. Various physical and social characteristics are used: Income groups, legal ownership status, and house types.

First, figure 42 shows the phase in which residents want to be involved in the process by income groups. At first glance, it is striking that the rate of expression of opinion from those whose annual income is either under 20.000 Euros or above 35.000 is higher than those whose annual income is between 20.000-35.000. Residents with an annual income of fewer than 20,000 Euros stated that being involved in the process in the early and final stages would make the process more effective (70% and 65%, respectively), while 70% of residents with an annual income of 35,000 and above stated that being involved in the process in the design phase was the most effective. In contrast, residents with an annual income of 20,000-35,000 Euros got the highest scores with 52% early phase and 48% design phase, while these rates remained at 30% for the implementation and final phases.

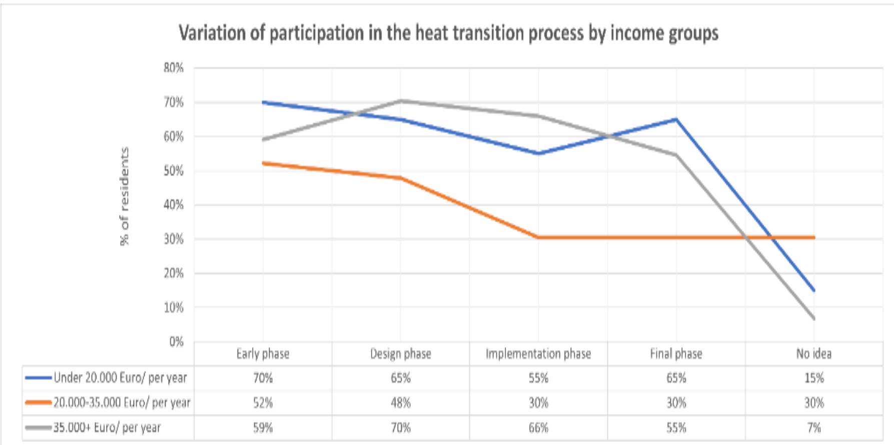


Figure 42.Effective participation by income groups

Second, figure 43 shows the percentage distribution of the heat transition phases that residents find most efficient to be involved in, by legal ownership status. According to figure 43, first of all, the heat transition phases that the homeowners find the most effective is the early and design phase (62% and 67% respectively). Willingness for the other phases is trending lower and sees a bottom at 44% for the final phase. A similar trend comes about for tenants from housing corporations. High percentages in the early phase and design phase then decline in later phases. While tenants from private landlords state the same willingness for almost all phases (excluding the implementation phase, which is at 33%), the most striking thing is that 27% of residents say they have no idea, which is the highest compared to homeowners and tenants of housing corporations.

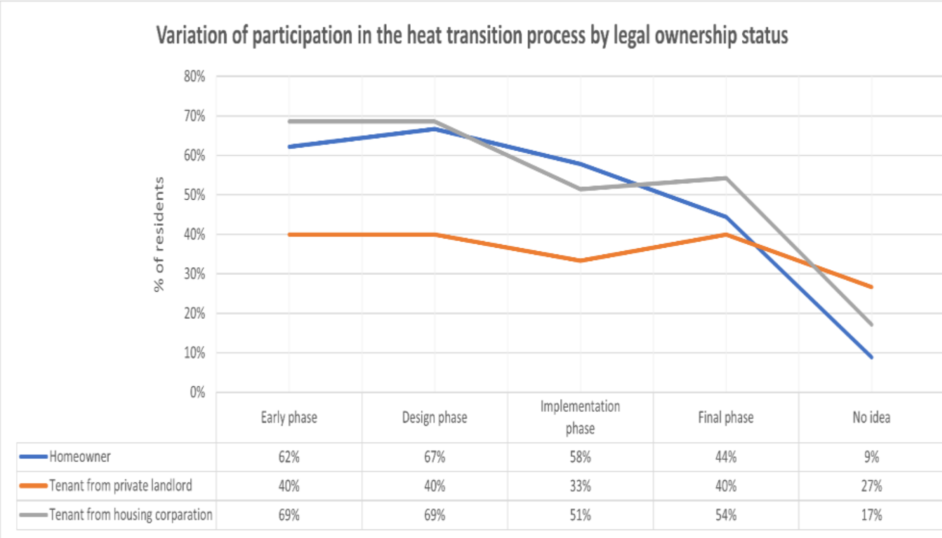


Figure 43.Effective participation by legal ownership status

Third, figure 44 shows the percentage distribution in which phases the residents living in different house types find their participation in the heat transition process more effective. While the general trend is that the participation of the residents will make the process less effective as the stages progress, 75% of the detached house's residents state that their participation in the design phase will make the process the most effective, which diverges from general trend.

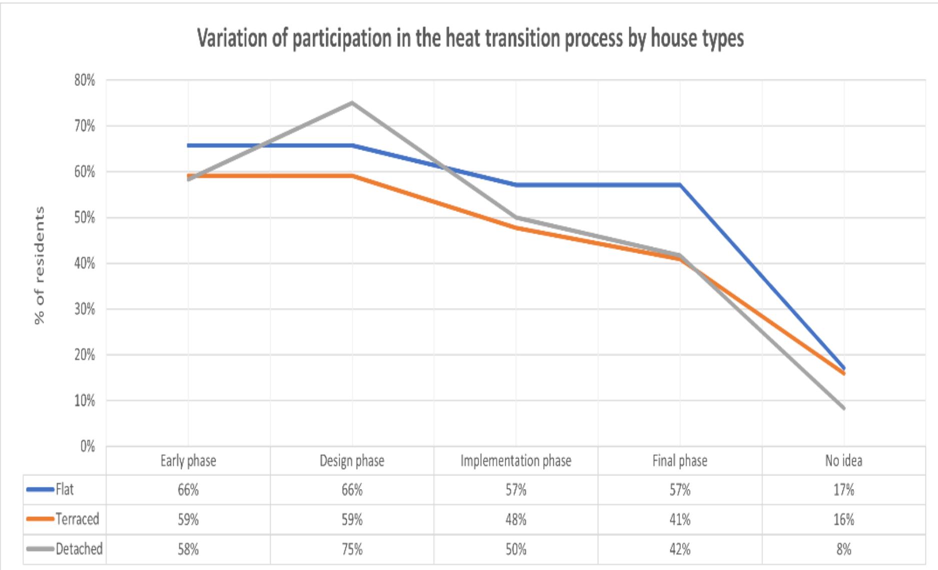


Figure 44.Effective participation by house types

4.4.2. Efficiency

In this section, the importance of cost-efficiency in making decision on the heat transition will be examined. The factors are used in this section are the income groups, the legal ownership status, and the age groups of participants. This section is prepared based on the 11th question of the field survey.

First, figure 45 shows to what extent cost-efficiency in heat transition is important according to income groups. As can be seen from figure 45, as the residents' income increases, the importance of cost efficiency, which is one of the driving factors when making decisions in heat transition, decreases. In detail, while 74% of the residents whose annual income is below 20,000 Euros stated that cost efficiency is an important factor in the heat transition, this rate is 64% for those whose annual income is between 20,000-35,000 Euros. The rate of those who stated that cost efficiency was the main factor in their decision was at the bottom at 49% among ones whose annual income is more than 35,000 Euros.

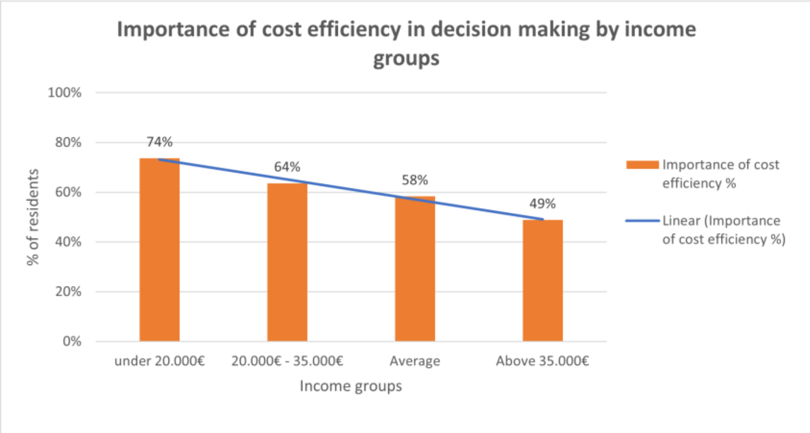


Figure 45.Importance of cost efficiency by income groups

Second, figure 46 shows how important cost efficiency is for different legal ownership statuses. As can be seen from figure 46, while 53% of the residents who are tenants from private landlords stated that cost efficiency is an important factor when deciding on heat transition, this rate is at approximately 70% among tenants of housing corporations. In contrast, only 45% of homeowners identified cost efficiency as a key factor when making decisions about the heat transition.

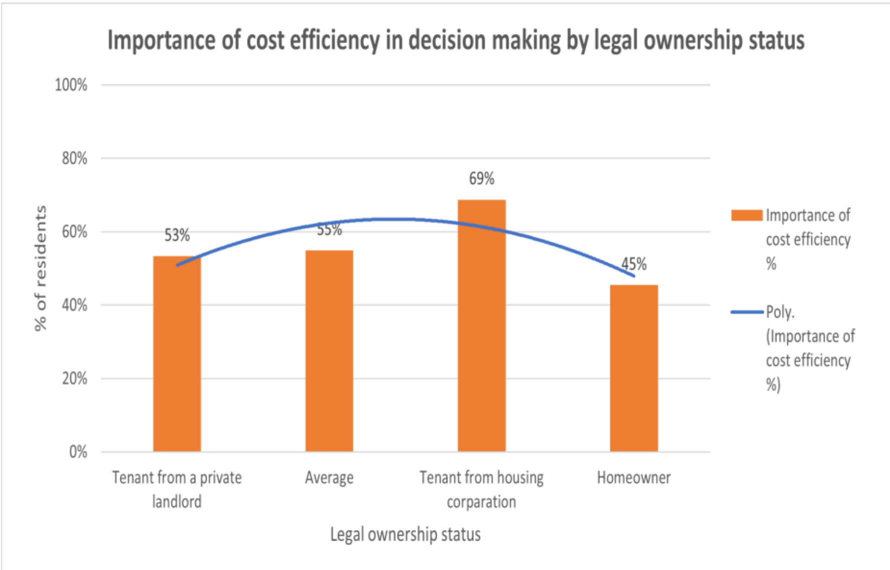


Figure 46.Importance of cost efficiency by legal ownership status

Third, figure 47 represents the variations of cost efficiency in making decisions according to different age groups of residents. As can be seen from figure 47, all age groups are almost equal at approximately 45% with only a 3% difference except for the group of people aged between 45-54. Almost three-quarters of those aged 45-54 stated that cost efficiency is an important factor in heat transition-related decision mechanisms.

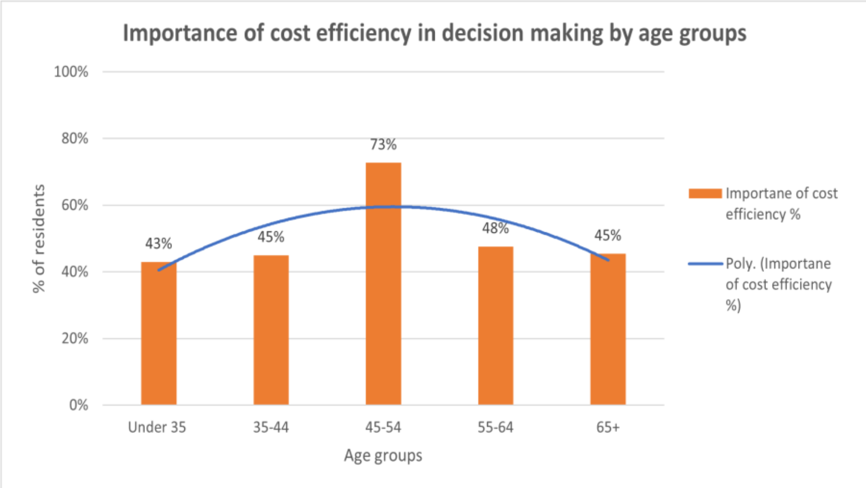


Figure 47.Importance of cost efficiency by age groups

On the other hand, it is noteworthy to mention that no correlation was found between the efficiency concept and the type of house and the house's age.

4.4.3. Social Acceptability

4.4.3.1. Social acceptability of new heating systems

In this section, the desire to replace the heat source with new generation heating sources (heat pump, connected heat network, etc.) among residents whose heat source is gas or fuel oil will be examined according to several factors: Resident's annual income, the house types, and legal ownership status. To do so, the 7th question of the field survey is employed in this section.

First, figure 48 shows how the willingness to replace existing heat sources changes in accordance with the annual income of residents. As can be seen from figure 48, there is an upward trend parallel to the income level. In detail, the willingness to change the existing heating system for residents whose income is less than 20,000 Euros per year is the lowest at 2.5 out of 5. While the willingness reaches its peak at 3.77 for those with an annual income of 20.000-35.000 Euros, this rate experiences a slight decrease of 0,13 and drops to 3.64 among those whose annual income is above 35.000 Euros.

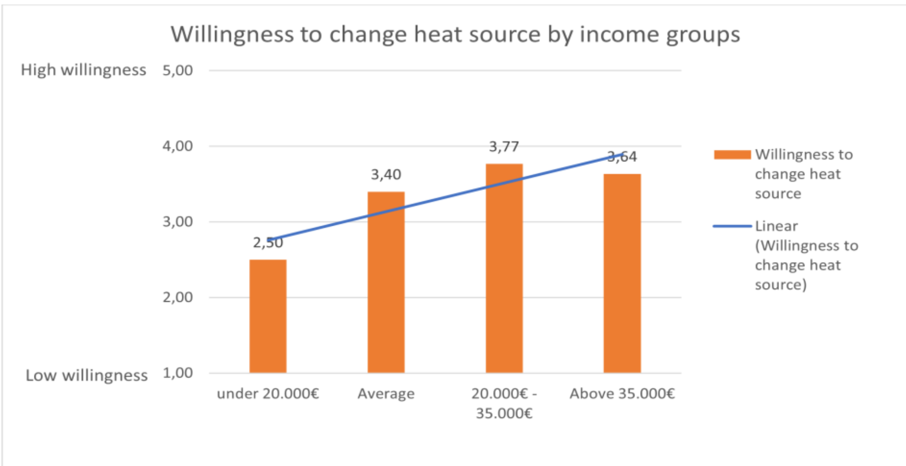


Figure 48.Willingness to change heat source by income groups

Second, figure 49 demonstrates the variation of the willingness in replacing existing gas/oil heat systems with new heating systems such as heat pumps by legal ownership status. According to figure

49, while the lowest willingness was 2.14 over the 5 among the tenants from the private landlords, this rate increased linearly and reached 2.4 in the tenants from the house companies. Then, the ratio increases dramatically, reaching the highest level of 3.18 out of 5 among homeowners.

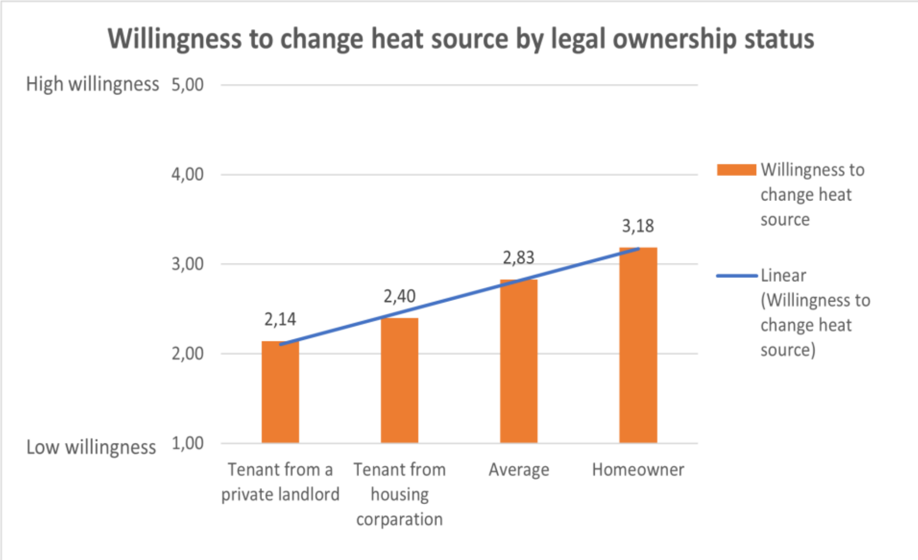


Figure 49.Willingness to change heat source by legal ownership status

Third, figure 50 shows how the willingness to change existing heating systems alters by house type. As can be seen from figure 50, flat/apartment residents' willingness to change the existing heating system is at the lowest level at 2.81/5. This willingness increased sharply, reaching 3.5/5 for those living in terraced houses, exceeding the average. Finally, the desire to change the heating system among those living in detached houses is at the highest level at 4.36/5.

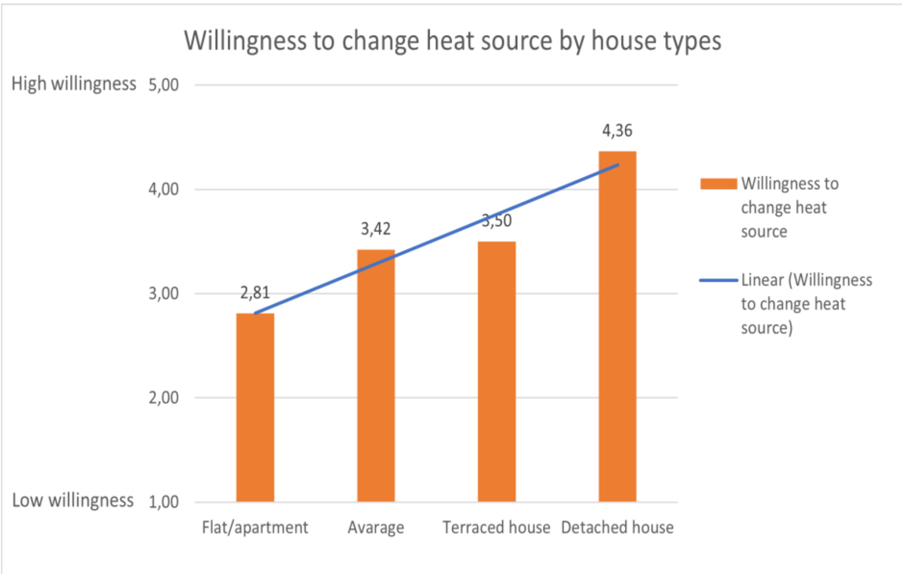


Figure 50.Willingness to change heat source by house types

On the hand, it should be stated that no correlation was found between the social acceptability of new heating systems and the age of residents and age of the house.

4.4.3.2. Social acceptability of the heat transition

In this section, the social acceptability of the heat transition will be examined by the income groups of participants, house types, house age group, legal ownership status, and age of residents respectively. This section predicates the 9th question of the field survey.

First, figure 51 represents the correlation between support for policy change and the income levels of residents. What can be concluded from figure 51 is that support for the realization of heat transition in all income groups is over 80 percent (>4/5). In detail, while the rate of support for the heat transition is 4.10/5 for residents with an annual income of fewer than 20.000 Euros, this rate is 4.17 with a slight increase for residents with a yearly income of 20.000-35.000 Euros. Finally, the rate reaches 4.23/5 for residents whose annual income is above 35.000 Euros.

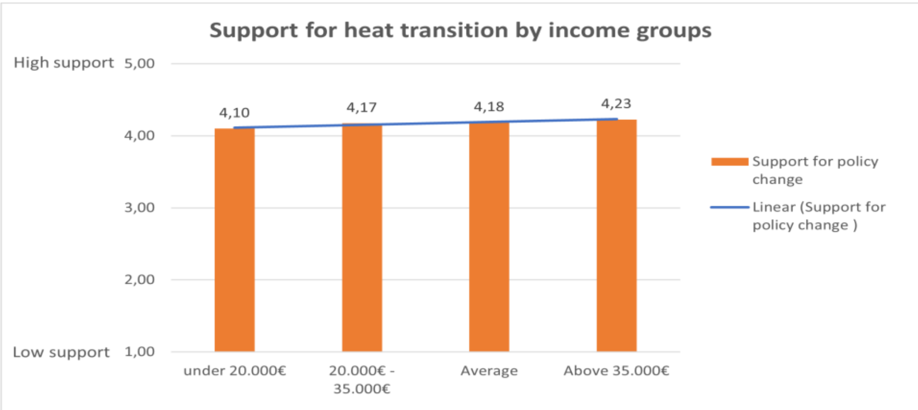


Figure 51.Support for the heat transition by income groups

Second, figure 52 shows how the support for the heat transition is changed by depending on the different house types. As can easily be seen from figure 52, while the rate of support for the process is at the lowest level with 4.11 out of 5 for the residents living in flats/apartments, this rate is 4.16 with a small increase for those living in terraced houses. Unlike those living in other house types, the rate of support for heat transition among residents living in detached houses peaks at 4.58/5, well above the average (4.20/5).

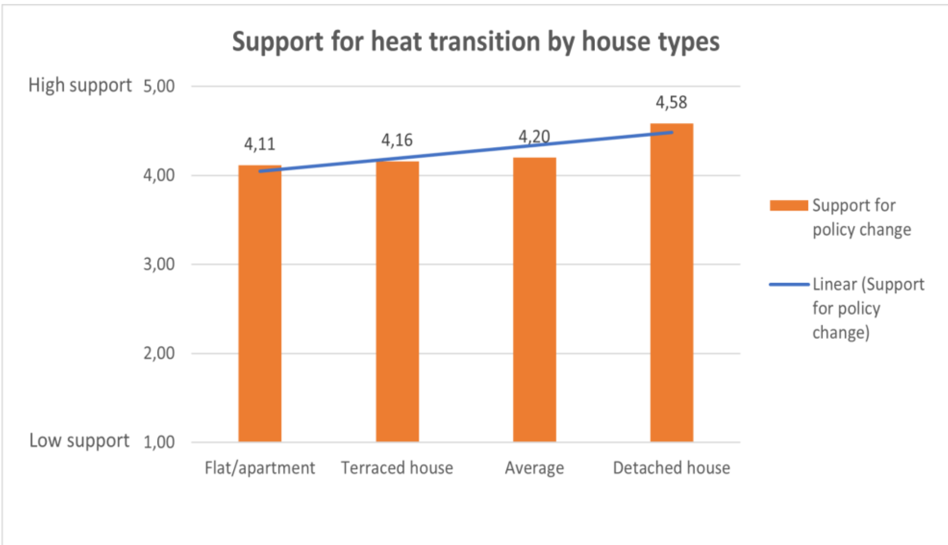


Figure 52.Support for the heat transition by house types

Third, figure 53 represents the variations of the support for the heat transition by the participant's house ages. At a first glance to figure 53, an expansionary support line is observed with the increasing age of the houses. In detail, the rate of supporting the heat transition among residents living in the house aged 0-10 years is at the highest level at 4.23/5. This rate then enters a downward trend and decreases to 4.14 among those living in houses aged 10-20. Then, the downtrend continues until the support rate experiences the bottom at 3.94 for those residing in the house aged 20-30 years. In the last part, the support rate increases again and becomes 4.18 out of 5 among those living in houses over 30 years old.

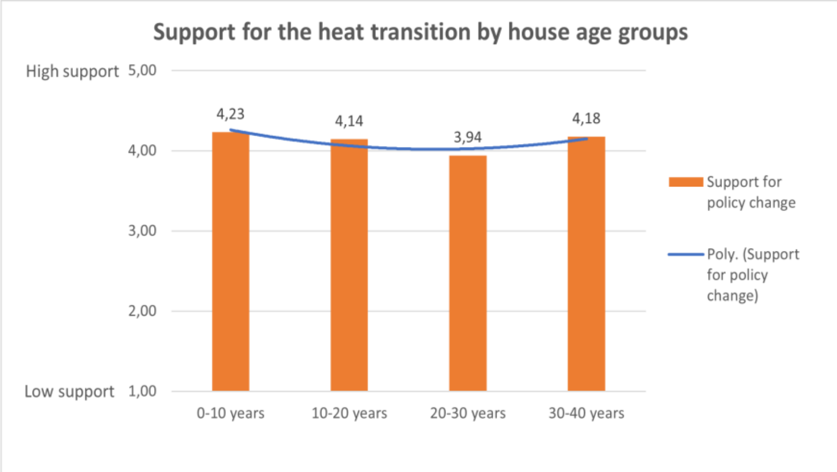


Figure 53.Support for the heat transition by the age of houses

Fourth, figure 54 shows the distribution of residents' support for the heat transition policy by home ownership status. According to figure 54, the lowest support for the heat transition policy is at 3.93/5 among tenants of private landlords, while it is slightly higher for homeowners with a rate of 4.09/5. The highest rate of support for the heat transition policies is at 4.31/5 among tenants of housing corporations.

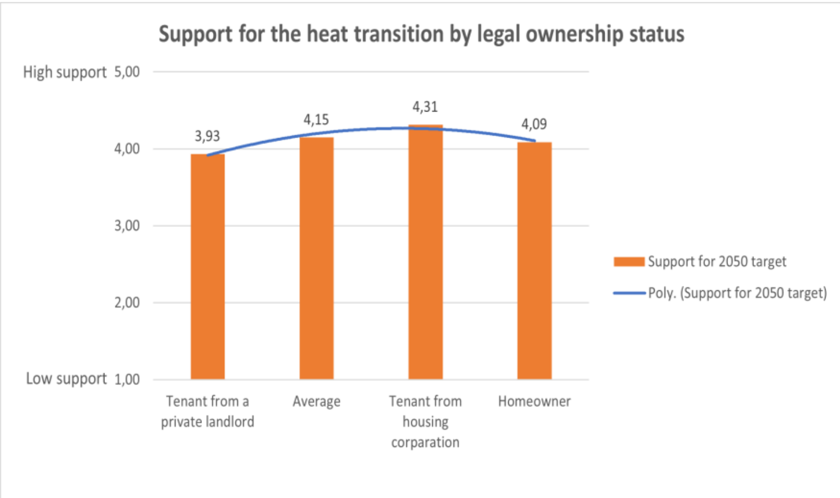


Figure 54.Support for the heat transition by legal ownership status

Lastly, figure 55 demonstrates the support for the heat transition policy by the age groups of residents. It can be seen from figure 55, while the support level was 4/5 among residents aged under 35, the ratio reaches its lowest at 3.6/5 among residents aged between 35 and 44. After that, the level of support rises as the age of residents increases. Finally, the support for the heat transition reaches its peak at 4,46/5 among residents aged 65 plus.

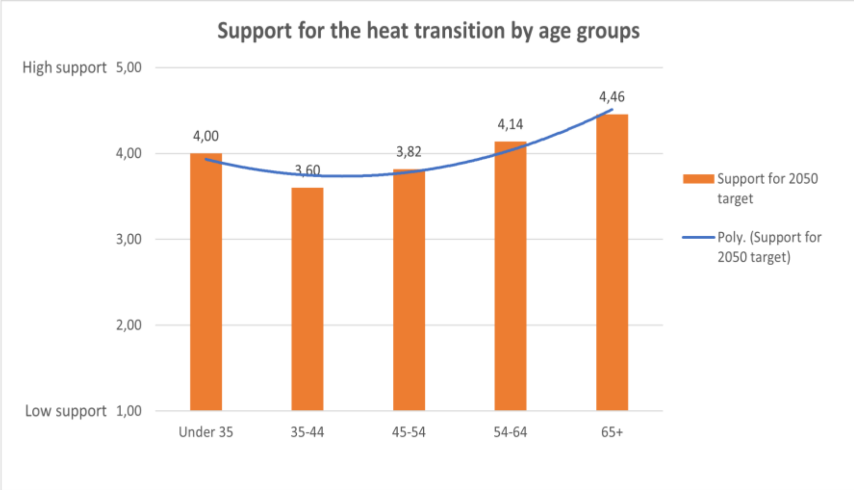


Figure 55.Support for the heat transition by age groups

4.5. Barriers and Opportunities

In this section the barriers and the opportunities in implementing the heat transition in Nijmegen will be explained based on the interviews conducted with experts and the survey results. This section is intended to answer the third sub-question asked in this research.

4.5.1. Barriers

In this section, barriers that slow down and/or block the heat transition of Nijmegen will be explained based on the interviews and field questionnaire conducted in this research. The barriers are divided into four different sections as follows: Financial, technical, physical, and social.

4.5.1.1. Financial Barriers

The first barrier identified in this study is the high cost of the heat transition. J. Doggen (personal communication, July 1, 2022) describes the transition as *'extremely expensive'*, while E. Maessen (personal communication, July 6, 2022) states that the heat transition of Nijmegen is much more expensive than anticipated due to the disruption of the supply chain after Covid 19 and the invasion of Ukraine. Hence, J. Doggen (personal communication, July 1, 2022) emphasizes the fact that the cost of the heat transition (insulation, installation of new heating systems, etc.) cannot be met by low-income groups. The survey's findings confirm that as income levels decline, support for the transition declines. For instance, the willingness to change existing gas or oil heating source is relatively lower in Hatert and Dukenburg compared to other neighborhoods due to the fact that these two neighborhoods have lower average income among others. In addition, answer no 5, 30,71 and 83 among the residents who participated in the survey stated that the heat network is extremely costly to the citizens. Therefore, achieving the decarbonization of Nijmegen is explicitly dependent on the existence of financial support that is able to ease the financial burden residents face. Second barrier identified is uncertainty of payoff for investments made for houses. As it is acknowledged in the survey results, due to the old age of the houses in Nijmegen, houses primarily need insulation before any heating solution is implemented. In addition, since cost-efficiency is the most important decision-making factor for residents in low-income neighborhoods, residents attach importance to how quickly their investments will pay off. J. Doggen (personal communication, July 1, 2022) tells that

'Finance is one of the most important driving factors in decision making.. people look at sort of the balance between the payoff.' Therefore, the uncertainty of whether investments will payoff is need to be cleared to achieve the realization of the heat transition in Nijmegen. Beside the main barriers explained above, there are several minor barriers within the financial barriers, which have an implicit impact on the heat transition of Nijmegen. One of the barriers in this group is the rental market, hence the barriers that tenants will face with the heat transition. According to J. Doggen (personal communication, July 1, 2022), once the transition happens, along with high investments made by both private landlord and housing corporation, the rents will increase. As approved by the results of the survey, tenants are less willing to participate/support/contribute to the heat transition compared to homeowners. Relatedly, J. Doggen (personal communication, July 1, 2022) emphasizes that tenants of private landlords may be reluctant to invest in the houses they rent. Considering that the inhabitants of Nijmegen are tenants from private owners in considerable proportions, it is considered as a barrier in the heat transition process of Nijmegen.

4.5.1.2. Technical Barriers

On the technical side, there are multiple barriers to the heat transition of Nijmegen. As it is aforementioned, the neighborhood approach is the primary strategy for heat transition in the Netherlands. However, according to E. Maessen (personal communication, July 6, 2022), the neighborhood approach constitutes a barrier as its scale is too big for applying a solution that fits all. He continues *'…what we learned is that a neighborhood with 2000 or 3000 houses is too big to find one solution.'* By examining the case studies, it can easily be seen that a neighborhood may contain multiple social and physical characteristics. For example, although about 500 homes in one part of the Hengstdal neighborhood have been converted to individual heat pumps for heating (E. Maessen, personal communication, July 6, 2022), this solution is unlikely to be used in Hengstdal's low-income areas due to the high cost of individual heat pumps. Furthermore, E. Maessen (personal communication, July 6, 2022) states that the houses built in the 1890s and 2000s exist in the same neighborhood in Nijmegen and adds that *'the difference is really big and to choose one solution, it's almost impossible if you have such a diversity of buildings.'* Therefore, the scale of the neighborhood approach is a barrier to the decarbonization of built environment in Nijmegen. Another barrier within the technical domain is the fact that the heat transition requires a much greater time than expected. E. Maessen (personal communication, July 6, 2022) claims that the heat transition in Nijmegen is not occurring as quickly as it should be because the process requires a lot more time and effort than the municipality had anticipated. The survey results confirm that some neighborhoods have not made any progress in terms of the heat transition even though the municipality should have begun to take off the gas in all chosen neighborhoods since the beginning of 2018 according to the heat vision published by the Municipality of Nijmegen. For example, the residents who reported that they were least informed by the municipality are from Hatert. According to E. Maessen (personal communication, July 6, 2022), the municipality was unable to devote time and resources to the Hatert district at that moment. For this reason, it is not surprising that the municipality will update its heat vision within the next year (E. Maessen, personal communication, July 6, 2022). To summurize, because the transition takes longer than anticipated, the Nijmegen heat transition encounters a time barrier that impede the process in some neighborhoods.

4.5.1.3. Physical Barriers

On the physical side, the barriers exist in the process are various. First, the most serious obstacle on the physical side to Nijmegen heat transition is the great need for insulation of houses. According to survey results, only about 34% of the respondents stated that the energy class of their houses is A and above. This confirms that a significant portion of the houses are disadvantaged in terms of energy saving, which requires a huge task of insulation in Nijmegen to achieve the decarbonization of built environment. E. Maessen (personal communication, July 6, 2022) argues that the age of the building is directly correlated to the need for insulation and states that the cost of insulation for a house increases as the house gets older. Therefore, neighborhoods, where the average income is relatively lower and/or where the average house age is older, may not be able to fulfill the isolation task that is vital for neighborhoods to achieve a gas-free built environment. Hence, insulation need is one of the major barriers to the heat transition of Nijmegen. Another barrier identified on the physical side is that new heating systems physically cause uncomfortable experiences for users. According to the survey results, participants 5, 50 and 77 state that heat pumps cause high noise and emphasize the need for sound insulation. By considering that some neighborhoods such as Hengstdal have no heat source that can be used, the primary heat solution for these neighborhoods is expected to be heat pumps (E. Maessen, personal communication, July 6, 2022). In addition, J. Doggen (personal communication, July 1, 2022) argues: *'...They (residents) have the power to say no right now. You can't be obliged to join a heating system at the moment.'* Therefore, the unpleasant physical properties of heating systems are one of the barriers that hamper the realization of the heat transition in Nijmegen.

4.5.1.4. Social Barriers

On social dimension, there are several barriers that impede the heat transition of Nijmegen. First, as it is aforementioned, the Netherlands aims to decarbonize the built environment by 2050. However, calculating based on human lifetime, it is difficult for citizens to incorporate a policy target that is set too far. J.Doggen (personal communication, July 1, 2022) expresses her thought as *'...I think residents, of course, they are more focused on how they live, where they live, with whom they live and about their life and not busy with the stuff behind it or not thinking about the stuff behind it. They don't have the date of 2050.'* Also, the transition target to 2050 is risky for citizens as it implies that gas will be available as a heating option by 2050. Therefore, the policy target that is set too far is decribed as a barrier for the heat transition of Nijmegen. Another significant barrier in the social sphere is that the tenants' voices are not sufficiently heard during the process and their participation in the process is limited. E. Maessen (personal communication, July 6, 2022) emphasizes the fact that tenants are not obliged to do anything about houses as homeowners do. As the survey study results will confirm, the groups with the lowest expectation alignment and the least willing to participate in the process are the tenants. Furthermore, the participants number 40, 43 and 59 explain that tenants do not get a lot of to say in the process. Number 43 clarifies by saying *'I would like to (change the heating system), but my landlord is holding back a lot'.* Therefore, the limited role and power of tenants is found to be a barrier to Nijmegen's heat transfer, given that the majority of Nijmegen's residents are tenants. Next, institutions except for the municipality of Nijmegen do not sufficiently inform the citizens is another barrier against the Nijmegen heat transition. As the survey results prove, residents who are primarily informed about heat transition by the municipality and other institutions are more willing to replace their gas/oil-based heating systems. However, according to E. Maessen (personal communication, July 6, 2022), institutions except the municipality are inadequate in informing residents about heat transition, particularly emphasizing the need for housing corporations to be more active. Correspondingly, the participant of survey, Number 95 states the fact that *'... In order to get the entire district off gas, more support and guidance from the government must be provided.'* Also, participant number 32, 41, 49 and 54 emphasize the lack of knowledge that they have about the transition. For these reasons, the inability of institutions except the municipality to adequately inform the public is identified as another barrier to the heat transition of Nijmegen. Last barrier identified within the social sphere is that the challenge of creating a process in which everyone participates. As it is aforementioned, the heat transition requires active citizen involvement in the process due to the fact that citizens have the last word in their heating system. However, J.Doggen (personal communication, July 1, 2022) states that it is not possible for everyone to participate in the process because taking off neighborhoods from natural gas has not become widespread yet. In practice, for example, in order to make the transition to heat pumps for about 500 houses in the Hengstdal neighborhood, the municipality plans to conduct a field survey in October, 2022 to measure the willingness of citizens to participate. At least seventy percent of residents must approve the process for the transition to take place (E. Maessen, personal communication, July 6, 2022). Considering the other barriers explained above, the difficulty of collective co-decision is a barrier to Nijmegen's heat transition.

4.5.1.5. Overview of Barriers

The barriers that either impede or slow down the heat transition in Nijmegen identified above can be seen from the table 9.

Financial Barriers	**Technical Barriers**	**Physical Barriers**	**Social Barriers**
High cost of the heat transition	Scale of the neighborhood approach is too large	High need for insulation	2050 policy target seems too far
Uncertainty of investment's payoff	The heat transition takes a longer time than projected.	Inconveniences of new heating systems	Inadequate effort of institutions (except the Municipality of Nijmegen) to inform residents
Uncertainty of rental market	-	-	Difficulty of reaching consensus

Table 9. Overview of the barriers existed in the heat transition in Nijmegen

4.5.2. Opportunities

In this section, opportunities that enabling and/or facilitating the heat transition of Nijmegen will be explained. Opportunities are divided into four different sections as follows: Financial, technical, physical, and social.

4.5.2.1. Financial Opportunities

Nijmegen has several opportunities in the process of achieving decarbonization of the built environment. First, the municipality of Nijmegen has a transition fund particularly allocated for the realization of the heat transition in the city (E. Maessen, personal communication, July 6, 2022). This resource provides an opportunity for the municipality to test heat transition projects in neighborhoods, as well as makes possible several services to happen such as public consultancy, informative events, panels and, etc. J. Doggen (personal communication, July 1, 2022) contends that as municipalities are given complete responsibility over the heat transition by the national government, local government plays a crucial role in the process. Therefore, the transition fund that the municipality of Nijmegen helds for the realization of the heat transition is identified as opportunity for Nijmegen. Second, the selection of Nijmegen's two neighborhoods (Dukenburg and Hengstdal) as pilots at the national and state level projects is another financial opportunity for the city. As it is aforementioned, Dukenburg is one of the 27 neighborhoods selected at the national level for heat transition and Hengstdal is part of "Green Deal natural gas-free neighborhoods" project ("Green Deal aardgasvrije wijken" in Dutch) at the national level and "District of the future" project ("Wijk van de toekomst" in Dutch) at the regional level. Considering that these projects are funded by the national government and the province of Gelderland, these projects will be a source of inspiration for the transition of other neighborhoods of Nijmegen. For these reasons, the selection of

Dukenburg and Hengstdal as pilot neighborhoods for the heat transition projects at the national and regional levels is an opportunity for the city of Nijmegen.

4.5.2.2. Technical opportunities

There are number of technical conveniences that are identified as opportunity for the realization of Nijmegen heat transition. First, the municipality of Nijmegen takes various roles in management of transition process based on the physical and social characteristics of neighborhoods. According to E. Maessen (personal communication, July 6, 2022), the municipality plays different roles depending on the neighborhood, assuming more of an accelerator role in neighborhoods where average income and educational level is relatively higher such as Hengstdal, and more of a director role in neighborhoods such as Dukenburg that lack the capacity to implement change on their own. The fact that the municipality of Nijmegen adopts different approaches that consider the different social and physical characteristics of the neighborhoods is an opportunity for the heat transformation in Nijmegen. Secondly, as it is aforementioned, there are areas where transition has been finalized in the city of Nijmegen. The existence of zones that are completely free of natural gas is another facilitating factor for Nijmegen in terms of proving that the process is in a running state. Based on her own research, J. Doggen (personal communication, July 1, 2022) states, *''...I found out that there are a lot of neighborhoods who(that) have at least some people enthusiastic for (about) the heat transition and you need to have a few. And once you have a few, you know the ball will start rolling and maybe more will join''.* Therefore, the availability of areas where the houses are completely taken off natural gas in Nijmegen is identified as a facilitating factor for the city's transition as that gives the rest of the city the impression that the process is active.

4.5.2.3. Physical opportunities

Several physical opportunities are identified in this research that is highly likely to facilitate the heat transition of Nijmegen. First, as it can be seen figure 8, the city of Nijmegen has a heat network, although it is not yet completed. When the heat network planned by the municipality is completed, the fact that many parts of the city will have access to the heat network. Therefore, the existence of heat network is identified as a facilitative factor in the transition process. Second, according to the survey results, an increase is observed in the insulation levels of the houses after the age of the houses exceeds 40 years. J. Doggen (personal communication, July 1, 2022) expresses the importance of insulation as, *''…housing age I think (it) is really important because if you want the heat transition to work and if you want a heating network, for example, in a neighborhood or homes should be isolated as much as possible because otherwise it probably won't work.''* Correspondingly, E. Maessen (personal communication, July 6, 2022) states that either high or low-temperature heating solutions will not work unless homes are adequately insulated. Therefore, based on the survey results, the relatively high level of insulation in houses aged over 40 was identified as a facilitating factor for Nijmegen heat transition.

4.5.2.4. Social opportunities

There are multiple social opportunities for the heat transition of Nijmegen. One of them is the existence of active neighborhood organizations that deals with energy-related problems of neighborhoods in Nijmegen. J. Doggen (personal communication, July 1, 2022) states that people with intrinsic motivation in neighborhood organizations can positively affect the process through factors such as active communication with residents and lobbying. Looking at the results of the survey, residents of Hengstdal were the ones most informed by the neighborhood organizations compared to residents of other neighborhoods, thanks to the Sustainable Hengstdal. Consequently, the willingness of residents to change their heating systems is relatively high in the Hengstdal, along with many other factors. As a result, it is acknowledged that the presence of neighborhood organizations in the case areas, both with and without a direct focus on energy, function as a facilitator in the heat transfer of Nijmegen. Second, the municipality of Nijmegen implements the heat transition program through a participatory approach, which is a facilitating factor for the city to achieve a gas-free built environment. As it is aforementioned, the heat vision (Warmtevisie in Dutch) published by the municipality indicates that the municipality is not alone in the heat transition process and the municipality cooperates with various partners from housing corporations to energy companies as well as civil society organizations. As a representative of the municipality, E. Maessen (personal communication, July 6, 2022) states, ‘‘…*It's not one or the other. Everybody (all stakeholders) has to join in’’.* Therefore, the participatory approach that the municipality applies in the heat transition of Nijmegen has been identified as a facilitating factor.

4.5.2.5. Overview of Opportunities

The opportunities that either enable or facilitate the heat transition in Nijmegen identified above can be seen from the table 10.

Financial Opportunities	**Technical Opportunities**	**Physical Opportunities**	**Social Opportunities**
Transition fund of the municipality	Different roles that municipality of Nijmegen assumes	Existence of heat network	Existence of active neighborhood organization
Having the pilot neighborhoods for the heat transition	Existence of decarbonized zones	Relatively high insulation in homes aged over 40	Participatory approach of the Municipality

Table 10.Overview of opportunities existed in the heat transition in Nijmegen

5. Conclusion & Discussion

The outcomes of this research have provided insight into how the context-specificness of neighborhoods influences the citizens' attitude and role in the heat transition, as well as the barriers and opportunities of the process in Nijmegen. However, the results of this research should be interpreted with caution due to the limitations of the research. Therefore, the paragraph 5.1 contains the answers to the sub-questions and the main research question of this research. Then, the findings of the research are discussed based on previous academic research in the same regard in paragraph 5.2. Subsequently, the limitations of this research are clarified in paragraph 5.3. Lastly, paragraph 5.4 contains recommendation for practice and science.

5.1. Conclusion

By conducting both a field survey and multiple interviews as wells as literature review on the influence of neighborhoods' different physical and social characteristics in the heat transition of Nijmegen, this research has tried to answer the following research question:

How do the physical and social characteristics of neighborhoods in Nijmegen have an influence on the residents' attitudes and role in the heat transition, and what are considered barriers and opportunities to accelerate the heat transition in Nijmegen?

This main question is divided into three sub-questions. To answer the main research question, sub-questions will be answered at the outset.

The first sub-question refers to the impact of the social and physical environment in which citizens live on their possible participation, support, and contribution to the Nijmegen heat transition. The first sub question is formulated as follows:

'How does the social and physical environment of the neighborhood affect the citizens' attitudes and behaviors in participating/supporting /contributing/etc., to the heat transition in Nijmegen?'

This sub-question is tried to be explored through the survey conducted in five neighborhoods of Nijmegen in accordance with the conceptual framework. The results that are extensively shared in the previous chapter, indicates multiple correlations between the environment that citizen live in and citizens' attitudes toward the heat transition. First, several social characteristics are used: income level, age and legal ownership status of the residents. First of all, it was concluded that the income level affects the attitudes of the residents toward the heat transition of Nijmegen by affecting the level of participation, contribution, and support to the process. In detail, it is discovered that residents' participation in learning programmes with the theme of heat transition increased as their income levels rose. In parallel, growing support for heat transition policies is correlated with rising income. Also, it has been found that as residents' income levels rise, so does their willingness to contribute individually to the heat transition. Next, in parallel with the increase in the income level of the residents, it was found that the importance of cost-efficiency decreases, while the importance of environmental concerns increases in decisionmaking regard to heat transition. Lastly, it has been found that the higher the income level, the higher the willingness of residents to replace their existing unsustainable heating systems. To conclude, the income level of citizens has a decisive role in the level of involvement, support, and contribution of citizens to the heat transformation of Nijmegen. The second social characteristic used in this research is the age of the citizens. First, it is concluded that there is no correlation between residents' willingness to contribute to the heat transition and the age of residents. In contrast, it is concluded that support for heat transition policies is high in the younger and older residents, while it is low in the middle age group. These findings are compitable considering the fact that while the age group of 45-54 is the group with the greatest concern about the cost of the heat transition, the importance of the economical part of the transition decreases in younger and older groups. Also, the groups of 45-54 performed the least participation in the social events related to the heat transition. On the other hand, It is found that the residents over the age of 54 showed higher participation in social learning activities and environmental concerns are in the first place in this group. To conclude, the age of citizens has an impact on one's willingness to participate in and support the heat transformation of Nijmegen. The last of the social characteristics employed in this research is legal ownership status. It is discovered that the homeowners are the ones that have the highest willingness in participation and contribution to the heat transition of Nijmegen. In contrast, it is not the homeowners but the tenants from the housing corporations that are the most supportive of the heat transition policy. This result is in line with the findings that homeowners' expectations have less aligned with national and local governments than that of tenants from housing corporations. Another important finding is that the tenants of the private landlords participated the least in the heat transition-themed activities and indicated the least support for the heat transition policy. In addition, compared to homeowners, both types of tenant groups are less willing to make an individual contribution to the process. These results are in line with the fact that the group with the lowest willingness to switch to sustainable heating systems is tenants of private landlords.

The age of the house and the house's type are the two physical characteristics that were used in this study. First, It has been concluded that as the age of the house that citizen lives increases, the citizens becomes more willing to learn about the heat transition by participating in informative events with regard to heat transition. In contrast, as the age of the house increases, the alignment of residents' expectations with national and local governments decreases. Besides, It is concluded that house age affects the neither residents' support for the heat transition policy nor their willingness to make individual contributions. Another physical characteristic employed in this research is house type. It is discovered that citizens living in detached houses have the highest willingness to participate, support and contribute to the process. In contrast, citizens living in flats/apartments showed the lowest willingness level of participation, support, and contribution. These findings are in line with the other results that detached house residents have the highest expectation alignment with national and local governments on heat transition, and this group has the highest willingness in changing existing heating systems with sustainable ones.

The second sub-question focuses on how neighborhoods' distinctive physical and social features affect the Nijmegen heat transition that is carried out by the neighborhood approach. The second sub-question is formulated as follows:

How do different characteristics of the neighborhoods have an impact on the neighborhood's capacity for the realization of the heat transition in Nijmegen?

To answer the second sub-question, four different neighborhood capacities are identified for this research: Organizational capacity, personal capacity, infrastructural capacity, and social-cultural capacity. It is concluded that higher organizational capacity is found in neighborhoods where the average annual income is higher, the proportion of homeowners is higher compared to tenants, and high detached house/flat ratio. In addition, the existence of neighborhood organizations is also found effective in increasing the organizational capacity of neighborhoods in Nijmegen. However, no correlation was found between neither the age of citizens nor the age of the house, and the organizational capacity of the neighborhood. Next, it is found that the personal capacity of the neighborhoods is higher in the neighborhoods where the income level is higher, and as a result of this, where the ratio of homeowner/tenant and detached house/apartment is high. In addition, it has been noticed that personal capacity decreases in neighborhoods where little or no information event/campaign is carried out. As mentioned in the previous section, it has been discovered that the level of participation in informative activities/events varies according to not only social factors such as income, age, and home ownership status but also physical factors such as the house age and type of house citizens live in. Next, it is found that the infrastructural capacity of neighborhoods is higher in neighborhoods where the average annual household income is higher as a result of the findings that high-income neighborhoods generally consist of younger houses and individuals that are more willing to support the process. Moreover, It is concluded that the social-cultural potential of the neighborhoods indirectly affects the heat transition process. It is concluded that environmental concerns in the decision-making on heat transition are more important for residents of neighborhoods where the income level is higher, whereas cost-efficiency is a priority for residents of neighborhoods where the average annual income is lower. Lastly, it is concluded that existence of active neighborhood organization and presence of informative events/campaigns in neighborhoods makes residents more aware about the environmental and societal part of the transition, in turn, increases the social-cultural potential of neighborhood for achieving a sustainable built environment.

The third sub-question refers to the existing barriers and opportunities of the heat transition of Nijmegen based on the analysis made. The third sub-question is formulated as follows:

What are the barriers and opportunities of the heat transition in Nijmegen?

An extensive explanation of the barriers and opportunities in the Nijmegen heat transition was made in section 4.4. What can be concluded is that the process of heat transition in the city of Nijmegen is slowed down by various barriers that are driven by problems both internal and external to the city. In parallel with this, it has been found that the city of Nijmegen has national and local opportunities that have the potential to accelerate the transition process. In detail, the main barriers to achieving the decarbonization of the built environment in Nijmegen primarily consist of the financial burden of the transition, the largeness of the scale in the neighborhood approach, and the unrealistic perception of the 2050 policy target among residents. Other barriers defined in this research can be classified as minor barriers. As this research examines the effects of local contexts on residents' attitudes and roles in the transition process, it is found that the some of the barriers can be eliminated or eased by the existence of appropriate methods determined based on the neighborhood's physical and social characteristics. On the other hand, the heat transition process in Nijmegen contains several opportunities that may speed up the transition across Nijmegen. In summary, the existence of financial resources for the transition process, the partial start of the transition in the pilot areas, and the participatory approach of the local governments that include the market and the civil society are the main opportunities in the heat transformation process in Nijmegen. It has been concluded that the opportunities can be used more goal-oriented way by taking the influence of local contexts on the residents' attitudes and roles into account as the transition process cannot be realized without the consent of the residents.

The three sub-questions' results are used to formulate an answer to the research's main question:

By considering the social and physical characteristics of the neighborhoods identified for this study, particularly the "income level," it is possible to stimulate the participation, support, and contribution of residents to the heat transition of Nijmegen in a flexible and/or modular way, and thus more efficiently, as more policy attention (information campaign, energy coach, etc.) can be focused on low-income groups. Also, using the information on the neighborhood's potential to achieve a sustainable built environment and the underlying factors is particularly promising in eliminating technical and social barriers. In parallel, it is obvious that having depth knowledge about the potential of neighborhoods will be beneficial to create neighborhood-oriented policies in heat transition in order to overcome the financial and technical barriers that exist in the process. Therefore, it is concluded that taking different local contexts of each neighborhood into consideration when making a policy can be employed as an effective tool to speed up the heat transition of Nijmegen.

5.2. Theoretical Discussion

As stated before, Coy et al. (2021) argue that communities were placed with the definitions of 'consumer, user, customer' in energy systems historically. However, despite the current patterns in energy systems, it is anticipated that communities will play a more significant role in the ongoing energy transition by adopting new technologies and influencing the design of the energy systems (Wahlund & Palm, 2022). In line with that, this research is aimed to comprehend how different social and physical characteristics of neighborhoods influence the role of citizens in the ongoing heat transition. To do so, this thesis harmonized the co-creation approach with the community capacity building theory. While the co-creation approach proposed by (Sillak et al., 2021) enables this research to find the economic, social, psychological, technical, and political challenges of heat transition (Itten et al., 2021), the theory of community capacity building proposed by (Middlemiss & Parrish, 2010) makes it possible to measure the capacity to change in the heat transition, which is depends on the nature of the social context and that of the agent (individual or community). In that sense, this thesis has contributed to theory building by paving the way for measuring the neighborhoods' capacities in combination with the co-creative approaches in energy transitions.

On the other hand, it is crucial to compare the research findings with the literature. Jansma et al. (2020) discuss that the local context in which citizens live has an impact on their behaviors when it comes to the energy transition. The findings of this research are in parallel with this, as the social and physical context of the neighborhoods where the citizens live have an impact on the citizens' willingness to participate/support/contribute to the heat transition. Besides, the research's findings also support the claim made by van der Waal et al. (2020) that the guidance of regional and local governments through expertise and financial support is effective on the behavior of citizens in the energy transition. Correspondingly, this research has also shown that the resident of neighborhoods that receive more expertise and financial support from local and national authorities are more willing to participate, support, and contribute to the heat transition.

In contrast to Kastner & Stern (2015) whose research asserts that there is a negative correlation between age and the adoption of measures, as older people are less convinced that their investment will pay off within the rest of their life, the findings of this research demonstrated that the elderly care about cost efficiency in the heat transition as much as other age groups do. In contrast, It is concluded that environmental concerns are more prioritized in decision-making with regard to heat transition among older age groups and support for heat transition policy is higher among older residents compared to others. Besides, Broers et al. (2019) and Ebrahimigharehbaghi et al. (2019) argue that environmental concerns play an important role in triggering interest in energy-efficient measures. In parallel with these findings, this study concluded that those neighborhoods where environmental concerns are the first priority in decision-making toward heat transition have shown the highest willingness to replace existing natural gas or oil-based heating systems with sustainable ones.

5.3. Limitations

This thesis contributes to a better understanding of how different physical and social characteristics of neighborhoods affects the citizens' participation/support/contribution to the heat transition. However, the way data is obtained and analyzed was shaped through researcher's preferences, which brings about some limitations for this research. In this section, the factors limiting the validity and reliability of the research will be discussed.

The internal validity of the research was partially preserved, as the research only tested certain social and physical characteristics of the neighborhoods. In the research, factors such as gender, education level, immigration status, which may be an important factor in the role of citizens toward heat transition in Nijmegen, could not be measured due to the potential to be perceived as offensive in the field survey. Nevertheless, the research was successful in measuring the factors specified in the methodological part: The income level, age, legal ownership status of residents, house age, and house type, in accordance with the research question. A second factor limiting the internal validity of this research is the lack of sufficient number of interviews. Even though the neighborhood organization of Duurzaam Hengstdal (Sustainable Hengstdal in Dutch) and several housing corporations that are active in Nijmegen are asked for an interview, the interview request has been declined by these parties. Nevertheless, the interviews with the representative of the municipality of Nijmegen and field expert on the heat transition was successfully taken place. As a result, the internal validity of this research could have been protected better if the problems mentioned above had been solved.

Second, the focus of external validity is on the research's generalizability and thereafter applicability to other situations. Five neighborhoods located in Nijmegen have been chosen as cases in this study to detect as different social and physical characteristics as possible. However, due to the fact that the heat transition is at an early stage, no other neighborhood in which the transition started has been found in Nijmegen. Similarly, the fact that all neighborhoods were chosen from the city of Nijmegen is the result of a subjective decision, which limits the external validity of this research. This decision is mainly taken due to the fact that Nijmegen is the only city where it is possible for the researcher to conduct a field survey. On the other hand, after conducting field survey in five neighborhoods of Nijmegen, only ninety-five valid responses were obtained, which were far below expectations. Therefore, the research findings should be approached with caution due to the several reasons. First, the participation in the field survey was unevenly dispersed in the selected neighborhoods, which may pose a risk for some neighborhoods to be underrepresented in the research findings. Second, the analysis of the field survey was made based on the mean average of the respondents' preferences. The research findings could have been improved by employing other statistical methods such as standard deviation, showing more accurately how much a set of values can vary or be dispersed. Despite all these limitations, the research findings are suitable for generalization as long as a neighborhood has one or more of the social and physical characteristics of the case studies.

Third, the repeatability of the research is related to its reliability. In order to ensure that the outcomes are the same when this research is reviewed by someone else, the steps were documented as accurately as possible. It is thought that high reliability was obtained in the results of this thesis as the survey analysis is documented in the codebook, which enables other researchers to reach the same results. However, because interviews are one of the qualitative data gathering methods, the results are open to the subjective interpretation of the researcher, which limits reliability even if the coding process of the interview analysis is documented.

5.4. Recommendations

5.4.1. Recommendations For Practice

Several recommendations for practice arose in light of the research findings. First, particularly the municipality of Nijmegen, as a main executive of the heat transition process, should invest more time and resources into making sure that the two groups take part in learning activities. The first of these groups is mainly composed of flat/apartment dwellers, who are often low-income renters, while the second category consists of tenants that hire houses from private landlords. As the results of the research demonstrate, the desire to make an individual contribution to the process increases in neighborhoods where participation in informative activities is high. Achieving the more participation of these groups may be beneficial in pushing low-income tenants to ask their landlords or housing corporations to take energy efficiency measures, such as home insulation that reduce their energy bills. The second recommendation is for the national government to ensure that tenants are not harmed by the costs that may arise from heat transition in low-income and tenant-dense neighborhoods. National government has various instrument such as social housing to control the rental market in residential sector. In this way, energy poverty and undesired relocations of tenants are prevented, while the financial burden arose by the transition does not deepen the poverty of low-income groups.

Another recommendation is for the planners/practitioners working within the municipality of Nijmegen to execute the process in specific neighborhoods. Social acceptance of the transition by residents in Nijmegen is very important for the realization of heat transition, as residents have the right not to change their heating systems until 2050 in accordance with current law. For this reason, the possible heating system scenarios in the neighborhoods should be wide enough for the residents to make their own choices. Furthermore, the stakeholders representing the state should create an environment where the citizens can make more than one choice in energy supply by making an agreement in a way that will not lead to a monopoly in energy prices of the energy providers in Nijmegen.

5.4.2. Recommendations For Further Research

A first recommendation for the scientific field is to do more research into the impact of the different physical and social characteristics of neighborhoods on the heat transition process. In order to conclude that the income level as a result of this research is the most important factor that determines the level of participation/support/contribution of the citizens in the heat transition, there is a need for further research that considers both the unresearched social factors such as gender, educational status, etc. and the unresearched physical factors such as existing heating resources available, housing stock, etc. In addition, by choosing neighborhoods from other cities that have begun the heat transfer instead of just the city of Nijmegen, different neighborhood potentials and resident behaviors steered by the social and physical differences of the neighborhoods toward the heat transition can be revealed in a much broader perspective.

A second recommendation for science would be the employment of more methods in collecting data to assess the different social and physical characteristics of neighborhoods. In this research, all neighborhood capacities in the heat transition, including the infrastructural capacities of the neighborhoods, were measured from the perspective of citizens, which is subjective and open to being biased. In addition, it is assumed that obtaining more data from more local actors may be more effective in determining the capacities of neighborhoods in the heat transition.

The last recommendation for science is to determine the policy approach required to eliminate the disadvantages arising from the different social and physical characteristics of neighborhoods in the heat transition. Although this research helped to identify the characteristics of disadvantaged neighborhoods in the heat transition, it did not provide a holistic policy approach to eliminate existing barriers. It is certain that more comprehensive research is needed for the determination of approaches that are capable of eliminating financial, technical, physical, and social barriers.

6. Bibliography

AllCharts.info. (2022, September Monday). *Statistieken wijk Dukenburg*. Retrieved from AllCharts.info: https://allecijfers.nl/wijk/wijk-07-dukenburg-nijmegen/

AlleCijfers. (2022, September Tuesday). *Statistieken buurt Hatert*. Retrieved from AlleCijfers.nl: https://allecijfers.nl/buurt/hatert-nijmegen/

AlleCijfers. (2022a). *Gemiddeld inkomen per inwoner*. https://allecijfers.nl/buurt/hengstdal-nijmegen/#inkomen

AlleCijfers. (2022b). *Statistieken buurt Hengstdal*. https://allecijfers.nl/buurt/hengstdal-nijmegen/

Aravena, C., Riquelme, A., & Denny, E. (2016). Money, Comfort or Environment? Priorities and Determinants of Energy Efficiency Investments in Irish Households. *Journal of Consumer Policy*, *39*(2), 159–186. https://doi.org/10.1007/s10603-016-9311-2

Avelino, F., & Wittmayer, J. M. (2016). Shifting Power Relations in Sustainability Transitions: A Multi-actor Perspective. *Journal of Environmental Policy & Planning*, *18*(5), 628–649. https://doi.org/10.1080/1523908X.2015.1112259

Bai, X., Roberts, B., & Chen, J. (2010). Urban sustainability experiments in Asia: Patterns and pathways. *Environmental Science and Policy*, *13*(4), 312–325. https://doi.org/10.1016/j.envsci.2010.03.011

Baxter, P., & Jack, S. (2010). Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *Qualitative Report*, *13*. https://doi.org/10.46743/2160-3715/2008.1573

Beauchampet, I., & Walsh, B. (2021). Energy citizenship in the Netherlands: The complexities of public engagement in a large-scale energy transition. *Energy Research and Social Science*, *76*(March), 102056. https://doi.org/10.1016/j.erss.2021.102056

Becker, S., Bryman, A., & Ferguson, H. (2012). *Understanding research for social policy and social work: themes, methods and approaches*. policy press.

Brisbois, M. C. (2019). Powershifts: A framework for assessing the growing impact of decentralized ownership of energy transitions on political decision-making. *Energy Research and Social Science*, *50*(July 2018), 151–161. https://doi.org/10.1016/j.erss.2018.12.003

Broers, W. M. H., Vasseur, V., Kemp, R., Abujidi, N., & Vroon, Z. A. E. P. (2019). Decided or divided? An empirical analysis of the decision-making process of Dutch homeowners for energy renovation measures. *Energy Research and Social Science*, *58*(August), 101284. https://doi.org/10.1016/j.erss.2019.101284

Brown, K. (2003). Three Challenges for a Real People-Centred Conservation. *Global Ecology and Biogeography*, *12*(2), 89–92. http://www.jstor.org/stable/3697558

Bryman, A. (2016). *Social Research Methods*. Oxford University Press. https://books.google.com.tr/books?id=N2zQCgAAQBAJ

Brymen, A. (2012). *Social Research Methods*.

Carlisle, K., & Gruby, R. L. (2019). Polycentric Systems of Governance: A Theoretical Model for the Commons. *Policy Studies Journal*, *47*(4), 921–946. https://doi.org/10.1111/psj.12212

CE Delft. (2016). *Een warm Nijmegen:Analyse van de toekomstige warmtevoorziening met CEGOIA*.

Cherry, C., Hopfe, C., MacGillivray, B., & Pidgeon, N. (2017). Homes as machines: Exploring expert and public imaginaries of low carbon housing futures in the United Kingdom. *Energy Research and Social Science*, *23*, 36–45. https://doi.org/10.1016/j.erss.2016.10.011

Correljé, A. F. (2011). Aardgas. Eén verleden en vele toekomstscenario's. *Energie in 2030. Maatschappelijke Keuzes van Nu*, 339–356. http://www.clingendael.nl/ciep/staff/?id=91

Coy, D., Malekpour, S., Saeri, A. K., & Dargaville, R. (2021). Rethinking community empowerment in the energy transformation: A critical review of the definitions, drivers and outcomes. *Energy Research and Social Science*, *72*(November 2020), 101871. https://doi.org/10.1016/j.erss.2020.101871

Creswell, J. (2013). Qualitative Inquiry & Research Design: Choosing Among Five Approaches. *SAGE Publications*, *11*.

Curtis, J., McCoy, D., & Aravena, C. (2018). Heating system upgrades: The role of knowledge, socio-demographics, building attributes and energy infrastructure. *Energy Policy*, *120*(November 2017), 183–196. https://doi.org/10.1016/j.enpol.2018.05.036

Dabrowska, J., & Fiegenbaum, I. (2014). When culture matters: Exploring the open innovation paradigm. *International Journal of Business Innovation and Research*, *8*(1). https://doi.org/10.1504/IJBIR.2014.058048

de Wildt, T. E., Boijmans, A. R., Chappin, E. J. L., & Herder, P. M. (2021). An ex ante assessment of value conflicts and social acceptance of sustainable heating systems: An agent-based modelling approach. *Energy Policy*, *153*(March 2020), 112265. https://doi.org/10.1016/j.enpol.2021.112265

DECC. (2013). *Electricity Generation Costs*. https://www.gov.uk/government/organisations/department-of-energy-climate-change/series/energy-bill

DellaValle, N., & Czako, V. (2022). Empowering energy citizenship among the energy poor. *Energy Research & Social Science*, *89*(June 2019), 102654. https://doi.org/10.1016/j.erss.2022.102654

Devine-Wright, P. (2007). Reconsidering public attitudes and public acceptance of renewable energy technologies : a critical review. *Architecture*, *Working Pa*(February), 1–15. http://geography.exeter.ac.uk/beyond_nimbyism/deliverables/bn_wp1_4.pdf

Doggen, J. (2021). *' OWN THE HEAT .'*

Duurzaam Hees. (2022, September Tuesday). *ABOUT SUSTAINABLE HEES*. Retrieved from Duurzaam Hees: http://duurzaamhees.nl/#overons

Duurzaam Hengstdal. (2022a). *No Title*. https://duurzaamhengstdal.nl/

Duurzaam Hengstdal. (2022b). *Wat is een Buurt Energie Systeem?*

Ebrahimigharehbaghi, S., Qian, Q. K., Meijer, F. M., & Visscher, H. J. (2019). Unravelling Dutch homeowners' behaviour towards energy efficiency renovations: What drives and hinders their decision-making? *Energy Policy*, *129*(June 2018), 546–561. https://doi.org/10.1016/j.enpol.2019.02.046

Eltham, D. C., Harrison, G. P., & Allen, S. J. (2008). Change in public attitudes towards a Cornish wind farm: Implications for planning. *Energy Policy*, *36*(1), 23–33. https://doi.org/https://doi.org/10.1016/j.enpol.2007.09.010

Energie Atlas. (2018). *No Title*.

Fink, A. (2003). *The Survey Handbook* (2nd ed.). https://doi.org/10.4135/9781412986328

Fournis, Y., & Fortin, M.-J. (2017). From social ‘acceptance’ to social ‘acceptability’ of wind energy projects: towards a territorial perspective. *Journal of Environmental Planning and Management*, *60*(1), 1–21. https://doi.org/10.1080/09640568.2015.1133406

Friese, S. (2012). Technical aspects of coding. In *Qualitative Data Analysis with ATLAS.ti* (pp. 63–90). SAGE Publications Ltd. https://doi.org/https://dx.doi.org/10.4135/9781529799590.n5

Geels, F. W., Sovacool, B. K., Schwanen, T., & Sorrell, S. (2017). The Socio-Technical Dynamics of Low-Carbon Transitions. *Joule*, *1*(3), 463–479. https://doi.org/10.1016/j.joule.2017.09.018

Gemeente Nijmegen. (2018). *Warmtevisie*.

Gemeente Nijmegen. (2022). *Hengstdal*. https://aardgasvrij.nijmegen.nl/mijn-wijk-aardgasvrij/hengstdal/

Gemeente Nijmegen. (2022, September Sunday). *Nijmegen Aardgasvrij*. Retrieved from Gemeente Nijmegen: https://aardgasvrij.nijmegen.nl/mijn-wijk-aardgasvrij/bottendaal

Government of the Netherlands. (2012). *Plan of Action Energy Saving in Built Environment*.

Grösche, P. (2010). Housing, energy cost, and the poor: Counteracting effects in Germany’s housing allowance program. *Energy Policy*, *38*(1), 93–98. https://doi.org/https://doi.org/10.1016/j.enpol.2009.08.056

Guardaro, M., Messerschmidt, M., Hondula, D. M., Grimm, N. B., & Redman, C. L. (2020). Building community heat action plans story by story: A three neighborhood case study. *Cities*, *107*(July), 102886. https://doi.org/10.1016/j.cities.2020.102886

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In *Handbook of qualitative research.* Sage Publications, Inc.

Gubrium, J. F., & Holstein, J. A. (2001). Handbook of interview research : context and method LK - https://ru.on.worldcat.org/oclc/963587678. In *TA - TT* -. Sage. http://catdir.loc.gov/catdir/enhancements/fy0658/00013201-d.html

Hansen, A., Nitschke, M., Saniotis, A., Benson, J., Tan, Y., Smyth, V., Wilson, L., Han, G. S., Mwanri, L., & Bi, P. (2014). Extreme heat and cultural and linguistic minorities in Australia: Perceptions of stakeholders. *BMC Public Health*, *14*(1). https://doi.org/10.1186/1471-2458-14-550

Hansen, A. R. (2016). The social structure of heat consumption in Denmark: New interpretations from quantitative analysis. *Energy Research & Social Science*, *11*, 109–118. https://doi.org/https://doi.org/10.1016/j.erss.2015.09.002

Hansen, A. R. (2018). ‘Sticky’ energy practices: The impact of childhood and early adulthood experience on later energy consumption practices. *Energy Research & Social Science*, *46*, 125–139. https://doi.org/https://doi.org/10.1016/j.erss.2018.06.013

Harlan, S. L., Brazel, A. J., Darrel Jenerette, G., Jones, N. S., Larsen, L., Prashad, L., & Stefanov, W. L. (2007). In the shade of affluence: the inequitable distribution of the urban heat island. In R. C. Wilkinson & W. R. Freudenburg (Eds.), *Equity and the Environment* (Vol. 15, pp. 173–202). Emerald Group Publishing Limited. https://doi.org/10.1016/S0196-1152(07)15005-5

Harrison, H., Birks, M., Franklin, R., & Mills, J. (2017). Case study research: Foundations and methodological orientations. *Forum Qualitative Sozialforschung*, *18*(1).

Hast, A., Syri, S., Lekavičius, V., & Galinis, A. (2018). District heating in cities as a part of low-carbon energy system. *Energy*, *152*, 627–639.

https://doi.org/https://doi.org/10.1016/j.energy.2018.03.156

Hessels, L. K., van Lente, H., & Smits, R. (2009). In search of relevance: The changing contract between science and society. *Science and Public Policy*, *36*(5), 387–401. https://doi.org/10.3152/030234209X442034

Hölscher, K., Frantzeskaki, N., McPhearson, T., & Loorbach, D. (2019). Capacities for urban transformations governance and the case of New York City. *Cities*, *94*(May), 186–199. https://doi.org/10.1016/j.cities.2019.05.037

International Energy Agency. (2020). The Netherlands 2020 - Energy Policy Review. *International Energy Agency*, 258. https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/The_Netherlands_2020_Energy_Policy_Review.pdf

Itten, A., Sherry-Brennan, F., Hoppe, T., Sundaram, A., & Devine-Wright, P. (2021). Co-creation as a social process for unlocking sustainable heating transitions in Europe. *Energy Research and Social Science*, *74*(August 2020), 101956. https://doi.org/10.1016/j.erss.2021.101956

Itten, A., Sherry-brennan, F., Sundaram, A., Hoppe, T., & Devine-wright, P. (2020). *State-of-the-art report for co-creation approaches and practices* (Issue January). https://doi.org/10.13140/RG.2.2.22835.17440

Jager, W. (2006). Stimulating the diffusion of photovoltaic systems: A behavioural perspective. *Energy Policy*, *34*(14), 1935–1943. https://doi.org/https://doi.org/10.1016/j.enpol.2004.12.022

Jansma, S. R., Gosselt, J. F., & de Jong, M. D. T. (2020). Kissing natural gas goodbye? Homeowner versus tenant perceptions of the transition towards sustainable heat in the Netherlands. *Energy Research and Social Science*, *69*(September 2019), 101694. https://doi.org/10.1016/j.erss.2020.101694

Johnson, V., & Hall, S. (2014). Community energy and equity: The distributional implications of a transition to a decentralised electricity system. *People, Place and Policy Online*, *8*, 149–167. https://doi.org/10.3351/ppp.0008.0003.0002

Kalkbrenner, B. J., & Roosen, J. (2016). Citizens' willingness to participate in local renewable energy projects: The role of community and trust in Germany. *Energy Research and Social Science*, *13*(2016), 60–70. https://doi.org/10.1016/j.erss.2015.12.006

Kastner, I., & Stern, P. C. (2015). Examining the decision-making processes behind household energy investments: A review. *Energy Research and Social Science*, *10*, 72–89. https://doi.org/10.1016/j.erss.2015.07.008

Kazmi, H., Keijsers, M., Mehmood, F., & Miller, C. (2022). Energy balances, thermal performance, and heat stress: Disentangling occupant behaviour and weather influences in a Dutch net-zero energy neighborhood. *Energy and Buildings*, *263*, 112020. https://doi.org/10.1016/j.enbuild.2022.112020

Kemp, R., Loorbach, D., & Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution. Special issue on co-evolutionary approach to sustainable development. *The International Journal of Sustainable Development and World Ecology*, *14*(1), 78–91. https://www.tandfonline.com/doi/abs/10.1080/13504500709469709

Kern, F., & Smith, A. (2008). Restructuring energy systems for sustainability? Energy transition policy in the Netherlands. *Energy Policy*, *36*(11), 4093–4103. https://doi.org/10.1016/j.enpol.2008.06.018

Kolkman, M. J., Veen, A. va. der, & Geurts, P. A. T. M. (2007). Controversies in water management:

Frames and mental models. *Environmental Impact Assessment Review*, *27*(7), 685–706. https://doi.org/https://doi.org/10.1016/j.eiar.2007.05.005

Koning, N. de, Kooger, R., Hermans, L., & Tigchelaar, C. (2020). *Aardgasvrij wonen: drijfveren en barrières van bewoners*. 79.

Korjonen-Kuusipuro, K., Hujala, M., Pätäri, S., Bergman, J. P., & Olkkonen, L. (2017). The emergence and diffusion of grassroots energy innovations: Building an interdisciplinary approach. *Journal of Cleaner Production*, *140*, 1156–1164. https://doi.org/10.1016/j.jclepro.2016.10.047

Lennon, B., Dunphy, N. P., & Sanvicente, E. (2019). Community acceptability and the energy transition: a citizens' perspective. *Energy, Sustainability and Society*, *9*(1), 35. https://doi.org/10.1186/s13705-019-0218-z

Li, L., Wang, Y., Wang, M., Hu, W., & Sun, Y. (2021). Impacts of multiple factors on energy consumption of aging residential buildings based on a system dynamics model–Taking Northwest China as an example. *Journal of Building Engineering*, *44*(April), 102595. https://doi.org/10.1016/j.jobe.2021.102595

Mah, D. N. yin, van der Vleuten, J. M., Hills, P., & Tao, J. (2012). Consumer perceptions of smart grid development: Results of a Hong Kong survey and policy implications. *Energy Policy*, *49*, 204–216. https://doi.org/10.1016/j.enpol.2012.05.055

Mallaband, B., & Lipson, M. (2020). From health to harmony: Uncovering the range of heating needs in British households. *Energy Research and Social Science*, *69*(June), 101590. https://doi.org/10.1016/j.erss.2020.101590

Marrelli, A. F. (2010). Conducting Interviews. In P. P. Phillips (Ed.), *ASTD Handbook of Measuring and Evaluating Training* (pp. 85–95). Association for Talent Development.

Matthews, B., & Ross, L. (2010). *Research methods : a practical guide for the social sciences*. New York (N.Y.) : Pearson Longman. http://lib.ugent.be/catalog/rug01:002512700

McIntosh, I., Sim, D., & Robertson, D. (2004). "It's as if you're some alien…' Exploring Anti-English Attitudes in Scotland. '. *Sociological Research Online*, *9*(2), 46–56. https://doi.org/10.5153/sro.922

Michelsen, C., & Madlener, R. (2010). Integrated Theoretical Framework for a Homeowner's Decision in Favor of an Innovative Residential Heating System. *E.ON Energy Research Center, Future Energy Consumer Needs and Behavior (FCN), FCN Working Papers*. https://doi.org/10.2139/ssrn.1620520

Middlemiss, L., & Parrish, B. D. (2010). Building capacity for low-carbon communities: The role of grassroots initiatives. *Energy Policy*, *38*(12), 7559–7566. https://doi.org/10.1016/j.enpol.2009.07.003

Miedema, J. H., Windt, H., & Moll, H. (2018). Opportunities and Barriers for Biomass Gasification for Green Gas in the Dutch Residential Sector. *Energies*, *11*. https://doi.org/10.3390/en11112969

Millar, M.-A., Burnside, N. M., & Yu, Z. (2019). District Heating Challenges for the UK. In *Energies* (Vol. 12, Issue 2). https://doi.org/10.3390/en12020310

Ministerie van Binnenlandse Zaken en Koninkrijkrelaties. (2019). *Klimaatakkoord Gebouwde Omgeving in het kort*. https://www.klimaatakkoord.nl/gebouwde-omgeving/documenten/publicaties/2019/06/28/klimaatakkoord-gebouwde-omgeving-in-het-kort

Ministry of Economic Affairs and Climate Policy. (2013). Energy report. In *IEEE Spectrum* (Vol. 19, Issue 6). https://doi.org/10.1109/mspec.1982.6366716

Ministry of the Interior and Kingdom Relations of the Netherlands. (2019). *Nijmegen - Aanvraag en Convenant Proeftuin Aardgasvrij Wijk.* Retrieved from Rijksoverheid: https://www.rijksoverheid.nl/documenten/convenanten/2019/02/26/nijmegen---convenant-over-grootschalige-proeftuin-met-een-aardgasvrije-wijk

Moon, K., & Blackman, D. (2014). A Guide to Understanding Social Science Research for Natural Scientists. *Conservation Biology : The Journal of the Society for Conservation Biology*. https://doi.org/10.1111/cobi.12326

Nava-Guerrero, G. del C., Hansen, H. H., Korevaar, G., & Lukszo, Z. (2021). The effect of group decisions in heat transitions: An agent-based approach. *Energy Policy*, *156*(June), 112306. https://doi.org/10.1016/j.enpol.2021.112306

Nieuwsbrief nr.12. (2022, September Monday). *Nieuwsbrief 12.* Retrieved from Nijmegen Aardgasvrij: https://mailchi.mp/efe2e2fbfb82/nieuwsbrief-aardgasvrij-bottendaal-nr-12-juni-2022

Noel, L., Zarazua de Rubens, G., Sovacool, B. K., & Kester, J. (2019). Fear and loathing of electric vehicles: The reactionary rhetoric of range anxiety. *Energy Research & Social Science*, *48*, 96–107. https://doi.org/https://doi.org/10.1016/j.erss.2018.10.001

Norberg-Schulz, C. (1979). *Genius Loci (Towards a Phenomenology of Architecture)*. Rizzoli.

Oorschot, L. (2020). Dutch hybrid neighbourhoods of 1860–1910 in heat transition: The case study of zeeheldenkwartier in the hague. *Energies*, *13*(20). https://doi.org/10.3390/en13205255

Owens, S., & Driffill, L. (2008). How to change attitudes and behaviours in the context of energy. *Energy Policy*, *36*(12), 4412–4418. https://doi.org/10.1016/j.enpol.2008.09.031

Özcan, K. M., Gülay, E., & Üçdoğruk, Ş. (2013). Economic and demographic determinants of household energy use in Turkey. *Energy Policy*, *60*, 550–557. https://doi.org/https://doi.org/10.1016/j.enpol.2013.05.046

Pak, S. (2018). *The Participatory Value Evaluation method: an application to the transition towards zero natural gas use at the local level of the neighborhood Hengstdal in Nijmegen*. https://repository.tudelft.nl/islandora/object/uuid%3A2a3982bf-b92a-44ec-810d-a39f8bc92b8b

Parks, R. B., Baker, P. C., Kiser, L., Oakerson, R., Ostrom, E., Ostrom, V., Percy, S. L., Martha, B., Whitaker, G. P., & Wilson, R. (n.d.). *The concept of coproduction of public services has captured increased attention as a potential means of increasing the effec- tiveness and efficiency of local government . In this article we ex- plore the concept of coproduction in an effort to sharpen th*.

Phillips, P. P., Phillips, J. J., & Aaron, B. (2013). *Survey Basics*.

Puerari, E., De Koning, J., von Wirth, T., Karré, P., Mulder, I., & Loorbach, D. (2018). Co-Creation Dynamics in Urban Living Labs. *Sustainability*, *10*, 1893. https://doi.org/10.3390/su10061893

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community*. SIMON AND SCHUSTER PAPERBACKS. https://books.google.com.tr/books?hl=tr&lr=&id=rd2ibodep7UC&oi=fnd&pg=PA13&ots=G6J9lXpkW0&sig=ekTc8p_-wFaC0-ftY0ZXEeAVrEw&redir_esc=y#v=onepage&q&f=false

Radtke, J. (2014). A closer look inside collaborative action: civic engagement and participation in community energy initiatives. *People, Place and Policy Online*, *8*(3), 235–248.

https://doi.org/10.3351/ppp.0008.0003.0008

Raman, S. (2003). *The significance of political rationality in governance: Assessing the energizing of UK building regulation 1990–2002*. University of Pittsburgh.

Reames, T. G. (2016). Targeting energy justice: Exploring spatial, racial/ethnic and socioeconomic disparities in urban residential heating energy efficiency. *Energy Policy*, *97*, 549–558. https://doi.org/https://doi.org/10.1016/j.enpol.2016.07.048

Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms. International. *Journal of Educational Investigations*, *3*(8), 51–59. https://www.researchgate.net/publication/325022648

Rijksoverheid(Dutch National Government). (2008). *Huurwoning [Rental house]*. https://www.rijksoverheid.nl/onderwerpen/woning-huren/vraag-en-antwoord/wat-zijn-mijn-rechten-bij-renovatie-van-mijn-huurwoning

Robertson, D., Mcintosh, I., & Smyth, J. (2010). Neighbourhood Identity: The Path Dependency of Class and Place. *Housing*, *Theory and*, 258–273. https://doi.org/10.1080/14036090903326429

Rodhouse, T. S. G. H., Pesch, U., Cuppen, E. H. W. J., & Correljé, A. F. (2021). Public agency and responsibility in energy governance: A Q study on diverse imagined publics in the Dutch heat transition. *Energy Research and Social Science*, *77*(March). https://doi.org/10.1016/j.erss.2021.102046

Roy, Robin;, & Caird, Sally and Potter, S. (2007). *People centred eco-design: consumer adoption of low and zero carbon products and systems* (J. Murphy (ed.)). Earthscan. http://shop.earthscan.co.uk/ProductDetails/mcs/productID/756/groupID/7/categoryID/17/v/9ad9e024-f9ca-40a6-aa34-8513ce257eb2

Rutherford, J., & Coutard, O. (2014). Urban Energy Transitions: Places, Processes and Politics of Socio-technical Change. *Urban Studies*, *51*(7), 1353–1377. https://doi.org/10.1177/0042098013500090

Saldana, J., Leavy, P., & Beretvas, N. (2011). *Fundamentals of Qualitative Research*. Oxford University Press, Incorporated. http://ebookcentral.proquest.com/lib/ubnru-ebooks/detail.action?docID=665394

Saunders, M., Lewis, P., & Thornhill, A. (2009). Understanding research philosophies and approaches. *Research Methods for Business Students*, *4*, 106–135.

Scheepers, M., Palacios, S. G., Jegu, E., Nogueira, L. P., Rutten, L., van Stralen, J., Smekens, K., West, K., & van der Zwaan, B. (2022). Towards a climate-neutral energy system in the Netherlands. *Renewable and Sustainable Energy Reviews*, *158*, 112097. https://doi.org/10.1016/j.rser.2022.112097

Schilling, J., Kruit, K., Schepers, B. L., Otten, G. J., Graaf, A. de, & Karthaus, M. (2019). Hybride warmtenetten. *Kansen Voor Den Haag. CE Delft, Delft*, *19*, 47.

Schleich, J. (2019). Energy efficient technology adoption in low-income households in the European Union – What is the evidence? *Energy Policy*, *125*, 196–206. https://doi.org/https://doi.org/10.1016/j.enpol.2018.10.061

Scholte, S., Yvonne de, K., de Wilde, T., Steenbekkers, A., & Carabain, C. (2020). *Op weg naar aardgasvrij wonen*. 1–69. https://www.scp.nl/publicaties/publicaties/2020/05/25/op-weg-naar-aardgasvrij-wonen

SER. (2019). *National Climate Agreement*. *June*, 247. https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands

Shove, E., & Walker, G. (2007). Caution! Transitions Ahead: Politics, Practice, and Sustainable Transition Management. *Environment and Planning A: Economy and Space*, *39*(4), 763–770. https://doi.org/10.1068/a39310

Sillak, S., Borch, K., & Sperling, K. (2021). Assessing co-creation in strategic planning for urban energy transitions. *Energy Research and Social Science*, *74*(January), 101952. https://doi.org/10.1016/j.erss.2021.101952

Sovacool, B. K., & Brisbois, M. C. (2019). Elite power in low-carbon transitions: A critical and interdisciplinary review. *Energy Research and Social Science*, *57*(June), 101242. https://doi.org/10.1016/j.erss.2019.101242

Sovacool, B. K., Demski, C., & Noel, L. (2021). Beyond climate, culture and comfort in European preferences for low-carbon heat. *Global Environmental Change*, *66*(October 2020), 102200. https://doi.org/10.1016/j.gloenvcha.2020.102200

Sovacool, B. K., & Martiskainen, M. (2020). Hot transformations: Governing rapid and deep household heating transitions in China, Denmark, Finland and the United Kingdom. *Energy Policy*, *139*(February), 111330. https://doi.org/10.1016/j.enpol.2020.111330

Späth, P., & Rohracher, H. (2015). Conflicting strategies towards sustainable heating at an urban junction of heat infrastructure and building standards. *Energy Policy*, *78*, 273–280. https://doi.org/10.1016/j.enpol.2014.12.019

Stern, P. C. (2014). Individual and household interactions with energy systems: Toward integrated understanding. *Energy Research and Social Science*, *1*, 41–48. https://doi.org/10.1016/j.erss.2014.03.003

Stuiver, M. E. (2020). *Reward Planning as Policy Instrument to Achieve a Sustainable*.

Swanborn, P. G. (1996). *Case-study's: wat, wanneer en hoe?.* Boom. https://books.google.com.tr/books?id=sYIKKBlQa68C

Thiel, S. van. (2014). *Research Methods in Public Administration and Public Management: An introduction* (1st editio). Routledge. https://doi.org/https://doi.org/10.4324/9780203078525

Trencher, G., Bai, X., Evans, J., McCormick, K., & Yarime, M. (2014). University partnerships for co-designing and co-producing urban sustainability. *Global Environmental Change*, *28*(1), 153–165. https://doi.org/10.1016/j.gloenvcha.2014.06.009

UN, E. and I. E. A. (2017). Towards a zero-emission, efficient, and resilient buildings and construction sector. In *Global Status Report 2017*. www.globalabc.org

Uyterlinde, M., & Gastkemper, N. (2018). Naar een wendbare wijkaanpak Het waarom en hoe van lokaal gestuurde wijkvernieuwing. *Platform31*, 1–30. https://www.platform31.nl/publicaties/naar-een-wendbare-wijkaanpak#

van den Wijngaart, R., van Polen, S., & van Bemmel, B. (2017). *Het Vesta Mais Ruimtelijk*. *december*.

Van Der Schoor, T., Van Lente, H., Scholtens, B., & Peine, A. (2016). Challenging obduracy: How local communities transform the energy system. *Energy Research and Social Science*, *13*(2016), 94–105. https://doi.org/10.1016/j.erss.2015.12.009

van der Waal, E. C., Das, A. M., & van der Schoor, T. (2020). Participatory experimentation with energy law: Digging in a 'regulatory sandbox' for local energy initiatives in the Netherlands. *Energies*, *13*(2), 1–21. https://doi.org/10.3390/en13020458

Van Eijk, C., & Steen, T. (2015). Why engage in co-production of public services? Mixing theory and empirical evidence. *International Review of Administrative Sciences*, *82*(1), 28–46. https://doi.org/10.1177/0020852314566007

Verschuren, P., & Doorewaard, H. (2010). *Designing a research project* (M. M. J. (ed.); 2nd ed.). Eleven International Publishing.

von Wirth, T., Gislason, L., & Seidl, R. (2018). Distributed energy systems on a neighborhood scale: Reviewing drivers of and barriers to social acceptance. *Renewable and Sustainable Energy Reviews*, *82*(October 2017), 2618–2628. https://doi.org/10.1016/j.rser.2017.09.086

Voorberg, W., Bekkers, V., & Tummers, L. (2014). A systematic review of co-creation and co-production: Embarking on the social innovation journey. *Public Management Review: An International Journal of Research and Theory*. http://hdl.handle.net/1765/51467

Vringer, K., de Vries, R., & Visser, H. (2021). Measuring governing capacity for the energy transition of Dutch municipalities. *Energy Policy*, *149*(October 2020), 112002. https://doi.org/10.1016/j.enpol.2020.112002

Vringer, K., van Middelkoop, M., & Hoogervorst, N. (2016). Saving energy is not easy: An impact assessment of Dutch policy to reduce the energy requirements of buildings. *Energy Policy*, *93*, 23–32. https://doi.org/10.1016/j.enpol.2016.02.047

Wahlund, M., & Palm, J. (2022). The role of energy democracy and energy citizenship for participatory energy transitions: A comprehensive review. *Energy Research and Social Science*, *87*(August 2021), 102482. https://doi.org/10.1016/j.erss.2021.102482

Werner, S. (2017). International review of district heating and cooling. *Energy*, *137*, 617–631. https://doi.org/https://doi.org/10.1016/j.energy.2017.04.045

Winkelcentrum Dukenburg. (2022, September Monday). *Winkelcentrum Dukenburg*. Retrieved from https://www.winkelcentrumdukenburg.nl/winkels/duurzaamwonen/

Wimbadi, R. W., & Djalante, R. (2020). From decarbonization to low carbon development and transition: A systematic literature review of the conceptualization of moving toward net-zero carbon dioxide emission (1995–2019). *Journal of Cleaner Production*, *256*, 120307. https://doi.org/10.1016/j.jclepro.2020.120307

Wolfram, M. (2018). Cities shaping grassroots niches for sustainability transitions: Conceptual reflections and an exploratory case study. *Journal of Cleaner Production*, *173*, 11–23. https://doi.org/10.1016/j.jclepro.2016.08.044

Wolsink, M. (2007). Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy Policy*, *35*(5), 2692–2704. https://doi.org/https://doi.org/10.1016/j.enpol.2006.12.002

WoonConnect. (2017). *Woonwijk Hengstdal te Nijmegen- analyse (hoofd) woningtypes*.

Yin, R. K. (2009). *Case Study Research: Design and Methods*. SAGE Publications. https://books.google.com.tr/books?id=FzawIAdilHkC

Appendices

Appendix 1. Questionnaire

INFORMATION AND CONSENT

You are invited to participate in a research project aiming to research citizens' opinions about the heat transition. The research takes place in the following five neighborhoods located in Nijmegen, the Netherlands. The neighborhoods are namely Dukenburg, Hengstal, Bottendaal, Hatert, and Stationsgebied Heijendaal. This research project is being carried out by Serhat Evrim, a master's student in Spatial Planning at Radboud University.

What is going to happen?

The procedure involves completing an online survey. Filling out the survey takes approximately 15 minutes. Be as comprehensive as possible with your answers.

Voluntary participation

Your participation in this study is voluntary. This means that you can withdraw your participation and consent at any time during the study, without giving any reason.

Because the data is anonymized immediately, it is not possible to have your research data deleted after the experiment.

What will happen to my data?

The research data we collect during this research will be used by scientists as part of datasets, articles, and presentations. The anonymized research data is accessible to other scientists for a period of at least 10 years. When we share data with other researchers, this data cannot be traced back to you.

All research and personal data are stored securely in accordance with the guidelines of Radboud University.

More information?

If you would like more information about this research, please contact Serhat Evrim:(telephone: +31620153661; e-mail: serhat.evrim@ru.nl)

If you have any complaints about this research, please contact the researcher or, contact the confidential counselors for Scientific Integrity by e-mail: vertrouwenspersonen@ru.nl or, contact the Scientific Integrity Committee of Radboud University. The secretary of the committee is M. Steenbergen: (m.steenbergen@bjz.ru.nl or 024 3611578) Executive and Legal Affairs.

More information about the Scientific Integrity Committee can be found here: https://www.ru.nl/english/research/other-research/academic-integrity/

CONSENT: Please select your choice below.

Click on the ''I Agree'' button below indicates that:

-You have read the above information

-You consent to participate to the research study as described in the above information

-You understand how the data of the research study will be stored and it will be used
-You voluntarily agree to participate
-You are at least 16 years of age

If you do not wish to participate in the research, please decline participation by clicking on the '' I do not want to participate'' button.

Please select one

- I agree(proceed to the survey)
- I do not want to participate

Skip To: End of Survey If INFORMATIE EN TOESTEMMING We nodigen U uit om deel te nemen aan een onderzoeksproject waarin we h... = Ik wil niet deelnemen

Q1 In which neighborhood of Nijmegen do you live?

- Dukenburg (Tolhuis, Zwanenveld, Meijhorst, Lankforst, Aldenhof and Malvert)
- Hengstal
- Bottendaal
- Hatert
- Stationsgebied Heijendaal
- Other

Skip To: End of Survey If In welke buurt van Nijmegen woon je? = Anders

Q2 What is your age category?

- ○ 0-18
- ○ 18-24
- ○ 25-34
- ○ 35-44
- ○ 45-54
- ○ 54-64
- ○ 65+
- ○ Prefer not to answer

Q3 Are you a homeowner or tenant?

- ○ Homeowner
- ○ Tenant from a private landlord
- ○ Tenant from housing corparation

Q4 Can you tell us about the total annual income of your household (before tax and deductions, but including any benefits/allowances)

- under 20.000€
- 20.000€ - 25.000€
- 25000€ - 30.000€
- 30.000€ - 35.000€
- Above 35.000€
- Prefer not to answer

Q5 How old is the building you currently live in?

- 0-10 years
- 10-20 years
- 20-30 years
- 30-40 years
- 50+ years
- Prefer not to answer

Q6 What type of house do you live in?

- ◯ Detached house
- ◯ Terraced house
- ◯ Semi-detached houses
- ◯ Flat/apartment
- ◯ Student dormitory or care homes
- ◯ Prefer not to answer

Q7 Which of the following(s) is the main source of heating in your home?

- ◯ Heating with oil or gas
- ◯ The heat pump
- ◯ The pellet or biomass boiler
- ◯ The hybrid boiler
- ◯ The cogeneration boiler
- ◯ The electric heating
- ◯ The district heating
- ◯ Other: ____
- ◯ I do not know

Skip To: Q9 If Welke van de volgende is de belangrijkste verwarmingsbron in uw huis? != Verwarmen met stookolie of gas

---

Q8 How likely do you think you would change your heating to one of the following sources in the next few years if given the chance?
Heat sources: The heat pump, district heating/heating network, hydrogen, biomass/bioenergy/wood, thermal solar energy/solar energy, etc.

- Very likely
- Somewhat likely
- Neither likely nor unlikely
- Somewhat unlikely
- Very unlikely
- No opinion

Q9 The Netherlands aims to transition to a gas-free built environment by 2050 with which all houses should be heated by either collective or private electricity-based heat resources. To what extent do you agree with this policy?

- strongly agree
- agree
- neutral
- disagree
- strongly disagree

Q10 Do you think that the expectation of local or national authorities on heat transition overlaps with the expectation of residents?

- Yes
- Partially
- No
- No idea
- Prefer not to answer

Q11 What would you describe as the most important driving force affecting your decision-making on energy-related issues since individual streets can only be disconnected from the gas grid when each home has voluntarily implemented an alternative heat option?
Choose as many as you like

- Cost efficiency
- Thermal comfort
- Environmental concerns (for ex. climate change)
- Anticipating new government rules and policies
- Energy security of the Netherlands
- Democratization of energy-use
- Contribute to the wider community (a societal purpose)
- Other: ____

Q12 Do you know the energy label of your home? If yes, what is the energy label of your house?

please choose

▼G ... Weet ik niet

Q13 Which category would you assign the insulation of your home?

- ○ Very well insulated
- ○ Well insulated
- ○ Not good, not bad
- ○ Poorly insulated
- ○ Very poorly insulated

Q14 Have you ever been informed by any of the following institutions and organizations about the heat transition that will take place in your neighborhood?
Choose as many as you like

- ☐ Ministry of Economic Affairs and Climate Policy
- ☐ Province of Genderland
- ☐ Municipality of Nijmegen
- ☐ Building and installation companies
- ☐ Energy distributors (Nuon and Engie)
- ☐ Local water board (Rivierenland or MARN)
- ☐ Grid operators (Liander, Firan or Indigo)
- ☐ The Radboud University, the HAN or ROC Nijmegen
- ☐ Association Energy Cooperatives Genderland(for ex. Burgers Geven Energie (BGE))
- ☐ Owners' Associations (Association of Owners) if applicable
- ☐ Neighborhood energy cooperative
- ☐ Other: ____
- ☐ Prefer not to answer

Q15 Have you ever attended any events with regard to the heat transition (the electricity options, energy efficiency measures, etc.) for your neighborhood?
Choose as many as you like

- ☐ Information/Orientation
- ☐ Workshop/Training
- ☐ Panel Discussion/Presentation
- ☐ Conference/Seminar
- ☐ Social/Networking
- ☐ Neighborhood meeting
- ☐ Other ____
- ☐ I have not attended any events
- ☐ Prefer not to answer

Q16 Which phase or phases do you think citizens should take an active role in heat transition?
Choose as many as you like

- ☐ Early phase (Identification of problem-solution recommendations)
- ☐ Design phase (Concept plans)
- ☐ Implementation phase
- ☐ Final phase (The assessment and monitoring of results)
- ☐ No idea
- ☐ Prefer not to answer

Q17 How would you assess the potential of your neighborhood to be a fully gas-free neighborhood, considering elements such as housing stock, energy infrastructure, and, income level of residents?

- ○ Very high potential
- ○ High potential
- ○ Not high, not low potential
- ○ Low potential
- ○ Very low potential

Q18 Which of the following option or options influenced you to give this score?
Choose as many as you like

- ☐ Housing stock
- ☐ Energy infrastructure
- ☐ Income level of neighborhood
- ☐ Current condition of the homes due to the construction or age of the homes
- ☐ Current condition of the homes due to the state of maintenance of the homes (the extent to which homes are well/poorly insulated and maintained)
- ☐ Willingness of residences
- ☐ National subsidies
- ☐ Trust in authorities
- ☐ Heating technologies
- ☐ No opinion
- ☐ Other: ____
- ☐ Prefer not to answer

Q19 Phasing-out gas in the neighborhood requires collective action from the residents. What kind of resource you would have provided for the collective action if needed?
Choose as many as you like

- ☐ Financial support
- ☐ Positive support
- ☐ Technical knowledge
- ☐ Provide information (About your house and energy use)
- ☐ Enthusiasm (Time and effort)
- ☐ Nothing
- ☐ Other ____
- ☐ Prefer not to answer

Q20 How would you rate your neighborhood's capacity to organize on environmental and sustainability issues?

- ○ Very high organizational capacity
- ○ High organisational capacity
- ○ Not high, not low
- ○ Low organisational capacity
- ○ Very low or no organisational capacity

Q21 Heat transition requires a high amount of investment (including home insulation, provision of new heat technologies, and, reconfiguration of energy infrastructure). Can you distribute a hundred points (100) over the actors according to what extent one actor is responsible to pay?
A higher score results in a higher cost for each actor

	0 10 20 30 40 50 60 70 80 90 100
National or local authorities	
Homeowners	
Housing corporations (for tenants)	
Energy infrastructure utility (Grid companies)	

Q22 When you think of emerging low-carbon heat business models, which of the following(s) are you interested in?
Choose as many as you like

- ☐ Heat output as a service (e.g., paying a monthly fee to lease and maintain a heating device, with the provider offering fuel and heat)
- ☐ Heat outcome as a service (e.g., like heat output as a service, but customers are charged for warmth rather than heat)
- ☐ Warmth payment plan (e.g., charging a house for a set number of warm hours per month)
- ☐ Energy payment plans (e.g., bundling a warmth payment plan with other energy services such as electricity or lighting)
- ☐ Asset leasing (e.g., the service provider charges a fixed monthly fee to lease the heating appliance, including maintenance and repairs; at the end of the contract, customers can buy out the appliance or have it removed by the provider)
- ☐ Efficient asset leasing (e.g., same as asset leasing, except with some kind of performance guarantee)
- ☐ Low-carbon heating retrofits, Community contracts between neighbors (e.g. peer-to-peer energy trading)
- ☐ No opinion
- ☐ Prefer not to answer

Q23 "How would you describe your perspective with regards to the heat transition in your neighborhood in your own words? (In one or a few sentences)
Max. 150 words

____

End of Block: HEAT TRANSITION SURVEY

Appendix 2. Interview Guidelines

Semi-Structured Interview Guide

I am grateful that you accepted my interview request, Mrs. Juul. I want to mention who I am and what I have been doing. I am a master's student at Radboud University and conduct a master's research in the scope of Spatial Planning-Cities, Water and Climate change department. To briefly mention the purpose of the thesis, the Dutch government aims to take off the residential areas from natural gas in order to reduce carbon emissions and combat global climate change. In this context, the neighborhood approach has been chosen as the main approach for realizing the heat transition, which attributes great importance to residents and community groups. This master research aims to reveal the impending and accelerating factors that exist in the heat transition of Nijmegen. This interview is expected to provide necessary information on how a neighborhood can be organized for the heat transition and the factors affecting the capacity of the neighborhood in that sense. Furthermore, actors involved in the Nijmegen heat transition process and the power relations of actors as well as activities that may foster the heat transition will try to be revealed. The format of the interview will progress in the form of a conversation with the questions. The information you provided will only be used for this research. It is expected that this interview lasts around one hour. However, the interview can be time-consuming, and the duration of the interview may exceed what is planned. More importantly, you always have a right to end this interview. Lastly, I would like to audio-record the conversation with the Microsoft team.

Establishing Rapport

Mrs. Juul, can you briefly explain where you work and what kind of role you have in this company?

1. **Community capacities**

Personal capacity

Prompt: The heat transition constitutes a socio-technical challenge that necessitates residents to contribute to the transition and cooperate with other stakeholders. How can residents be more willing to contribute to the heat transition?

Additional Prompt: Do you describe the lack of mental ownership among residents toward the heat transition as a barrier? If yes, how this barrier can be overcome?

Infrastructural capacity

Prompt: To what extent the existing infrastructure such as housing stock, housing age, gas network, or insulation level of housing in a neighborhood affects the community's capacity to act on heat transition?

Organizational capacity

Prompt: In most cases, the optimal solution is collective heating systems which require a consensus and the ability to act together for residents. How can a neighborhood be more organized and how likely is being organized to speed up the heat transition?

Cultural capacity

Prompt: Would it be said that the historical or cultural background of a community in a neighborhood may trigger the capacity of this community to act on the heat transition?

2. **Actors, roles, and power relations**

Prompt: Residents keep the power to have the last word in their heating systems. How this power has an impact on the power relations among actors that are involved in the heat transition?

Additional Prompt: Can you identify the main obstacles that exist in the collaboration process of the heat transition at the neighborhood level? And, how can these barriers be overcome?

3. **Activities that foster transformative power**

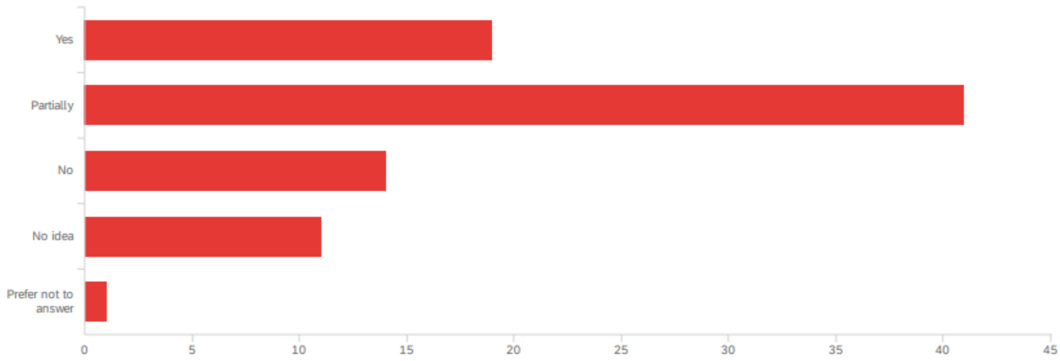
Social Learning

Prompt: Municipality of Nijmegen is leading the informative activities aiming to increase the awareness of residents on the heat transition. However, these efforts do not always lead to strong ownership of the heat transition for a resident. What should be done to increase citizen ownership and participation in the heat transition? What are the common mistakes made by institutions organizing these kinds of activities?

Expectation alignment

Prompt: In the survey conducted in 5 neighborhoods of Nijmegen for this research, I asked the residents to what extent their own expectations were in line with the expectations of national and local governments. As it can be understood from the image, not all participants believe that the expectations on the heat transition are aligned. How can residents be more convinced that the national and local authorities share the same destiny?

Q10 - Do you think that the expectation of local or national authorities on heat transition overlaps with the expectation of residents?



Resource acquisition

Prompt: It is stated in the municipal heat vision report that the total cost of taking off natural gas in residential areas in Nijmegen will be between 1.3 and 2 billion euros. In the survey study, I asked the residents by whom this fee should be paid. The results show that participants stated that almost half of the cost should be paid by national or local authorities. Is that feasible when we take into consideration the fact that finance is one of the most important driving factors in decision-making for residents?

Q21 - Heat transition requires a high amount of investment(including home insulation, provision of new heat technologies, and, reconfiguration of energy infrastructure). Can you distribute a hundred points(100) over the actors according to what extent one actor is responsible to pay? A higher score results in a higher cost for each actor

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	National or local authorities	0.00	100.00	52.41	25.61	655.72	73
2	Homeowners	0.00	100.00	35.65	25.58	654.46	68
3	Housing corporations (for tenants)	0.00	100.00	45.92	30.85	951.69	62
4	Energy infrastructure utility (Grid companies)	0.00	100.00	40.85	28.18	794.33	68

Semi-Structured Interview Guide

I am grateful that you accepted my interview request, Mr. Erik. I want to mention who I am and what I have been doing. I am a master's student at Radboud University and conduct a master's research in the scope of Spatial Planning-Cities, Water and Climate change department. To briefly mention the purpose of the thesis, the Dutch government aims to take off the residential areas from natural gas in order to reduce carbon emissions and combat global climate change. In this context, the neighborhood approach has been chosen as the main approach for realizing the heat transition, which attributes great importance to residents and community groups. This master research aims to reveal the impending and accelerating factors by looking at different characteristics of neighborhoods in Nijmegen. This interview is expected to provide necessary information about the economic feasibility of taking off natural gas in the neighborhoods. Also, it is aimed to reveal whether any physical or social characteristics of a neighborhood can lead to a different approach to the realization of the heat transition in the neighborhoods. The format of the interview will progress in the form of a conversation with the questions. The information you provided will only be used for this research. It is expected that this interview lasts around one hour. However, the interview can be time-consuming, and the duration of the interview may exceed what is planned. More importantly, you always have a right to end this interview. Lastly, I would like to audio-record the conversation with the Microsoft team if you give permission.

Establishing Rapport

Prompt: Mr. Erik, can you briefly explain where you work and what kind of role you have in the municipality of Nijmegen?

Current situation of the heat transition in Nijmegen

Prompt: In the heat vision of Nijmegen published in 2018, it was stated that the transition was not at the desired speed. Considering the past 4 years, what would you say about the current state of the transition?

Additional Prompt: What has the municipality done to accelerate the transition in last 4 years? What were the barriers encountered?

Economic feasibility of the transition

Prompt: Heat transition is costly. What are the priorities or sensitivities of the municipality in its economic approach in the heat transition?

Additional Prompt: What are the factors that increase or decrease the cost between one neighborhood and another? (The energy infrastructure, housing stock, or legal ownership of the house)

Neighborhood approach and neighborhood capacities

Prompt: Each neighborhood has its own social and physical characteristics, which may require a different approach for each neighborhood. Are there any impeding or accelerating factors that are caused by either the social or physical context of the neighborhood in the heat transition of Bottendaal, Dukenburg, Hatert, Hengstal, and Heijendaal? (House age, income level, infrastructure of the neighborhood)

Additional Prompt: How important for residents to be organized with their neighbors in terms of the economic feasibility of the heat transition? How can citizens' capacity to organize with their neighbors be increased?

Citizen participation in the heat transition

Prompt: Although the importance of citizens' participation in the process is emphasized in the Nijmegen heat vision, the duties, roles, and responsibilities of citizens are not fully defined. In which or which of the early phase, design, implementation, and evaluation-follow-up processes can the active participation of citizens contribute to accelerating the process? Can active citizen participation in the heat transition slow down the process?

Business case

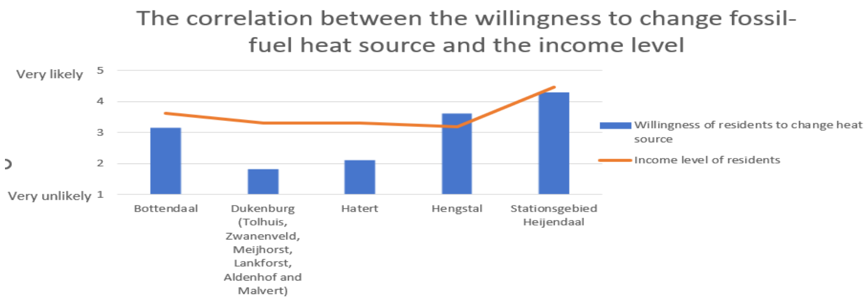
Prompt: The municipality is committed to its citizens that they are not going to pay high energy bills in the heat vision. What policies or regulatory steps are required for each neighborhood or street to become a business case? (to lower the social and financial cost of transition)

Prompt: Can cost-effective, socially acceptable, and efficient heating systems help to make neighborhood business cases?

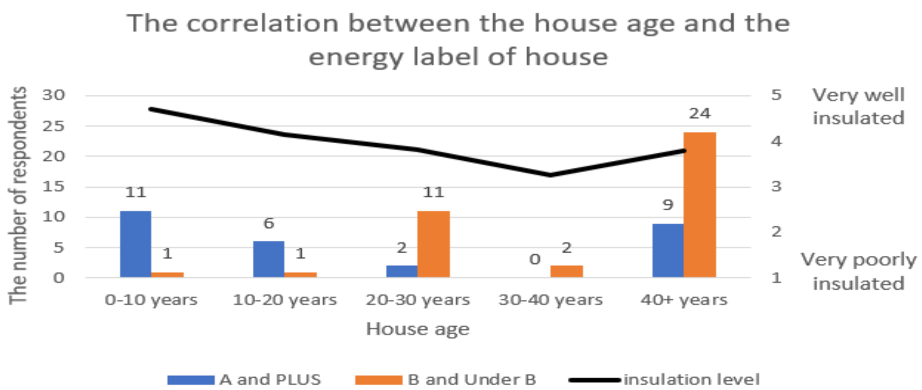
Questionnaire reviews

In this part, I will share with you some of the preliminary results of the survey study I conducted in 5 districts of Nijmegen. I will ask you to share the points you find important.

1. In this graphic, first of all, it is seen to what extent the residents of the 5 neighborhoods are willing to change their fossil-based heat sources. In addition, the average income level of the neighborhoods is also shown in the chart. There seems to be a correlation between income level and willingness to change. What would your comments be about this graphic?



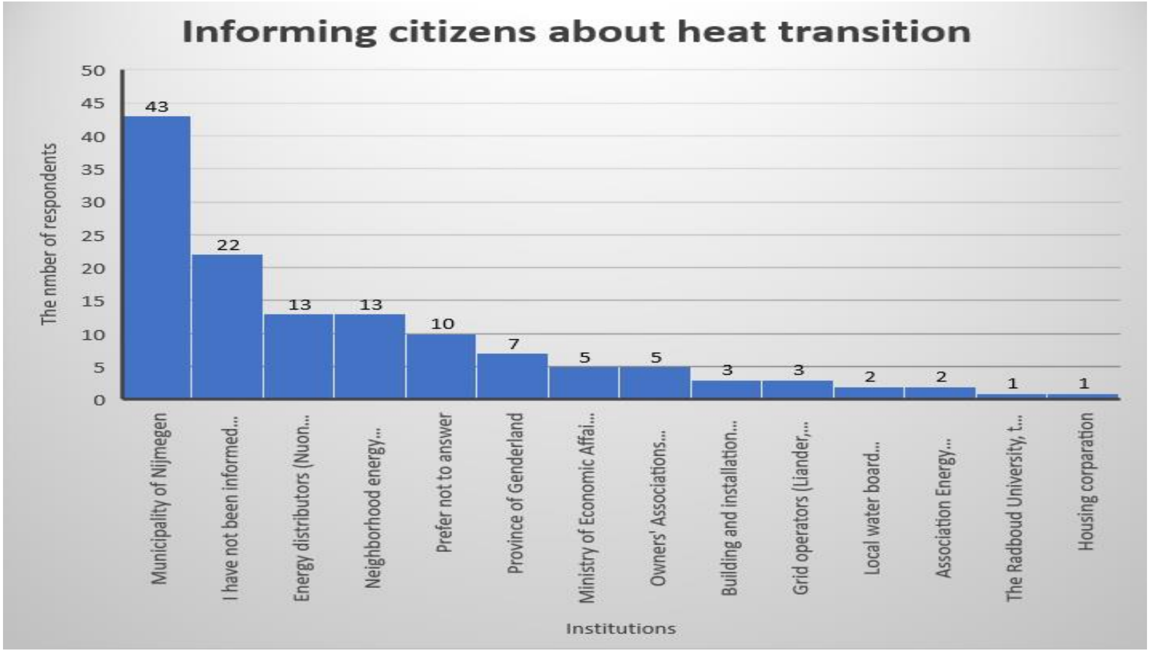
2. It is clearly seen in this graph that the age of the house directly affects the energy label of the house. However, unlike the correlation, as you can see from the black line in houses over 40, there seems to be relatively high isolation. This difference may be a mistake of the survey study, but it may show that the higher age of the houses may have pushed people to isolation measures. What are your comments?

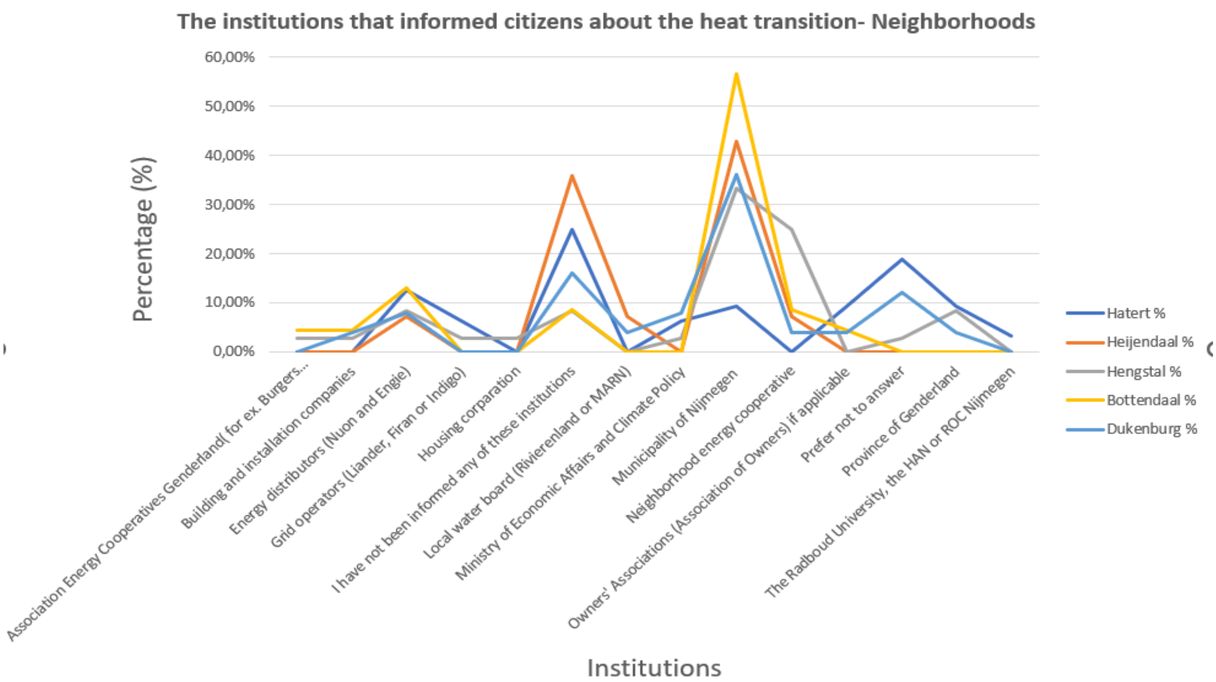


3. In the first table, it is seen that the municipality has made the biggest effort to inform the public about heat conversion. However, in the second table, only about 10 percent of

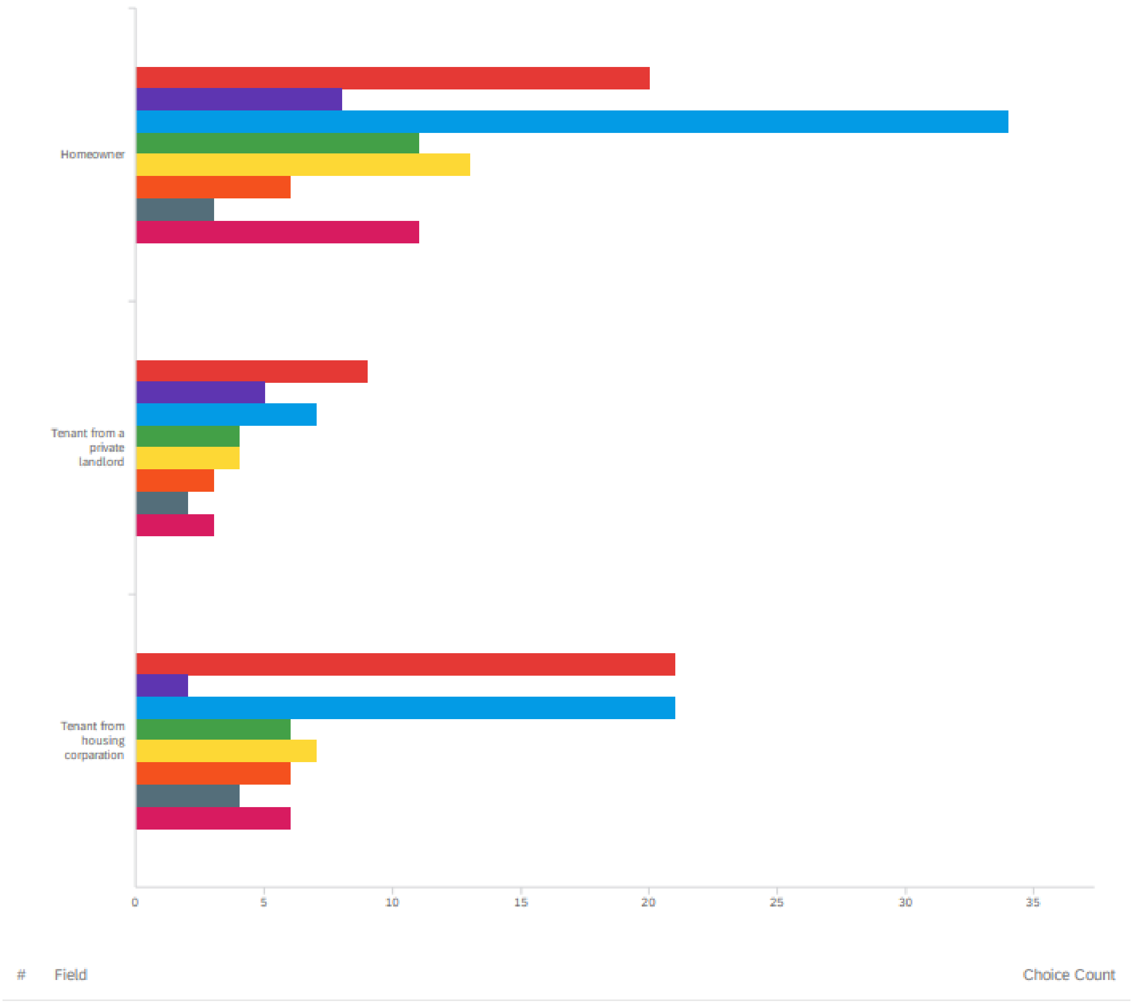
the residents in the Hatert neighborhood said that they received information from the municipality of Nijmegen.

First of all, why does the municipality give such importance to raising awareness of the residents? Secondly, why does it seem that there is little information provided by the municipality in Hatert district, unlike other districts?





4. We asked residents about the factors that affect their decision on energy transition. The answers of landlords, private tenants, and housing company tenants are shown in the chart below. While landlords keep environmental concerns first, cost-efficiency is seen first among tenants. What are the reasons for this?



Red	Cost- efficiency
Purple	Thermal comfort
Blue	Environmental concerns
Green	Anticipating new government rule and policy
Yellow	Energy security of the Netherlands

My questions end here, thanks for your contribution to the study.

Is there anything else you want to add?

Appendix 3. Codes

Interview codes

Code Groups
ACTOR RELATIONS (4)
ACTORS (8)
AUTHORITIES (8)
BARRIERS (30)
BUSINESS CASE (6)
CITIZENS (7)
COMMUNICATION (9)
COMMUNITY ORGANISATIONS (17)
INFORMATION (5)
MUNICIPALITY (13)
NEIGHBORHOOD APPROACH (10)
NEIGHBORHOOD CAPACITIES (16)
NEIGHBORHOODS (18)
NEW HEATING TECHNOLOGIES (4)
PARTICIPATION (4)
PHYSICAL ASPECT (8)
POLICY (7)
SOCIAL ASPECT (11)
SOLUTIONS (23)
TRANSITION (8)

Survey codes-Question 23

Code Groups
ACTORS (4)
BARRIERS (6)
HEAT (16)
HEAT TRANSITION (16)
NEIGHBORHOODS (7)
OTHERS (3)
PERSONAL CAPACITY (6)
SOLUTIONS (8)