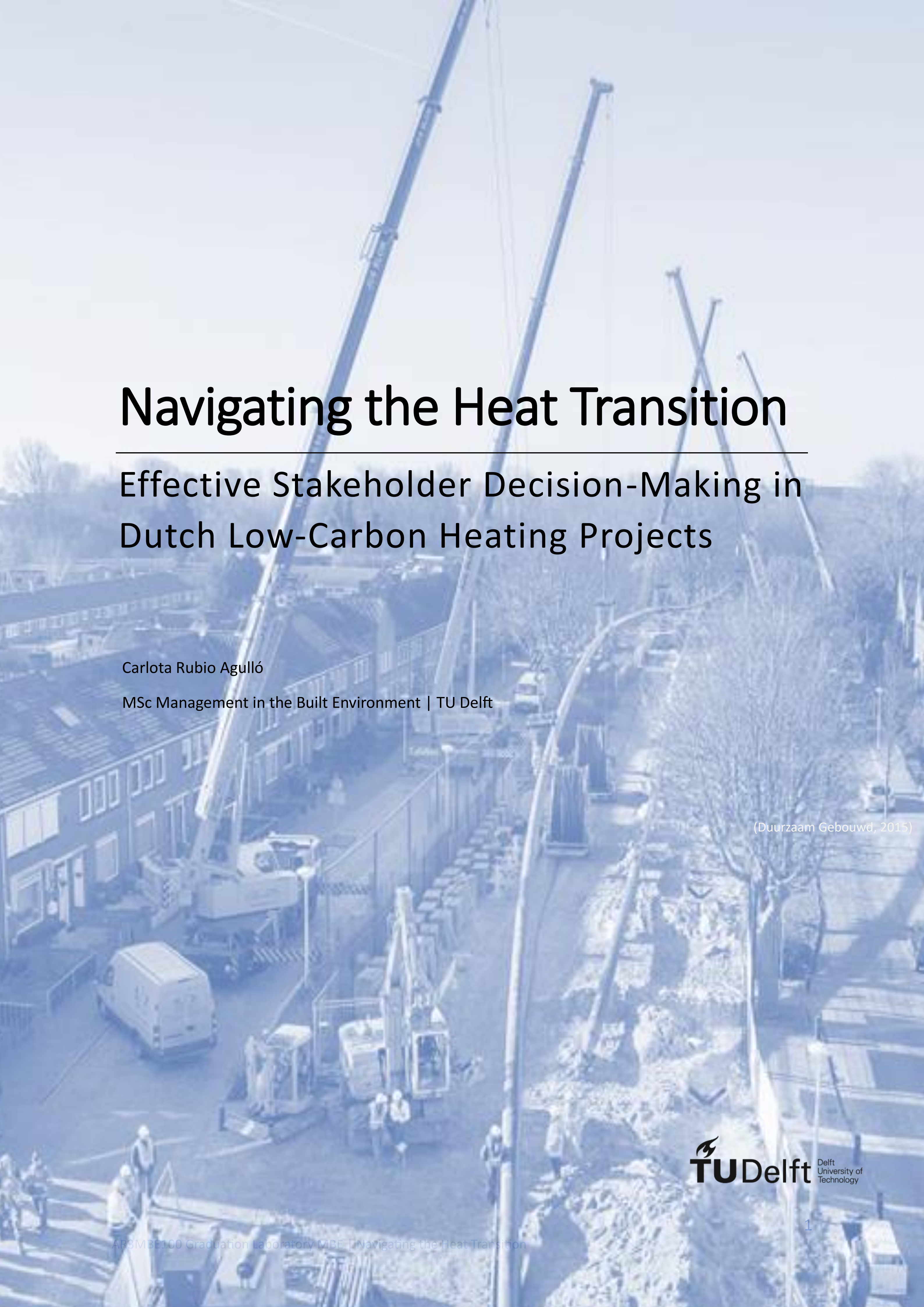

Navigating the Heat Transition

Effective Stakeholder Decision-Making in Dutch Low-Carbon Heating Projects

Carlota Rubio Agulló

MSc Management in the Built Environment | TU Delft

(Duurzaam Gebouwd, 2015)

ABSTRACT

The Dutch government's 2050 initiative to transition all buildings from natural gas to sustainable heat systems underscores the critical role of stakeholder alignment in energy transition projects. Despite its importance, existing literature lacks a comprehensive analysis of the mechanisms required for effective stakeholder collaboration in heat grid projects. This study addresses this gap through an explorative qualitative analysis, employing interviews and a representative case study to examine: How can collective decision-making be orchestrated to overcome the barriers of low-carbon heating grid projects in mixed-use neighbourhoods? The findings identify the primary barriers to project success as political-legislative uncertainty, lack of transparency & trust, and lack of participation & cooperation, and propose a collective decision-making framework for enhancing stakeholder decision-making processes outlining which stakeholders should be involved during barrier/stakeholder intensive moments. The research contributes to the literature on collaborative innovation for heating grids by outlining strategies for overcoming obstacles in heat grid project implementation, highlighting the significance of coordinated action among diverse stakeholders for achieving energy transition goals.

Keywords: District heating networks, Heat grids, Mixed-use neighbourhoods, Decision-making, Stakeholders Collaboration, Non-technical barriers

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Carlota Rubio Agulló
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CONTENTS

ABSTRACT 2
COLOPHON 3
ACKNOWLEDGEMENTS 4
Graphics Index 7
List of Figures 7
List of Tables 8
List of Abbreviations 8
1.0 INTRODUCTION 10
1.1 Introduction 10
1.2 Problem statement 13
1.3 Societal and scientific relevance 14
1.4 Research questions 15
2.0 THEORETICAL BACKGROUND 17
2.1 Mixed-use neighbourhoods 17
2.1.1 Mixed-use neighbourhood theory 17
2.1.2 Mixed-use neighbourhoods in the Netherlands 19
2.2 Heating grids 21
2.3 Stakeholders of the energy transition 23
2.3.1 Stakeholders of the energy transition in mixed-use neighbourhoods 26
2.3.2 Stakeholders of heat grid projects 26
2.4 Barriers and drivers 27
2.4.1 Barriers and drivers of the energy transition 27
2.4.2 Barriers in heat grid projects 31
2.4.3 Barriers in heat grid projects in the Netherlands 31
2.5 Collective decision-making 33
3.0 RESEARCH METHODOLOGY 35
3.1 Research design 35
3.2 Data collection 37
3.2.1 Desk study 37
3.2.2 Interviews & case study design 38
3.2.3 Expert validation interviews 39
3.3 Data analysis 39
3.3.1 Interviews and case study 39
3.3.2 Expert interviews 40
3.4 Data plan 40

3.5 Ethical considerations 40
4.0 RESEARCH OUTPUTS 42
4.1 Goals and objectives 42
4.2 Deliverables 42
4.3 Dissemination and audiences 42
4.4 Personal study targets 42
5.0 ANALYSIS 45
5.1 Methods of analysis 45
5.1.1 Interview contents and questions 45
5.1.2 Interview coding and analysis 45
5.1.3 Case study selection 47
5.2 Generic analysis 48
5.2.1 Generic decision-making process 48
5.2.2 Generic analysis of barriers 52
5.2.3 Generic collective decision-making views 64
5.3 Case study – Groenoord, Schiedam 70
5.3.1 Mixed-Use in Groenoord 71
5.3.2 Barriers 71
5.3.3 Decision-Making Process 72
5.3.4 Conclusion 75
6.0 DISCUSSION 81
6.1 Validated Decision-Making Process 82
6.2 Barriers in the Decision-Making Process 84
6.3 Solutions to Barriers in Low-Carbon Heating Grid Projects 88
6.4 Collective Decision-Making Approach 100
7.0 CONCLUSION 106
7.1 SQ1: Who are the stakeholders of low-carbon heating grid projects in mixed-use neighbourhoods and what are their attributes? 106
7.2 SQ2: What is the current decision-making process in place? 107
7.3 SQ3: What are the barriers encountered in low-carbon heating grid projects in mixed-use neighbourhoods and when do they occur? 108
7.4 SQ4: What is the role of the collective in low-carbon heating grid projects in mixed-use neighbourhoods? 108
7.5 MRQ: How can collective decision-making be orchestrated to overcome the barriers of low-carbon heating grid projects in mixed-use neighbourhoods? 109
8.0 LIMITATIONS & RECOMMENDATIONS 111
BIBLIOGRAPHY 112

Appendix A – Data management plan ... 120
Appendix B – Interview Protocol ... 125
Appendix C – Generic Decision-Making Process ... 128
Appendix D – Case Groenoord Barriers Framework ... 130
Appendix E – Original vs Validated Decision-Making Process ... 132

Graphics Index

List of Figures

Figure 1: The Energy Transition ... 10
Figure 2: District heating system ... 11
Figure 3: District heating value chain ... 12
Figure 4: Conceptual model (author) ... 15
Figure 5: Mixed land use in four dimensions ... 18
Figure 7: Neighbourhood typology categorization ... 19
Figure 8: Rotterdam typology ... 20
Figure 9: The Hague typology ... 20
Figure 10: Utrecht typology ... 20
Figure 11: Amsterdam typology ... 20
Figure 12: Power interest matrix (author, adopted from Maqbool et al., 2022) ... 25
Figure 13: Stakeholder roles in sustainable neighbourhood projects ... 25
Figure 14: Stakeholder roles in heat grid projects ... 27
Figure 15: Motivators of the energy transition ... 28
Figure 16: Barriers of the energy transition ... 29
Figure 17: Summary of the barriers in the implementation of district heating projects the different stakeholder categories ... 31
Figure 18: Research methodology framework (author) ... 35
Figure 19: Research methodology triangulation (author) ... 37
Figure 20: Generic decision-making process (author) ... 48
Figure 21: Generic initiation phase of decision-making process (author) ... 49
Figure 22: Generic feasibility phase of decision-making process (author) ... 49
Figure 23: Generic contracting phase of decision-making process (author) ... 51
Figure 24: Validated barriers per stakeholder group (author) ... 60
Figure 25: Validated barriers per phase (author) ... 61
Figure 26: Validated barriers per phase for energy companies (author) ... 62
Figure 27: Validated barriers per phase for regional government (author) ... 62
Figure 28: Validated barriers per phase for consultancy bureau (author) ... 63
Figure 29: Validated barriers per phase for municipality (author) ... 63
Figure 30: Validated barriers per phase for housing associations (author) ... 64
Figure 31: Validated barriers per phase for energy cooperatives (author) ... 64
Figure 32: Stakeholder views on collective decision-making impact (author) ... 65
Figure 33: Collective decision-making views per phase (author) ... 65

Figure 34: Groenoord heat grid 70
Figure 35: Decision-making process in Groenoord (author) 74
Figure 36: Governance structure in Groenoord case 75
Figure 37: Validated decision-making process (author) 82
Figure 38: Decision-making process with mapped barriers (author) 87
Figure 39: Barriers and their corresponding solutions (author) 89
Figure 40: Solutions strategy (author) 90

List of Tables

Table 1: Potential stakeholders in energy transition projects (author) 24
Table 2: Barriers in energy transition projects (author). 30
Table 3: Research Methods (author) 37
Table 4: Case study selection criteria (author) 38
Table 5: Interviews (author). 46
Table 6: Case study selection justification (author) 47
Table 7: Process diagram legend (author) 48
Table 8: Barriers Framework (author) 52
Table 9: Barriers in mixed-use neighbourhoods (author) 59
Table 10: Groenoord stakeholders and their attributes (author) 76
Table 11: Barriers in the initiation phase (author) 84
Table 12: Barriers in the feasibility phase (author) 84
Table 13: Barriers in the contracting phase (author) 85
Table 14: Key barriers (author) 88
Table 15: Solution to barriers in heat grid projects (author) 90
Table 16: Collective decision-making during the decision-making process (author) 101

List of Abbreviations

CDM – Collective Decision-Making

DH – District Heating

DHN – District Heating Network

DMP – Decision-Making Process

GHG – Greenhouse Gases

RES – Regional Energy Strategies

SH – Stakeholders

RES – Regional Energy Strategies

TVW – Transitievisie Warmte

VVE – Verenigingen van Eigenaren

WCW – Wet Collectieve Warmtevoorziening

Part 1

Introduction

CONTENT

1.1 Introduction
1.2 Problem Statement
1.3 Societal and scientific relevance
1.4 Research questions

1.0 INTRODUCTION

1.1 Introduction

It is evident that climate change is an urgent matter at a global scale which requires efforts intercontinentally. In order to stress this global emergency and create a plan of approach to tackle it, the UN COP21 Paris Agreement was established by world leaders in 2015 to set long-term goals for all nations to tackle climate change. The most notable goal being to limit the increase in global temperature in this century to a minimum of 2°C and ideally to 1,5°C by reducing global greenhouse gas (GHG) emissions by 45% by 2030 and by 2050 become net-zero (United Nations, n.d.-b, n.d.-a). Although this is an accepted fact, in 2021 the COP26 review of the Paris Agreement reported that there has been negligible impact on the goals and that given the policies in place at the time, the trajectory shows that there will be a 2,8°C global temperature increase by 2030. This report further exemplifies the urgency of multi-industry transformations to reduce greenhouse gas emissions (United Nations Environment Programme, 2022). In the European Union, energy generation is responsible for around 40% of total energy CO2 emissions, making it a crucial point of attention (Valkhof, 2020). Therefore, alternative energy sources, such as renewable sources like solar or wind, are needed to replace fossil fuel sources and decrease CO2 emissions (United Nations, n.d.-a). However, new strategies to manage this switch of energy sources is needed in order to meet energy demand (Bekebrede et al., 2018). This is referred to as the effective energy transition, which is defined as "a timely transition towards a more inclusive, sustainable, affordable and secure energy system that provides solutions to global energy-related challenges, while creating value for business and society, without compromising the balance of the energy triangle" (Valkhof, 2020). Figure 1 shows the energy triangle which must remain balanced

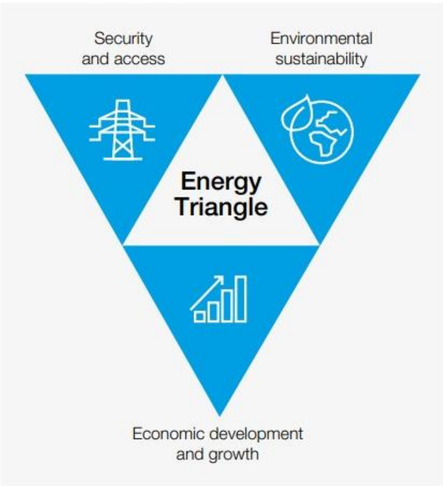


Figure 1: The Energy Transition
Source: Valkhof, B. (2020). Energy Transition 101: Getting back to basics for transitioning to a low-carbon economy. Mission Possible Platform. https://www3.weforum.org/docs/WEF_Energy_Transition_101_2020.pdf

Honing into the Netherlands, country specific goals have been set complementary to the Paris Agreement. As per the 2019 Climate Act, the government stated an aimed reduction of greenhouse gas emissions by 49% by 2030, and a reduction of 95% by 2050 (Climate Agreement, 2019). however, these goals have now changed to a 55% reduction by 2030 and net-zero by 2050 (Hammingh et al., 2022). However, the Netherlands Environmental Assessment Agency (PBL) found that the country is not currently on schedule to reach the emissions reduction target by 2030 due to its heavy reliance on fossil fuels (IEA, 2020). PBL reported that given the current pace of the transition, the decrease in greenhouse gas emissions in the country is expected to reach between 39% and 50% by 2030, which falls below the set goals. This is due to the fact that greater climate ambitions demand faster implementations and increased policies and legislation (Hammingh et al., 2022).

In the Climate Agreement, the Dutch government has stated its priority of phasing out natural gas by 2050, given that it is the main heat supply source for households. Therefore, new sustainable heating systems that are reliable and affordable are of importance to reduce the reliance on fossil fuels in the Netherlands and consequently decrease emissions. Given that there are many neighbourhoods in which electrification is not possible, district heating or heating grids are ideal implementations (ten Haaft, 2020). Sustainable district heating, also known as heat grids, is network of pipes that form a grid through which water that is heated by means of renewable energy flows. These grids can then provide heating for homes, and other buildings and infrastructure (Gasunie, 2022). District heating is not a new discovery and has been present in Dutch infrastructure for many years, such that currently there are 18 major district heating networks and 100 smaller scale networks that provide heating for many households (Niessink, 2019). Many of these heating networks are currently powered by natural gas, however if connected to renewable heat sources, such system can provide a sustainable solution to heating as they produce approximately 60% less greenhouse gas emissions than the conventional natural gas boilers that are currently in place. Common renewable heat sources that can be used in heat grids include residual heat, solar thermal energy, geothermal energy, biomass, and aquathermy (Milieu Centraal, n.d.). These heating networks are used in districts and neighbourhoods to provide efficient heat transportation and distribution while enhancing energy efficiency and reduced carbon emissions (ENGIE, 2013). Figure 2 below shows how district heating can look on a neighbourhood scale.

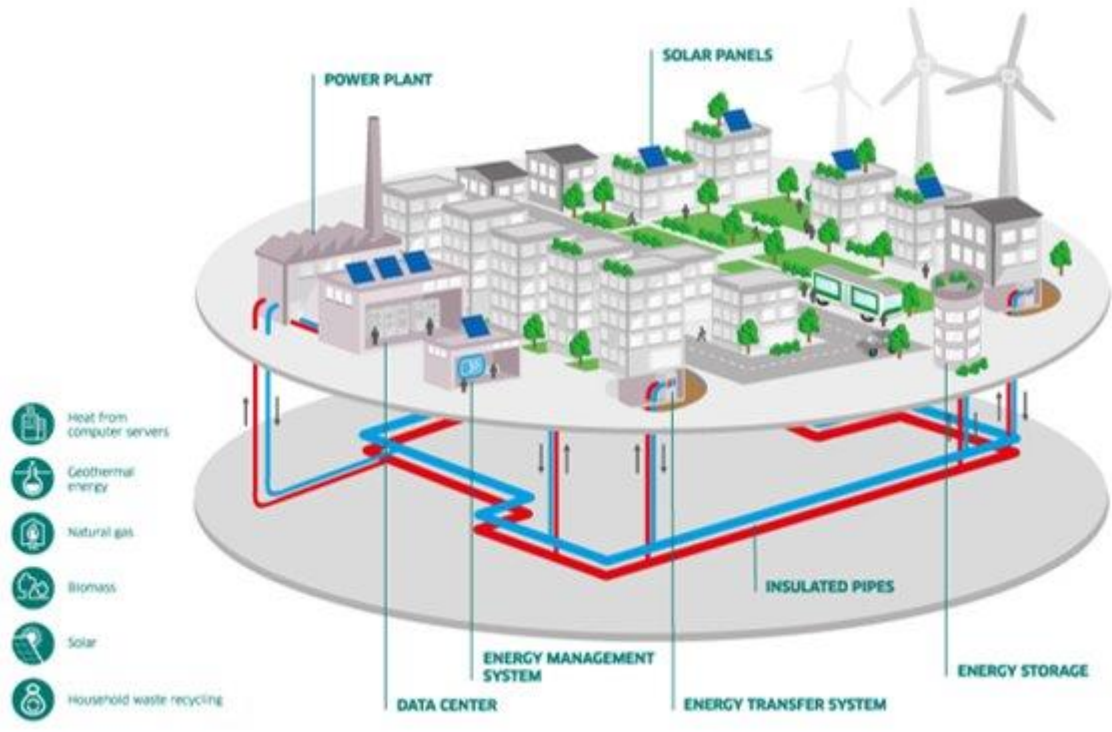


Figure 2: District heating system
Source: ENGIE. (2013, February 11). District heating and cooling systems. Engie. https://www.engie.com/en/businesses/district-heating-cooling-systems

Cities are made up of neighbourhoods, and typically are of a mixed-use nature, such that mixed-use neighbourhoods can be defined as a collection of multiple buildings which in combination consist of two or more functions. There are many examples in the Netherlands of mixed-use neighbourhoods, such as Zuidas in Amsterdam that comprises of residential and office buildings, shops, cultural and sports facilities, and catering establishments (Amsterdam Zuidas Informatiecentrum, 2023). Given the mixed nature of such neighbourhoods, the number of stakeholders with their own perspectives increases, meaning there is a greater chance for clashing views and conflicts arising. This is an important consideration in district heating projects given that mixed-use neighbourhoods are ubiquitous and hence heating networks will most likely be located in such an area.

District heating projects are established by the municipalities, due to the Climate Agreement's framework which has required municipalities to be involved in the Regional Energy Strategy (RES) at a regional level, and generate a heat transition vision and district implementation plan (Transitievisie Warmte en Wijkuitvoeringsplan) at a municipal level to provide a roadmap for the implementation of heating grids per district (Rijksdienst voor Ondernemend Nederland, 2022). Such projects can then be simplified into three components: the heat source or production, the heat distribution and transportation, and the heat supply to consumers (ten Haaft, 2020). As previously mentioned, there are various options that are possible regarding the heat source, and the choice of source is dependent on what is possible in the district and is specified in the Transitievisie Warmte. The distribution and transportation of the heat occurs between the source and the heat grid, and between the heat grid and the supply source. This component is typically managed by an energy network operator such as Gasunie. Finally, the heat is supplied to the consumers, which can be home owners or housing associations for example, who buy the energy from the heat supplier (R. Prins, personal communication, 2 June 2023; ten Haaft, 2020). Figure 3 below shows the typical simplified chain of district heating.

Figure 3: District heating value chain
Source: ten Haaft, M. (2020, July 1). The Future Dutch District Heating System. Accenture. https://www.accenture.com/nl-en/blogs/insights/anticipating-the-future-dutch-district-heating-system

Like in any construction project, there are many decisions that must be made throughout the process of the projects. However, since these projects are established by municipalities, more specifically by a city council, and involves different parties such as the energy generator, the energy distributor, and the consumers, it has been observed that there is a lack of top down management (Blasch, 2021; R. Prins, personal communication, 2 June 2023), meaning that there is a lack of a central project manager or controller that ensures the alignment of the project's outcomes and involved stakeholders (Alketbi & Gardiner, 2014). For this reason, it is common for the parties to individually approach the challenges that they may encounter without discussing with the other involved parties. However, this becomes an important issue later on in the project process because at a certain point in the project, the different parties will need to come together to agree on certain measures, such as for example at the time of selling and buying the heat. Since the parties have not been collaborating throughout the process, they typically enter conflict at such stages due to their misalignment. For example, if the heat generator has incurred additional costs which cause the final heating price to increase but has not communicated early on with the consumer, they may refuse to pay the proposed amount. This example serves to demonstrate an impactful barrier that occurs during the process of district heating projects which is the lack of trust and transparency between parties (R. Prins, personal communication, 2 June 2023). This ties into the studied barriers of a lack of cooperation and a resistance from companies working on district heating projects (Reda et al., 2021). Additionally, another key barrier involves the financing aspect of such projects, as briefly touched upon in the previous example, both from the consumers' perspective as well as the energy companies and sector parties (R. Prins, personal communication, 2 June 2023; Reda et al., 2021). When combined with the lack of trust and transparency and the unwillingness to collaborate and cooperate, these problems become wicked meaning that they are complicate, complex, and difficult to resolve (Lönngren & Van Poeck, 2021). Additionally, given that there is no central project manager or controller, these conflicts are increasingly difficult to resolve due to the collaborative barriers stated, which can often result in the long delay of projects (R. Prins, personal communication, 2 June 2023). This phenomenon demonstrates that there is a lack of collectivity in such projects, which can be understood at the joint participation and collaboration of the key parties to mutually strive for a successful project outcome (Moradi & Kähkönen, 2022).

This lack of communication and collaboration throughout the project process results in the minor challenges that inevitably arise to be tackled individually by the affected parties rather than in combination with all involved parties. When repeated, this causes a snowball effect further along the project process such that once the parties inevitable come together to make a decision or confront an issue, the problem is already too complex and much more difficult to resolve (R. Prins, personal communication, 2 June 2023). Therefore, it is clear that it is the decision-making moments that highlight the challenges of the project. It is for this reason that the entire project process is evaluated, and the decision-making process is analysed for its potential improvement to avoid or mitigate such challenges. From the presented challenges and barriers, it can be hypothesized that an increase in collectivity could alleviate the severity of some of the problems by attempting to avoid the causation of the snowball effect. Furthermore, the collaboration between parties in the early phases of the projects in combination with an established collective decision-making process that is applied for the duration of the project could mitigate the risk of wicked problems given that challenges can be tacked together as they arise.

1.2 Problem statement

Global warming and the pressing issues associated with it are evident. The Paris Climate Agreement in 2015 was a crucial step towards making a conscious global decision to work towards ameliorating climate change. More specifically, the Dutch government's National Climate Agreement delineating the decision for the Netherlands to reduce its greenhouse gas emissions by 49%, by 2030 and reduce by 95% by 2050. However, in 2019 the Netherlands Environmental Assessment Agency found that the country is not currently on schedule to reach these emissions reduction targets (IEA, 2020). Given that heating accounts for 50% of buildings' energy demand and 80% of direct CO_2 emissions in the built environment, it is of utmost importance to rapidly accelerate the improvement of heating systems (IEA, 2022a). In order for these sustainability goals to be reached, it is clear that decisions and changes need to be made to improve the process towards the energy transition in the built environment.

Therefore, it is imperative for inhabitants, organizations, and public authorities to rely on each other and work together to reach the set objectives (Climate Agreement, 2019).

The process of the energy transition is complex and consists of many decision-making levels which require appropriate management to ensure that conflicting interests demonstrated by the many involved stakeholders and decision-makers are aligned to be able to take efficient actions. From the national and international agreements in place, it is clear that higher levels of collective decision-making are well-established and committed to the energy transition (Biresselioglu, Demir, Kaplan, et al., 2020). However, the slow pace of the energy transition in the built environment makes evident that there are many barriers that must be overcome and challenges that have and will arise when striving for the transition. The lack of top-down coordination in energy transition projects in the built environment (Blasch, 2021) exemplifies the importance of collective decision-making with all stakeholders in such projects due to the need for independently optimized decisions to be collectively organized (Blasch, 2021) in order for the projects to be successful.

The concept of mixed-use is ambiguous and is often used interchangeably with the terms mixed land-use or mixed-use development. Due to the fact that single-use neighbourhoods has demonstrated a direct correlation to urban sprawl (UN Habitat, 2014), Dutch planning policies have focused on encouraging the concept of mixed-use development and the compact city for the past couple of decades (Hoppenbrouwer & Louw, 2005) which is visible in the fact that many neighbourhoods in large cities are mixed-use. Mixed-use neighbourhoods and developments will continue to grow due to its environmental friendliness and financial benefits, however there is limited research in this area (Rabianski et al., 2020). Furthermore, research has shown the importance of improved decision-making strategies for project leaders (Heravi et al., 2015). This is of increased importance in energy transition projects on an urban scale due to the much larger and more complex pool of stakeholders in such projects, which indisputably generates more issues or magnifies already present issues in existing processes (Hamdan et al., 2021a). Nonetheless, research on the field of sustainable interventions in neighbourhoods is primarily focused on the financial feasibility of the projects, and are mainly focused on specific projects such as heat pumps and PV. However, there is extremely limited research on the process of implementing district heating in a neighbourhood, let alone a mixed-use neighbourhood. Furthermore, there is a lack of research on the impact of stakeholders on the decision-making process with regards to identified limitations of energy technology options for neighbourhoods. Where there has been research on this topic, it is typically focused on single-use or single-ownership neighbourhoods (Haase & Baer, 2021).

Therefore, by addressing the involved stakeholders and developing a tool to improve the collective decision-making process in sustainable heat grid projects within mixed-use neighbourhood scan allow for the challenges encountered by the energy transition to be tackled more smoothly.

1.3 Societal and scientific relevance

This research will provide both societal and scientific impacts. The societal relevance of the research pertains to the contributions it will bring to help accelerating the energy transition. The knowledge that will be acquired through this research will be able to be used in order to increase efficiency when collaborating in projects related to the energy transition, specifically in sustainable heat grids which are a high point on the government's agenda for the energy transition. This will provide beneficial contributions to not only the energy transition and in combating climate change, but also in general collaborative projects as the insights obtained will be able to be applied to a variety of fields.

The scientific relevance of this research relates to the research gap that has been identified in literature. Much research has been conducted on stakeholder management and its impact on a project's process. However, further research needs to take place regarding the influence of knowing and addressing the relevant stakeholders and determine a strategy to improve their collaboration during the decision-making process with the aim of overcoming barriers and improving efficiency in projects. This is particularly important in projects pertaining to the energy transition given the plethora of stakeholders and actors involved and the rapidly approaching deadlines in place.

1.4 Research questions

Based on the goal of the research, the following research questions will be explored. The main research question states:

> *How can collective decision-making be orchestrated to overcome the barriers of low-carbon heating grid projects in mixed-use neighbourhoods?*

In order to answer the main research question, several sub research questions will be examined.

SQ1: Who are the stakeholders of low-carbon heating grid projects in mixed-use neighbourhoods and what are their attributes?
SQ2: What is the current decision-making process in place?
SQ3: What are the barriers encountered in low-carbon heating grid projects in mixed-use Neighbourhoods and when do they occur?
SQ4: What is the role of the collective in low-carbon heating grid projects in mixed-use neighbourhoods?

Figure 4 below shows the conceptual model for this research.

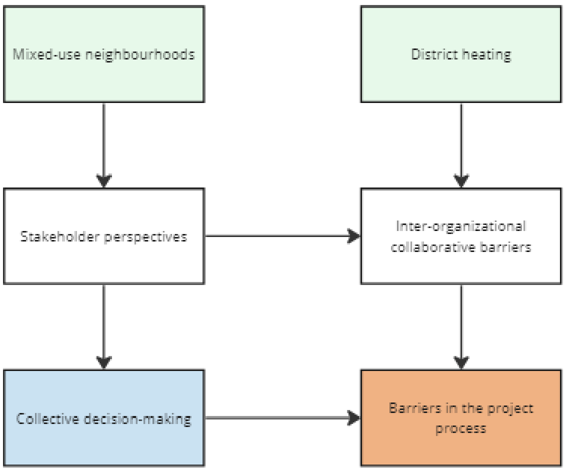


Figure 4: Conceptual model (author)

Part 2

Theoretical Background

CONTENT

2.1 Mixed-use neighbourhoods

2.2 Heating grids

2.3 Stakeholders of the energy transition

2.4 Barriers and drivers

2.5 Collective decision-making

2.0 THEORETICAL BACKGROUND

2.1 Mixed-use neighbourhoods

2.1.1 Mixed-use neighbourhood theory

In Europe, the concept of mixed-use development is recognized as an essential component of urban revitalization and the idea of a compact city. There are two main reasons for which mixed-use development is encourage. Firstly, it seeks to minimize travel needs by providing a diverse range of amenities and services in close proximity. Secondly, it contributes to the vibrancy and diversity of urban areas, enhancing their overall attractiveness (Hoppenbrouwer & Louw, 2005). Additionally, it has been proposed that mixed-use development also contributes to the reduction of crime likelihood and improves overall sustainability of cities (Coupland, 1996). The concept of mixed-use is ambiguous and is often used interchangeably with the terms mixed land-use or mixed-use development and has a variety of definitions attributed to it. Mixed-use can be looked at through several lenses such as environmental, social, design, and institutional, hence the ambiguity of its definition. The idea of mixed land-use is an area in which there is a combination of commercial, residential, office, industrial, or other type of land-use (UN Habitat, 2014). Coupland defines mixed-use development as the retention or creation of a mix of varying uses in cities or neighbourhoods (Coupland, 1996), while Priemus et al. defines multiple land-use as “the fulfilment of multiple functions within a certain space and a certain time” which can be used as a definition for mixed land-use as well. Similarly, the Urban Land Institute provides a definition for mixed-use projects as a project with three or more physically integrated revenue-producing functions, such as housing, employment, recreation and transportation. However, Hoppenbrouwer and Louw argue that a mix of two or more functions can also constitute an area as having mixed land-use. Furthermore, literature distinguishes between primary mixed uses, such as residential and major employment or service functions, and secondary mixed uses, which consists of shops, restaurants, and small-scale facilities (Hoppenbrouwer & Louw, 2005).

Mixed-use can also be evaluated through the dimensions of time, verticality, horizontality, and shared premises. The concept of the time dimension regards the sequential use of space which recognizes that functions can be temporally combined, enabling a single space to serve multiple purposes consecutively (Hoppenbrouwer & Louw, 2005). Meaning that a singular space can also be considered mixed-use. A common example of this would be if a house is also used as an office such that during the day it has the use of an office and in the evening has a residential use. The vertical dimension regards the vertical integration of functions, such as integrating residential units above commercial establishments like shops, exemplifies multiple land-use as it utilizes the same ground surface for multiple purposes. Similarly, the horizontal dimensions can be looked at through a more geographical perspective and regards the horizontal integration of functions, while the shared premises dimension consists of a singular building space with multiple functions (Hoppenbrouwer & Louw, 2005). Figure 5 shows a visual representation of the different dimensions of mixed-use.

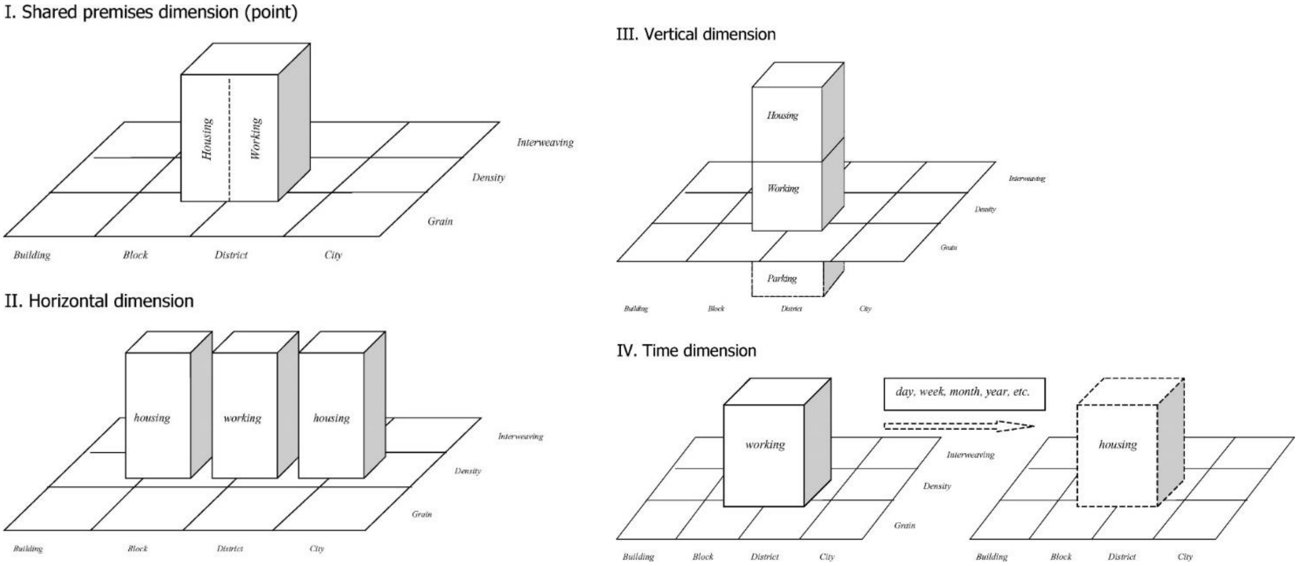


Figure 5: Mixed land use in four dimensions
Source: Hoppenbrouwer, E., & Louw, E. (2005). Mixed-use development: Theory and practice in Amsterdam's Eastern Docklands. European Planning Studies, 13(7), 967–983. https://doi.org/10.1080/09654310500242048

Additionally, it is important to consider the geographical scale of mixed-use development as different definitions consider different scales such as at a building-complex, neighbourhood, or local scale (Hoppenbrouwer & Louw, 2005). Therefore, it is important for this research to define the neighbourhood scale. Broadly speaking, a neighbourhood implies the geographical area in which certain attributes are investigated. Neighbourhood dimensions are defined by the types of boundaries applied which determine its size. The typical boundaries that are applied are categorized as either administrative units such as postal codes, circular buffers defining circles with radii at specific addresses, or road network buffers which similarly define radii around an address to determine the road travel accessibility (Mavoa et al., 2019).

Additionally, mixed-use neighbourhoods are a pillar of sustainable neighbourhoods and cities. Sustainable neighbourhoods and cities have three key features: they are compact, integrated, and connected. In addition to these features, there are five principles for the development and planning of these: sufficient space for streets and a competent street network, high density, mixed land-use, social mix, and limited land-use specialization (UN Habitat, 2014). It is evident that the principle of mixed land-use and limited land-specialization are characteristics of mixed-use neighbourhoods. The United Nations Habitat stresses that in order to create sustainable neighbourhoods, a minimum of 40% of neighbourhood floor space should be allocated for economic use, and that single function blocks are limited such that they ideally cover less than 10% of any neighbourhood in order to reduce urban sprawl (UN Habitat, 2014). Given the importance of increasing sustainability in our society and environment, it is clear that mixed-use neighbourhoods and developments will continue to grow.

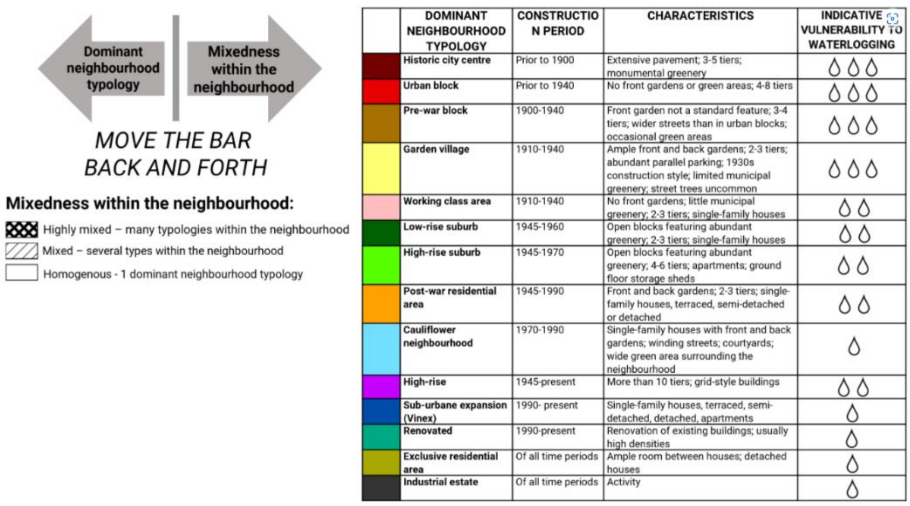
Tangibly speaking, a mixed-use neighbourhood can be categorized as such if the percentage of economic floor area is 40-60% of the total floor area, and/or if residential floor area accounts for 30-50% of total floor area (UN Habitat, 2014).

Given that there are several definitions for mixed-use neighbourhoods, this research will define a mixed-use neighbourhood as a collection of multiple buildings which in combination consist of two or more land-use types.

2.1.2 Mixed-use neighbourhoods in the Netherlands

Mixed-use neighbourhoods as a result of the concept of the compact city has been prominent in Dutch urban planning for the past couple of decades and has been part of Dutch urban policy since the 1980s, as a strategy to mitigate urban sprawl and foster urban renewal. This has been implemented by intensifying the land use within existing communities and encouraging greenfield developments in existing built-up areas. The concept began being implemented in Amsterdam when the municipality published the 'De stad centraal' structure plan that introduced the concepts of compactness and mixed-use into the policy goals to simultaneously improve the levels of housing stock and employment. These concepts have now been widely encouraged in the country's large cities such as Rotterdam, Utrecht, and more, primarily with the aim of mixing housing and employment (Hoppenbrouwer & Louw, 2005).

To properly understand mixed-use neighbourhoods in the Dutch context, it is necessary to look at the neighbourhood typologies. Building typologies is the grouping of buildings based on their function, form, and construction in order to analyse similar building types by identifying their common characteristics and features (Archisoup, n.d.). This definition can be interpolated for neighbourhood typologies in the same way such that neighbourhoods are categorized based on their building typologies. Neighbourhood typologies provide immensely valuable data for the understanding of what a neighbourhood consists of and can be used for many different research streams. A map created with GIS software for the purpose of climate-proofing research shows the composition of almost every neighbourhood in the Netherlands (Hogeschool van Amsterdam & TAUW, 2021). In order to classify the typologies of the county's neighbourhoods, the following categories were determined as shown in Figure 7.



	DOMINANT NEIGHBOURHOOD TYPOLOGY	CONSTRUCTIO N PERIOD	CHARACTERISTICS	INDICATIVE VULNERABILITY TO WATERLOGGING
	Historic city centre	Prior to 1900	Extensive pavement; 3-5 tiers; monumental greenery	💧💧💧
	Urban block	Prior to 1940	No front gardens or green areas; 4-8 tiers	💧💧💧
	Pre-war block	1900-1940	Front garden not a standard feature; 3-4 tiers; wider streets than in urban blocks; occasional green areas	💧💧💧
	Garden village	1910-1940	Ample front and back gardens; 2-3 tiers; abundant parallel parking; 1930s construction style; limited municipal greenery; street trees uncommon	💧💧💧
	Working class area	1910-1940	No front gardens; little municipal greenery; 2-3 tiers; single-family houses	💧💧
	Low-rise suburb	1945-1960	Open blocks featuring abundant greenery; 2-3 tiers; single-family houses	💧💧
	High-rise suburb	1945-1970	Open blocks featuring abundant greenery; 4-6 tiers; apartments; ground floor storage sheds	💧💧
	Post-war residential area	1945-1990	Front and back gardens; 2-3 tiers; single-family houses, terraced, semi-detached or detached	💧💧
	Cauliflower neighbourhood	1970-1990	Single-family houses with front and back gardens; winding streets; courtyards; wide green area surrounding the neighbourhood	💧
	High-rise	1945-present	More than 10 tiers; grid-style buildings	💧💧
	Sub-urbane expansion (Vinex)	1990- present	Single-family houses, terraced, semi-detached, detached, apartments	💧
	Renovated	1990-present	Renovation of existing buildings; usually high densities	💧
	Exclusive residential area	Of all time periods	Ample room between houses; detached houses	💧
	Industrial estate	Of all time periods	Activity	💧

Figure 6: Neighbourhood typology categorization
Source: Hogeschool van Amsterdam, & TAUW. (2021, August 2). Neighbourhood typology. ArcGIS StoryMaps.https://storymaps.arcgis.com/stories/7996855e7af84fd0966a07f34a901bb2

This framework was used in order to show on the map the neighbourhood compositions within a city. As can be seen, a distinction is made between mixedness within the neighbourhood and its key characteristics. In this case, mixedness refers to a mixture of typologies such that if a neighbourhood has minimum 50% of the same building typology it is considered to be homogenous, if there is 25-50% of the same typology it is mixed, and if less than 25% of the typology is the same then the neighbourhood is very mixed. The neighbourhoods were demarcated based on their postal code 6 level (Kleerekoper et al., 2018). Figures 8, 9, 10, and 11 show the composition of neighbourhood typologies for the large Dutch cities of The Hague, Rotterdam, Utrecht, and Amsterdam.

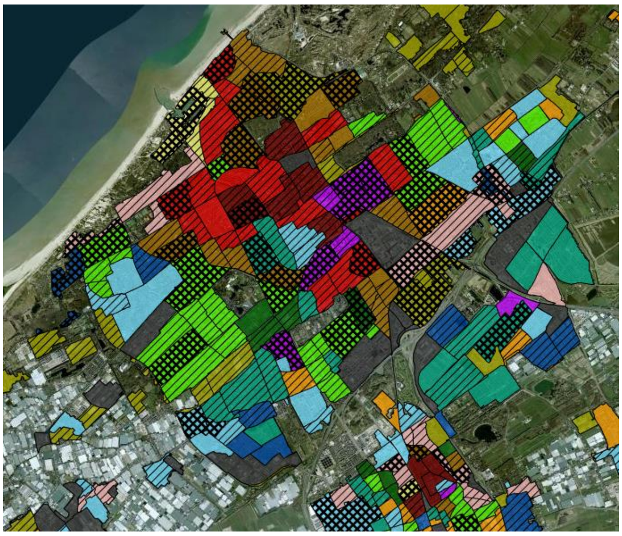


Figure 8: The Hague typology

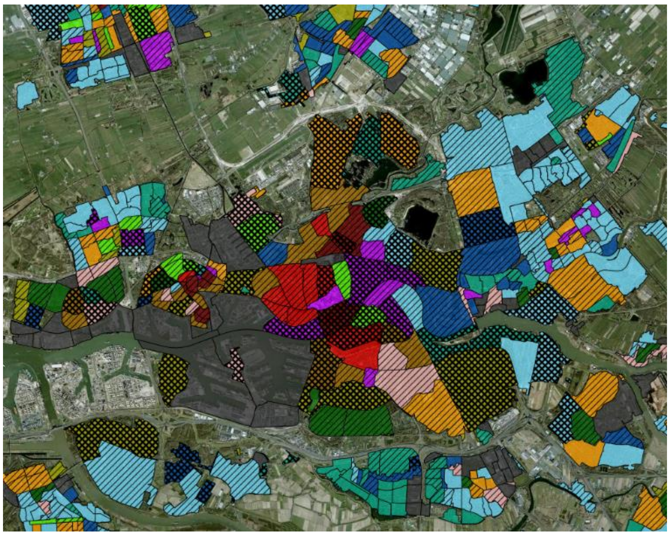


Figure 7: Rotterdam typology

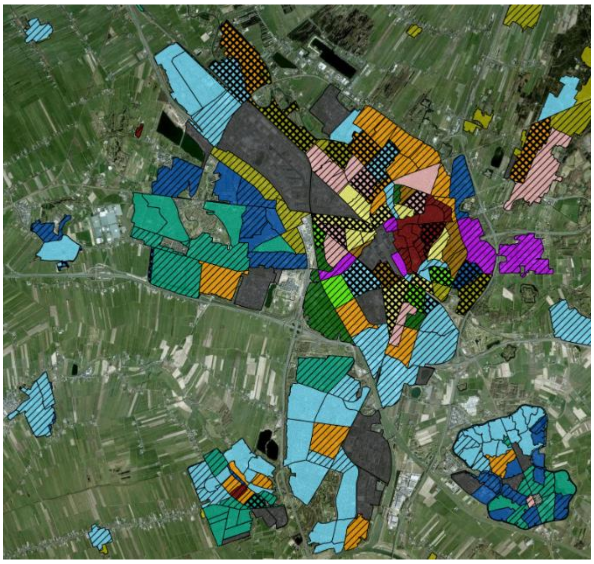


Figure 9: Utrecht typology

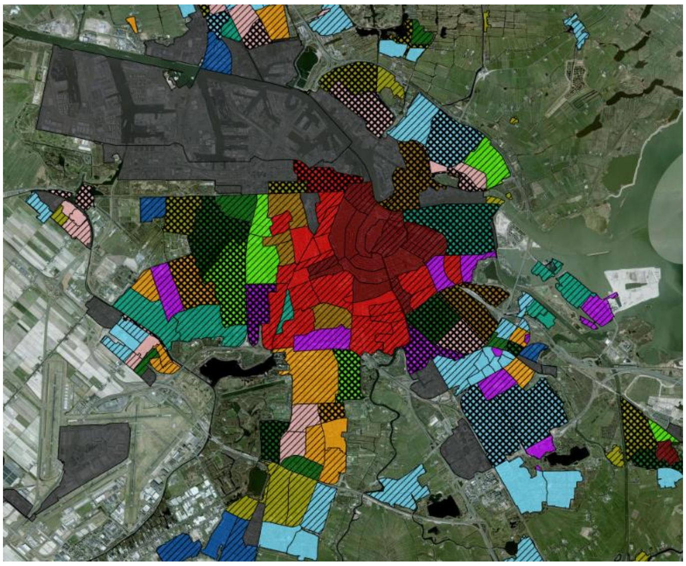


Figure 10: Amsterdam typology

Source for figures 10, 11, 12, 13: Neighbourhood typology. (n.d.). [Interactive map]. Retrieved 28 May 2023, from https://climadapserv.maps.arcgis.com/apps/StorytellingSwipe/index.html?appid=c1b11baf14c443879c62b3af83b658b6&embed

As can be seen, each city consists of different characteristics, however it is clear that all cities contain a large portion of mixed-typology neighbourhoods (*Neighbourhood Typology*, n.d.). Given the mixedness, it can be assumed that the majority of these mixed-typology neighbourhoods are also mixed-use. However, due to the lack of specification on the map regarding mixedness, it cannot be assured solely using the map as a reference. Nonetheless, the maps give a comprehensive view on the composition of neighbourhoods in some of the main Dutch cities.

It is notable that mixed-use neighbourhoods are becoming increasingly popular in the Netherlands. These neighbourhoods are designed to be walkable and bikeable, with a mix of residential, commercial, and retail spaces (City of Amsterdam, n.d.). The Netherland's commitment to these types of neighbourhoods can be seen through regional policies and masterplans such as for example the Comprehensive Vision Amsterdam 2050 developed by the City of Amsterdam council. One example of a mixed-use neighbourhood in the Netherlands is the Haven-Stad in Amsterdam which is being developed as a sustainable urban district. The district will contain schools, shops, housing, greenery, and more and be tailored for reducing car usage by ameliorating public transport and bicycle paths (Programma Havenstad, n.d.). Other examples of mixed-use neighbourhoods include Centrum and Zuidas in Amsterdam, or Kop van Zuid and Kralingen in Rotterdam. Additionally, new builds and new development projects are increasingly designed as mixed-use. Some examples include Hyde Park in Hoofddorp which vertically and horizontally includes mixed-use by having residential, retail, and restaurants in the apartment blocks (Hyde Park BV, 2023). Fenix Warehouse in Rotterdam consists of both housing and retail in a vertical dimension, while De Kroon in The Hague consists of offices and residential in both the vertical and horizontal dimensions (ArchDaily, n.d.). This demonstrates the commitment to mixed-use in Dutch urban planning.

It should be noted that in the Netherlands there has been many efforts to integrate different socio-economic groups given that this was one of the primary aims of Dutch housing policy in the mid-1990s in order to stimulate social cohesion and address issue that stemmed from isolated low-income neighbourhoods (Bektaş & Taşan-Kok, 2020). Such neighbourhoods that consist of mixed socio-economic groups is also often referred to in literature as mixed developments or districts (Boschman et al., 2013). However, this will not be considered as mixed-use in the scope of this research.

Furthermore, there are various ways in with mixed-use neighbourhoods are categorized in the neighbourhood. Primarily they are categorized based on their spatial density and use mix through indices such as the Floor Space Index (FSI) and the Mixed Use Index (MXI) (PBL, 2019b). These have been combined in the RUDIFUN model, created by the Netherlands Environmental Assessment Agency, to provide an indication of an urban area's morphology and density from a city block, neighbourhood, district, or municipal scale (PBL, 2019a).

2.2 Heating grids

In order to decrease the greenhouse gas emissions, Europe has seen a shift towards improving heating systems through electric heating and cooling using heat pumps and implementing heat grids (European Commission et al., 2016). Heat grids, also known as district heating and heating networks, consist of a system of pipes that transports water that has been heated using an energy source. They are not a new technology and have already been in use in many countries for decades. Large urban areas in Beijing and Seoul rely on district heating to supply heat to buildings and industrial sites, as well as Milan, Stockholm (Delmastro, 2020), numerous parts of Denmark and the Netherlands (Gasunie, 2022), and various smaller areas including university campuses and medical institutions around the world also actively use the technology. Currently, fossil fuels globally dominate the heat supply of district heating networks (Delmastro, 2020), and in the Netherlands in particular it is common for heat networks to be driven by natural gas combustion (Milieu Centraal, n.d.). However, there is immense potential for its decarbonisation through the use of renewable energy sources as the supply of heat. When supplied by renewable sources, district heating provide significant opportunities for reducing greenhouse gas emissions (Milieu Centraal, n.d.) while being efficient, affordable, and adaptable (Delmastro, 2020). Greenhouse gas emissions have been shown to decrease approximately 60% when comparing a renewably sourced heat grid to a conventional natural gas boiler. There are many options for the renewable sourcing of heat for district heating including, but not limited to, aquathermy, biomass, geothermal energy, ground heat in combination with a heat pump, residual heat, and solar thermal energy (Milieu Centraal, n.d.).

Literature expresses the evolution of district heating in five generations. The fourth generation is that which has been receiving the most attention recently due to its increased potential with renewable energy sources due to a lower and more adaptable temperature for distribution. Additionally, this generation is able to meet low-energy buildings' requirements in the existing building stock. The fifth, and latest, generation is more commonly implemented in new build projects due to its heavy reliance on the supplied heat at very low temperatures to buildings which requires large modifications to be made, resulting in high investment costs. Nonetheless, both generations can greatly decrease emissions. Furthermore, heat pumps are commonly used in district heating to incorporate the electricity market and use renewable energy sources in an aim to stabilize fluctuating electricity prices (Reda et al., 2021). However, in the Netherlands the current electricity capacity is insufficient for such demand and hence heat pumps are used more sparingly (PBL et al., 2022).

The Dutch government has set the objective of phasing out natural gas as per the Climate Agreement, by increasing electric heat pumps, green gas, and district heating (Milieu Centraal, n.d.). There is an increased focus on district heating by the government given that it can provide sustainable, affordable, and reliably supply of heat for the nation's demand. Currently, there are 18 major and 100 minor heat grid networks in place in the Netherlands (Segers et al., 2019), and 40% of the nation's municipalities have expressed their commitment to develop district heating primarily using residual waste heat and geothermal heat. However, the affordability of these projects is a key issue (ten Haaft, 2020). In conventional gas systems, there are various providers which can be chosen. However, in heating grids there is only one owner who supplies the heat for each grid network or system. This means that there is a risk of monopolies driving heat prices for maximum profit. In order to protect consumers from this, the Dutch government will be implementing the Collective Heat Supplies Act (Wet Collectieve Warmtevoorziening (WCW)) which combines gas price regulations including greenhouse emissions standards. In the Netherlands, the price of heat is connected to the price of natural gas which could be problematic. Therefore, this new act that will be implemented from 2024 will regulate the prices and ensure a maximum return for heat companies to attempt to make district heating an affordable solution to climate change (Milieu Centraal, n.d.). Therefore, heating suppliers need to establish a value chain that provides affordable, secure, and sustainable heat to consumers (ten Haaft, 2020).

It is evident that transitioning to sustainable district heating is not merely an issue of expanding the use of renewable energy, it also requires the development of business models, financing mechanisms, and policies to make the transition possible (Delmastro, 2020; Reda et al., 2021). Given the Netherland's strong focus on district heating, the government and commercial parties have created and instilled several programs and action plans in order to make the goals a reality. The Heat Roadmap Netherlands, based on the Heat Roadmap Europe, explains what areas must be focused on in order for the country to transition into district heating in a timely manner. The document states that implementation plans for the Netherlands must focus on four key points to achieve an efficient, affordable, and decarbonized heating sector:

1. Savings for end-users
2. Expansion of thermal infrastructure
3. Increased utilization of excess heat and heat production units

4. Implementation of individual heat pumps in sub-urban areas

(Paardekooper et al., 2018). Furthermore, the Dutch government has required all regions in the country to collaborate in the creation of the Regional Energy Strategy (RES) in which governments, residents, businesses, grid operators, energy cooperatives, and social organisations in 30 energy regions have worked together to develop region specific strategies to achieve the country's energy transition together (Regionale Energiestrategie, n.d.). At a municipal level, each municipality has been required to generate a Heat Transition Vision and Implementation Plan (Transitievisie Warmte en Wijkuitvoeringsplan) every 5 years, in accordance to the Climate Agreement, to delineate the municipality's timeline for the disconnection of specific neighbourhoods from natural gas as well as their possible sustainable heat source (VNG, n.d.-b) and its expected cost. The Heat Transition Vision developed by government representatives, grid operators, residents, and property owners, provides a planning and implementation approach and guidance for all involved parties (Rijksdienst voor Ondernemend Nederland, 2022). Moreover, there are various other initiatives such as the Natural Gas-Free Neighbourhoods Programme (Programma Aardgasvrijewijken) that provides a step-by-step plan for the heat transition (Programma Aardgasvrije Wijken, n.d.-b), the Clime and Energy Roadmap for Municipalities providing a yearly and per sector overview of municipal goals (VNG, n.d.-a), and others. Additionally, there are several subsidies and financial mechanisms in place such as the Investment Subsidy Renewable Energy and Energy Saving (ISDE) (IEA, 2022b), Stimulation of Sustainable Energy Production scheme (SDE+) the Sustainable Energy Transition Incentive Scheme (SDE++) (IEA, 2020), and others to support and push for the heat transition. All of the mechanisms in place demonstrate the Netherland's commitment to widespread district heating, therefore heating companies must accelerate their efforts in order to meet the demand for district heating (ten Haaft, 2020).

2.3 Stakeholders of the energy transition

The energy transition encompasses a wide range of stakeholders whose involvement should be duly considered. Stakeholder identification is an ongoing process throughout the project's life cycle (Maqbool et al., 2022), but literature indicates that the identification and relevance of these stakeholders are often lacking in literature due to a lack of predefined sustainability goals (Baumann et al., 2019). However, this is needed for projects to be successful by ensuring that the stakeholders' demands, expectations, and needs are appropriately addressed (Maqbool et al., 2022).

Generally speaking, such projects typically involve stakeholders such as buyers, clients, contractors, developers, government agencies, investors, regulators, sponsors, suppliers, small- and medium-size enterprises (SMEs), and users. It is common for stakeholders to be categorized as either primary or secondary stakeholders. Primary stakeholders are those that directly contribute to the economic and operational aspects of the project. An example of this is a developer or a contractor. Secondary stakeholders are those that are impactful to the project but are only involved when needed during the development process. An example of this is the local authority (Hamdan et al., 2021a).

It is also common for stakeholders to be categorized as internal or external stakeholders. Internal stakeholders are those who are directly associated or involved with the project, for example through employment, investment, or ownership. External stakeholders are those who are affected by the actions taken and outcomes generated by the project and who can also influence its success. Examples of this are suppliers or advocacy groups (Maqbool et al., 2022). Effective management of both internal and external, as well as primary and secondary stakeholders is crucial in energy transition projects for their success. Table 1 below shows some examples of relevant stakeholders in energy transition projects.

Table 1: Potential stakeholders in energy transition projects (author)

Primary vs Secondary	Internal vs External	Stakeholder	Example	Sources
Secondary	External	Government bodies	Central government, local authority, municipality, regional regulatory authority (such as the European Union), international agency	(Murrant & Radcliffe, 2018) (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020) (Hamdan et al., 2021b) (Kaundinya et al., 2009)
Primary	External	Policy makers	Can include government bodies	(Biresselioglu, Demir, Demirbag Kaplan, et al., 2020) (Baumann et al., 2019) (Grafakos et al., 2010)
Primary	Internal	Energy supplier	Energy producer, energy provider, transmission systems operator, power exchange, utility company	(Biresselioglu, Demir, Demirbag Kaplan, et al., 2020) (Murrant & Radcliffe, 2018)
Primary	Internal	Individual consumers	Households, condominium management, households associations, community groups	(Biresselioglu, Demir, Demirbag Kaplan, et al., 2020) (Murrant & Radcliffe, 2018)
Primary	Internal	Investors	Financial institutions, individual investors	(Hamdan et al., 2021b)
Secondary	External	NGO's and non-profit organizations	Non-profit housing developers, philanthropic organizations, consumer associations, community energy groups	(Baumann et al., 2019) (Kaundinya et al., 2009) (Hamdan et al., 2021b) (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020) (Murrant & Radcliffe, 2018)
Primary	External	Enterprises	Private businesses, local and national businesses, social enterprises, small- and medium-sized enterprises (SMEs)	(Murrant & Radcliffe, 2018) (Hamdan et al., 2021b)
Secondary	External	Academia	R&D institutions	(Murrant & Radcliffe, 2018) (Hamdan et al., 2021b)
Secondary	External	Trade associations/unions	Chamber of commerce and industry	(Murrant & Radcliffe, 2018) (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020)
Secondary	External	Professionals in the energy and climate policy field	Academics, consultants, governmental representatives, climate policy experts	(Grafakos et al., 2010)

Primary	Internal	Design & construction third parties	Developers, contractors, owners, operators, design companies, material suppliers, consulting companies	(Hamdan et al., 2021b)

Given the complexities of stakeholder categorization, stakeholder mapping is a common practice that is conducted to generate a comprehensive list of the types of stakeholders, analysing their characteristics and values to facilitate effective stakeholder engagement (Maqbool et al., 2022). The most common mapping technique used is the power-interest matrix which organizes the stakeholders into the groups of 'keep satisfied', 'manage closely', 'keep informed' and 'monitor' depending on their positioning on the matrix. Figure 12 displays an example of a power-interest stakeholder map.

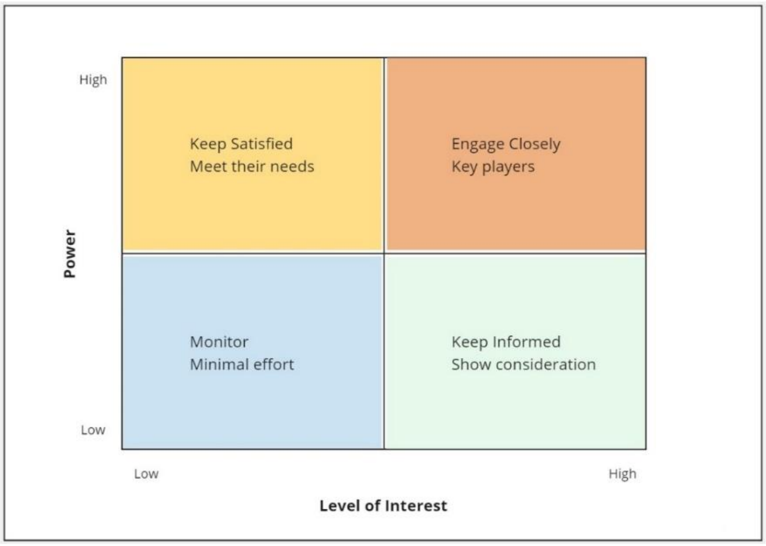


Figure 11: Power interest matrix (author, adopted from Maqbool et al., 2022)

Furthermore, research has shown that stakeholder involvement evolves over time to adapt to the complex and uncertain nature of sustainability-related goals and the presence of multiple actors in these projects. This dynamic nature underscores the non-linear nature of stakeholder involvement in energy transition projects, with each project phase requiring different attention and measures (Hamdan et al., 2021a). Figure 13 gives an example of how stakeholder roles can adapt throughout the life cycle of a sustainable neighbourhood project.

Stakeholder roles in SN projects.

Stakeholders	Conceptualization	Preparation	Implementation	Closure
Central governments	Regulator	Funder	–	–
Local authorities	Convener; Regulator; Planner	Facilitator; Funder; Integrator	Enforcer	Facilitator
Nonprofit housing developers	Convener; Planner	Facilitator; Funder; Integrator	Facilitator; Integrator; Implementer	Facilitator
Philanthropic organizations	Facilitator	Facilitator; Funder	–	Facilitator
R&D institutions	Facilitator; Planner	Facilitator	Facilitator	Facilitator
Private housing developers	Convener	Funder; Integrator	Implementer; Integrator	Finisher
Consulting companies	Planner	Planner	Implementer	–
Design companies	Planner	Planner	Implementer	–
Construction companies	–	–	Implementer	Finisher
Material suppliers	–	–	Implementer	–
Financial institutions	–	Funder	–	–

Figure 12: Stakeholder roles in sustainable neighbourhood projects
Source: Hamdan, H. A. M., Andersen, P. H., & De Boer, L. (2021). Stakeholder collaboration in sustainable neighbourhood projects—A review and research agenda. Sustainable Cities and Society, 68, 102776. https://doi.org/10.1016/j.scs.2021.102776

The image shows that the same stakeholder may possess a different role at different phases of the project. However, existing research has yet to sufficiently address these dynamics and shifting roles of stakeholders that is observed as projects progress through its phases (Hamdan et al., 2021a).

2.3.1 Stakeholders of the energy transition in mixed-use neighbourhoods

It is evident that the successful implementation of energy transition systems in mixed-use neighbourhoods relies on clearly defined project objectives communicated to stakeholders (Kaundinya et al., 2009). In the context of the energy transition within mixed-use neighbourhoods, various stakeholders play critical roles including those previously mention. However, given the nature of mixed-use neighbourhoods, other more specific stakeholders also need to be considered. Broadly speaking, there are found key groups of stakeholders in this context: local residents, local businesses, government agencies, and non-profit organizations. Local residents and community members (Lennon et al., 2019) consist of those residing in and constantly experiencing the area in which the project is taking place and are often key stakeholders involved in the planning and implementation of energy transition projects in their neighbourhood. Similarly, local businesses are of equal importance as local residents in mixed-use neighbourhood projects as they are also residents in a way and may benefit from reduced energy costs and increased economic opportunities. Additionally, government agencies have an important influence in such projects whether at the local, state, or federal level as may provide funding or incentivizing policies to support the project. Similarly, non-profit organizations may also provide financial support for the project or managerial assistance through organizing community outreach efforts or even providing technical support. Lastly, investors are influential in such projects through their financial contributions (Hamdan et al., 2021a). These are sometimes categorized in public projects as individual or collective, formal or informal, and local or non-local stakeholders (Munda, 2016). It is interesting to note that the categorisation of stakeholders' changes for mixed-use neighbourhood projects regarding whether they are internal or external stakeholders. For example, in conventional construction projects it is said that government bodies and the local community are external stakeholders. However, if the government is an investor or the client of the project in the neighbourhood then they would be internal stakeholders of such projects.

Effective coordination among the diverse stakeholders, such as local communities, governments, social actors, project developers, and financial organizations, has proven influential in the accomplishment of community energy systems (Koirala et al., 2016) as are energy transition projects within mixed-use neighbourhoods. Furthermore, there is a strong link between stakeholder identification and project success given that acknowledging the unique expectations and needs of each stakeholder allows for them to be addressed to mitigate conflicts effectively (Maqbool et al., 2022). Therefore, although some general stakeholders have been mentioned here, the specific stakeholders must be identified, and these will depend on the nature of the project and the local context.

2.3.2 Stakeholders of heat grid projects

Given the exploration of stakeholders in the energy transition, the specific stakeholders in heat grid projects must be evaluated. In these projects, there are four key stakeholders each possessing different roles: housing corporations, tenants/homeowners, local governments, and grid operators (Bouw, 2015). Figure 14 below provides an overview of these stakeholders and their roles.

Stakeholder	Housing corporations	Tenants/ homeowners	Local governments	Grid operators
Roles	Initiator, coordinator, shareholder, owner	Shareholder, heat purchaser	Initiator, coordinator, facilitator, shareholder, (co)financer, owner, heat purchaser	Network owner, investor, coordinator

Figure 13: Stakeholder roles in heat grid projects
Source: Bouw, K. (2015). Towards an expansion of heat networks in the Netherlands. *ResearchGate, 12*(1), 16-21.

As can be seen, the initiators of such projects tend to be the housing corporations and the local governments, while the shareholders include the housing corporation, tenants/homeowners, and local governments. Additionally, the housing corporations, local governments, and grid operators are coordinators of such projects (Bouw, 2015), demonstrating that they collaborate to execute the project. It is interesting to note that both tenants/homeowners and local governments are heat purchasers (Bouw, 2015), pointing at the commonality of such projects occurring in mixed-use neighbourhoods such that some buildings are government-owned and others are residential.

2.4 Barriers and drivers

2.4.1 Barriers and drivers of the energy transition

The energy transition is a complex feat whose projects involves a variety of parameters and processes which require the careful management of various decision-making levels, namely during the design and implementation process phases. This means that stakeholders and decision-makers must be in harmony, although they typically possess conflicting goals and interests. For this reason, it is imperative to examine the barriers and motivators experienced by them. Literature has presented that the relevant decision-makers in energy transition projects can be categorized in three groups: formal social-units, collective decision-making units, and individual consumers engaging in joint contracts. Formal social units are comprised of actors who hold significant influence over decisions on energy choices, including policy makers, energy providers, public authorities, municipalities, and other similar stakeholders. Collective decision-making units are comprising of groups or organisations of stakeholders such as energy producer and consumer associations, chambers of commerce and industry, transmission system operators, and power exchanges. Lastly, individual consumers engaging in joint contracts consists of individuals who come together through joint contracts to enhance their negotiation power, which includes households forming groups, condominium management, and households associations (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020). These decision-making units represent stakeholders who have the potential to either impede or drive energy transition initiatives, and may perceive barriers and motivators differently, highlighting the importance of understanding their differences and dynamics.

It is crucial to acknowledge the significance of barriers and motivators, as they have the potential to hinder, delay, or completely impede the process and its phases as well as help achieve the success of the project. These barriers often extend beyond the control of decision-makers and are present across different layers of decision-making. Commonly recognized barriers for stakeholders at all levels include a lack of information, awareness, and participation. At the collective and individual decision-making levels, economic and financial restrictions and costs pose significant obstacles. The existing literature categorizes barriers to the energy transition into economic, technological, political, personal, and social dimensions. In the analysis, barriers are identified based on two aspects: factors that hinder the initiation of action and variables that discourage or impede the process's execution. On the other hand, motivators serve as positive mediators that directly or indirectly contribute to the success of the process. While policies, such as international agreements, or organizational targets, establish the foundation and drive the energy transition, numerous other factors enable decision-making bodies to actively engage with the processes and effectively bring them to fruition. Furthermore, motivators act as agents that initiate actions and catalyse the execution of steps throughout the process, thereby facilitating and supporting its progress (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020).

In order to grasp the root causes of the barriers that arise in energy transition projects, it is important to first understand the motivators. While technological, political, and environmental factors are important, studies have found that it is the effectiveness of quality information and storytelling that truly motivates individuals. From the perspective of the different decision-making units, it has been found that formal social units acknowledge that global market dynamics have a prominent role in supporting the energy transition and use this to activate relevant processes. Once mobilized by formal social unit entities, the industry takes charge of the transition process, due to their innovation capabilities and alignment with contemporary trends. At lower levels of collective decision-making, such as companies, the focus shifts towards concepts like competition, marketization, and cost reduction. It has also been found that the pressure to reduce energy expenditures serves as a catalyst for energy transformation within collective decision-making units. This motivation leads businesses to explore alternative energy sources, implement energy-saving policies, and even pursue self-generation strategies to maintain their competitiveness. For individuals, the primary interest lies in decreasing electricity bills, with economic factors serving as the main justification for energy investments (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020). While climate-based consequences are generally welcomed, they may not always be integral to the decision-making process (Osman, 2017). Furthermore, providing appropriate and reliable information to individuals becomes paramount in securing social acceptance and support for energy transition efforts. Despite the recognition of the importance of open communication, communication channels between decision-making units and stakeholders often remain one-sided monologues. Overcoming this hurdle is crucial for effective collaboration and decision-making. Three main categories of motivators emerge: economic, personal, and informative. Factors like globalization, new business development, marketization, the influence of key opinion leaders, passionate innovators, quality information, and storytelling all contribute to driving the progress of energy transition projects (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020). These motivators can be demonstrated in Figure 15.

Figure 14: Motivators of the energy transition
Source: Biresselioglu, M. E., Demir, M. H., Demirbag Kaplan, M., & Solak, B. (2020). Individuals, collectives, and energy transition: Analysing the motivators and barriers of European decarbonisation. Energy Research & Social Science, 66, 101493. https://doi.org/10.1016/j.erss.2020.101493

As previously stated, barriers can greatly stunt such projects. It is interesting to note that studies have found that barriers are often attribute to lower levels of decision-making, while higher levels acknowledge the inevitability of the energy transition. Nonetheless, barriers span across the different decision-making units and impact all stakeholders. The key barriers include challenges related to the perceived value of energy, personal and social barriers, uncertainty, perceived risk, and administrative barriers. A major hindrance is the perception of energy as a low-valued utility, which discourages action on energy efficiency. Additionally, individuals often lack detailed knowledge about energy efficiency, leading to reluctance, doubt, and fear regarding investment recovery and burdens for both individuals and small businesses. This is impacted by the typical lack of immediate realization of benefits from energy efficiency investments. Furthermore, general uncertainty, innovation or product-related risks, and regulatory uncertainty further pose a barrier for such projects (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020). Studies have shown that perceptions of risks and benefits have a great impact of acceptance of energy transition projects, which goes hand in hand with the level of perceived knowledge on the proposed technologies given that there is an inverse relationship between levels of perceived knowledge and levels of perceived risk (Linzenich et al., 2020).

Personal and social barriers, such as lack of awareness, inertia, ignorance, resistance to change, and negative perceptions of the energy transition, also play a role. These can sometimes be attributed to information overload, and power and information asymmetry between stakeholders or decision-making units. It is interesting to note that studies have found that there is often a perception that the energy transition primarily benefits the well-off which stems from cultural values and social status, and further nourishes scepticism. Additionally, administrative barriers are noteworthy and arise from organizational complications, resource scarcity, mismanagement, transparency issues, difficulty in decision-making, and conflicts. Similarly, procedural barriers tend to discourage investment in energy-efficient solutions as a result of complex and burdensome requirements (Biresselioglu, Demir, Demirbag Kaplan, et al., 2020). These barriers can be demonstrated in Figure 16.

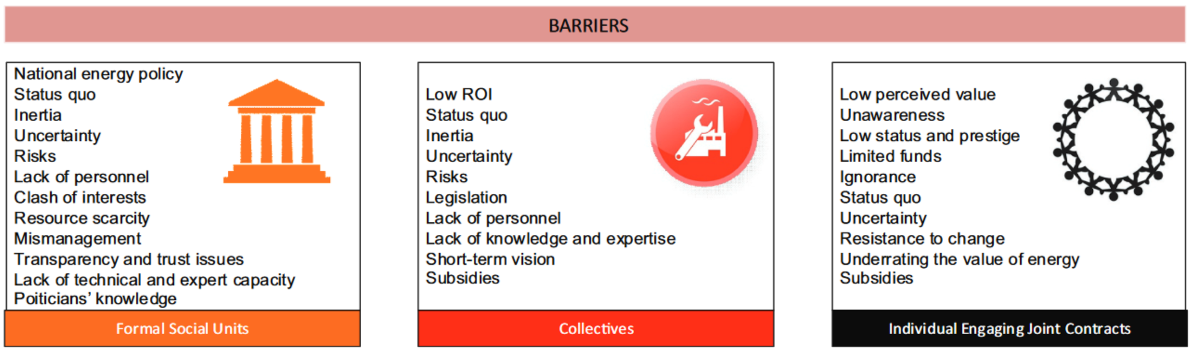


Figure 15: Barriers of the energy transition
Source: Biresselioglu, M. E., Demir, M. H., Demirbag Kaplan, M., & Solak, B. (2020). Individuals, collectives, and energy transition: Analysing the motivators and barriers of European decarbonisation. Energy Research & Social Science, 66, 101493. https://doi.org/10.1016/j.erss.2020.101493

The barriers can be categorized into economic, technological, political, personal, and social dimensions. Additionally, they can be impactful by hindering the initiation of actions and/or discouraging or impeding the execution of processes. Biresselioglu et al. and Linzenich et al.'s identified key barriers have been summarized in table 2 and categorised into their dimension and impact.

Table 2: Barriers in energy transition projects (author).

Barrier	Dimension	Impact
Lack of information	Personal, Social	Hinder initiation
Lack of awareness	Personal, Social	Hinder initiation
Perceived value of energy	Personal, Social	Hinder initiation
Inertia	Personal, Social	Hinder initiation
Ignorance	Personal, Social	Hinder initiation
Resistance to change	Personal, Social	Hinder initiation
Negative perceptions of the energy transition	Personal, Social	Hinder initiation
Lack of participation	Political, Personal, Social	Discourage or impede process's execution
Lack of transparency and trust	Political, Social	Discourage or impede process's execution
Organizational complications	Political (Administrative)	Discourage or impede process's execution
Resource scarcity	Political (Administrative)	Discourage or impede process's execution
Mismanagement	Political (Administrative)	Discourage or impede process's execution
Difficulty in decision-making	Political (Administrative)	Discourage or impede process's execution
Stakeholder conflicts	Political (Administrative)	Discourage or impede process's execution
Lack of well-defined direction	Political (Administrative)	Discourage or impede process's execution
Economic and financial restrictions	Economic	Hinder initiation
Costs	Economic	Discourage or impede process's execution
Uncertainty and innovation/product-related risks	Technological, Social	Hinder initiation
Perceived risk	Economic, Technological, Personal, Social	Hinder initiation
Perceived technological risk and uncertainty	Technological	Hinder initiation
Perceived regulatory risk and uncertainty	Political	Hinder initiation
Perceived political-legislative uncertainty	Political, Social	Hinder initiation

2.4.2 Barriers in heat grid projects

In order to understand the barriers encountered in heat grid projects, Reda et al. deciphered the key stakeholder categories of such projects to be energy companies, new entrant firms, sector associations, research organizations, policymakers, cities, public interest groups, and building owners (Reda et al., 2021). Using these stakeholder perspectives, Figure 17 was created summarizing the barriers encountered in sustainable district heating network implementation for and between the stakeholder categories.

Table 2
Summary of the barriers to the implementation of the concept across the different stakeholder categories. The factors along the diagonal are the individual barriers for each stakeholder category, whereas the factors in bold below the diagonal are those shared among stakeholders.

	Energy companies	New entrant firms	Sector associations	Research organisations	Policymakers	Cities	Public interest groups	Building owners
Energy companies	*Biomass lock-in, sunk costs, profitability, building owners lack time and expertise, electricity tax, immature technology, lack of waste heat, lack of smart DH*							
New entrant firms	Lack of smart DH	*Energy companies' resistance, mindset, market distortions, permit procedures, lack of smart DH*						
Sector associations	Lack of waste heat, immature technology, electricity tax	Permit procedures	*Lack of waste heat, immature technology, RES intermittency, permit procedures, energy companies' resistance, electricity tax, lack of cooperation*					
Research organisations	Immature technology, biomass lock-in, lack of waste heat	Energy companies' resistance	Lack of waste heat, immature technology, energy companies' resistance	*Lack of incentives for thermal storage, immature technology, biomass lock-in, market functioning, lack of waste heat, energy companies' resistance*				
Policymakers	Immature technology, biomass lock-in, electricity tax	X	Immature technology, RES intermittency, electricity tax	Immature technology, biomass lock-in	*Energy security, immature technology, biomass lock-in, energy prices, conservative policies, electricity tax, RES intermittency, social acceptance*			
Cities	Immature technology	Energy companies' resistance	Immature technology, energy companies' resistance	Immature technology	Immature technology	*Limited influence on energy companies, energy companies' resistance, immature technology*		
Public interest groups	Sunk costs, biomass lock-in	Energy companies' resistance	Energy companies' resistance	Energy companies' resistance, biomass lock-in	Biomass lock-in	Energy companies' resistance	*Lack of awareness, complexity energy systems, conservative policies, sunk costs, energy companies' resistance, biomass lock-in*	
Building owners	Building owners lack time and expertise	Energy companies' resistance	Energy companies' resistance	Energy companies' resistance	X	Energy companies' resistance	Energy companies' resistance	*Building owners lack time and expertise, energy companies' resistance*

Figure 16: Summary of the barriers in the implementation of district heating projects the different stakeholder categories
Source: Reda, F., Ruggiero, S., Auvinen, K., & Temmes, A. (2021). Towards low-carbon district heating : Investigating the socio-technical challenges of the urban energy transition. *Smart Energy, 4,* 100054. https://doi.org/10.1016/j.segy.2021.100054

It can be seen that the most reoccurring barriers include biomass lock-in, immature technology, and energy companies' resistance. Biomass lock-in refers to the situation in which heavy investments are or have been made in fossil fuel-intensive infrastructure which leads to the prolonging, delaying or prevention of the transition to low-carbon alternatives (Sato et al., 2021), posing a great barrier for heat grid projects. Additionally, the barrier of energy companies' resistance refers to their resistance to change attributed to underlying interests or an antiquated mindset (Reda et al., 2021). It is evident that various barriers presented can be interdependent. When combined with the previously mentioned barriers of the energy transition, it is evident that there are many overlapping barriers.

2.4.3 Barriers in heat grid projects in the Netherlands

Honing into Netherlands-specific projects, the key challenges that occur when developing a heat grid in an existing building stock environment is convincing the tenants and homeowners to agree to this change, primarily with regards to the switch to electric cooking, the boiler replacement, and the required works and renovations and to efficiently plan for the heat grid to coincide with renovations, planned boiler replacement, etc. (Bouw, 2015). However, focusing on the existing building stock is crucial to reduce CO_2 emissions and can be largely beneficial in high density area with higher heat demand and great amounts of potential end users. More specifically, there is an important focus on apartment buildings that already have central heating as connecting to a heat grid can be more cost-efficient than switching to individual boilers. Furthermore, in the Netherlands, many end users have the perception that with a gas connection they would be paying less than with a district heating network connection, despite the Heat Act's attempt to protect such customers from high prices (Huygen et al., 2011). This is due to the fact that the Netherlands has one of the lowest European prices for gas boilers due to the country's extensive gas network, which generates a large resistance to change from gas to renewable district heating given the consumer's perception of the value of energy (Osman, 2017). Additionally, this issue may be a result of the monopolistic nature of district heating networks (Akerboom et al., 2014; Szendrei & Spijker, 2015). Typically in the Netherlands, the heat grid owner also delivers the heat to the connected homes which does not allow for competition. This is not always the case, however due to the possibilities of changing heat providers in the gas market, the fact that connecting to a heat grid means that you are unable to change energy or heat supplier brings resistance from customers (Osman, 2017). This perspective has been aimed to be tackled with the establishment of the Dutch Heat Act, however many customers continue to feel uneasy with this situation and can stem from a lack of trust and transparency. Furthermore, an important challenge in heat grid projects is obtaining the approval and permission of tenants and homeowners to connect their properties to the grid, and the connection of existing residential areas to the grid are typically difficult and costly. Furthermore, district heating networks have a fragmented value chain meaning that the production, transport and distribution, and supply is organized separately which require the involvement of many stakeholders and complicated agreements (Osman, 2017). This can result in delays, increased costs, and stakeholder complications.

A major technological problem for heat grids is the experienced losses of heat throughout the network which consequently must be compensated by supplementary heat generation (Rezaie & Rosen, 2012). Therefore, this must be considered in the design of the system in order to obtain an optimal and cost-efficient solution. For this, the heat demand is crucial as the piping can be designed based on the current demand, however it is ideal to design with future demand in mind to allow for the network to expand in the future and consequently generate increased revenue. Nonetheless, this comes with a lot of uncertainty as it must also consider potential lower energy requirements in the future from energy efficiency measures (Åberg & Henning, 2011). Additionally, due to the intermittency of renewable energy supply, storage is increasingly important however not being sufficiently considered (Bouw, 2015). Furthermore, due to existing obstacles and greater installation resource intensity combined with a lack of experience in group housing solutions, the construction of district heating infrastructure in the existing building stock is increasingly technically complex, costly, and is paired with increased required renovation works (Bouw, 2015; Osman, 2017).

Moreover, various studies have found that tenants and homeowners are primarily concerned about the costs associated with heat grids whether that be the renovation costs, or connection costs (Dóci & Vasileiadou, 2015; Roos & Manussen, 2011). This is also the case for companies and governments given the high initial investments required and their associated risks, the large construction costs due to required technological improvements, high capital costs, low return on investment, long payback times, and limited profitability opportunities. Additionally, the uncertainties regarding future heat demand and pricing of district heating prices paired with the fact that external benefits of heat grids such as decreased emissions, decreased primary energy consumption, and improved quality of air are not included in the business, rendering the business case for heat grids unfavourable (Bernotat & Lübke, 2014; Bouw, 2015; Osman, 2017).

Therefore, the combination of barriers from the energy transition and district heating networks serves as a catalogue of common barriers that occur in such projects and provides a basis for the framework from which to validate the empirical data acquired in this research.

2.5 Collective decision-making

In order to share and expand best practices in district heating projects, collaboration, communication, and transparency is crucial between stakeholders (Delmastro, 2020). Additionally, given the complexity and large number of stakeholders of district heating in mixed-use neighbourhoods, democratic cooperation is needed. Of course, it is difficult to reach each individual person affected by the project, however groups of stakeholders can be formed and can work collaboratively with the other stakeholder groups. Stakeholder groups can be for example housing associations or grid operators. This concept is widely accepted, which is why it is clearly stated in the participation guide for the Natural Gas-Free Neighbourhoods Programme in the Netherlands (Programma Aardgasvrije Wijken, n.d.-a). However, it has been observed that this does not occur in practice (R. Prins, personal communication, 2 June 2023). Therefore, it is clear that adopting a collective decision-making approach can be beneficial in district heating projects in mixed-use neighbourhoods.

Collective decision-making can be explained as the participation of multiple stakeholders in the decision-making process such that the decisions of the project are made as a team or collective to ensure maximal benefit for all project stakeholders, from energy suppliers to end users. This decision-making approach can stimulate efficiency and effectiveness of district heating projects by identifying potential challenges and developing solutions in a collaborative manner (Caramizaru & Uihlein, 2020). Of course, collaboration can cause disagreements, however by including the expertise of all stakeholders to create a joint solution will make to final solution overall more effective than if it were to be generated unilaterally. However, it is important to note that collective decision-making should not merely focus on the social aspect of the project, it should integrate the technical aspects with the social aspects to generate a joint decision-making process. By encouraging productive and deliberate dialogue, interdisciplinary decisions can be made which not only will enhance learning between disciplines but will also shift the focus of the project to one that is collective rather than individual. This type of dialogue presents the opportunity of sharing different views and motivations on the projects which can in turn create mutual understanding between stakeholders and create a group atmosphere resulting in cooperative behaviour (Bouw et al., 2023).

Notwithstanding, there are various challenges that are encountered when adopting a collective decision-making approach. Examples include cognitive biases, complexity of information, dominance of one or more individuals, stakeholder fatigue, hidden assumptions, and more. These challenges can result in resistance to interacting with other stakeholders and participating in the decision-making process. However, if adequately managed, collective decision-making can provide immense benefits to the project through collective learning, the generation of stakeholder networks (Bouw et al., 2023)**,** and the combined use of stakeholder expertise to overcome barriers in the most effective way possible.

Part 3

Research Methodology

CONTENT

3.1 Research design

3.2 Data collection

3.3 Data analysis

3.4 Data plan

3.5 Ethical considerations

3.0 RESEARCH METHODOLOGY

3.1 Research design

To answer the research questions, an explorative qualitative study will be undertaken. The research will be divided into three phases such that the first phase focuses on the data collection of the current situation, the second phase focuses on stakeholder interviews and an applied case study to evaluate the processes undertaken during the projects, and the third phase will be an applied validation of the outcomes obtained from the previous phases. From this, it will be possible to critically define collective decision-making in the context of sustainable interventions in mixed-use neighbourhoods and allow for the development of a diagnosis of where collective decision-making is needed to develop guidance. A qualitative method is chosen in order to be able to measure collective decision-making and stakeholder involvement. Figure 18 below shows the research methodology framework for this study.

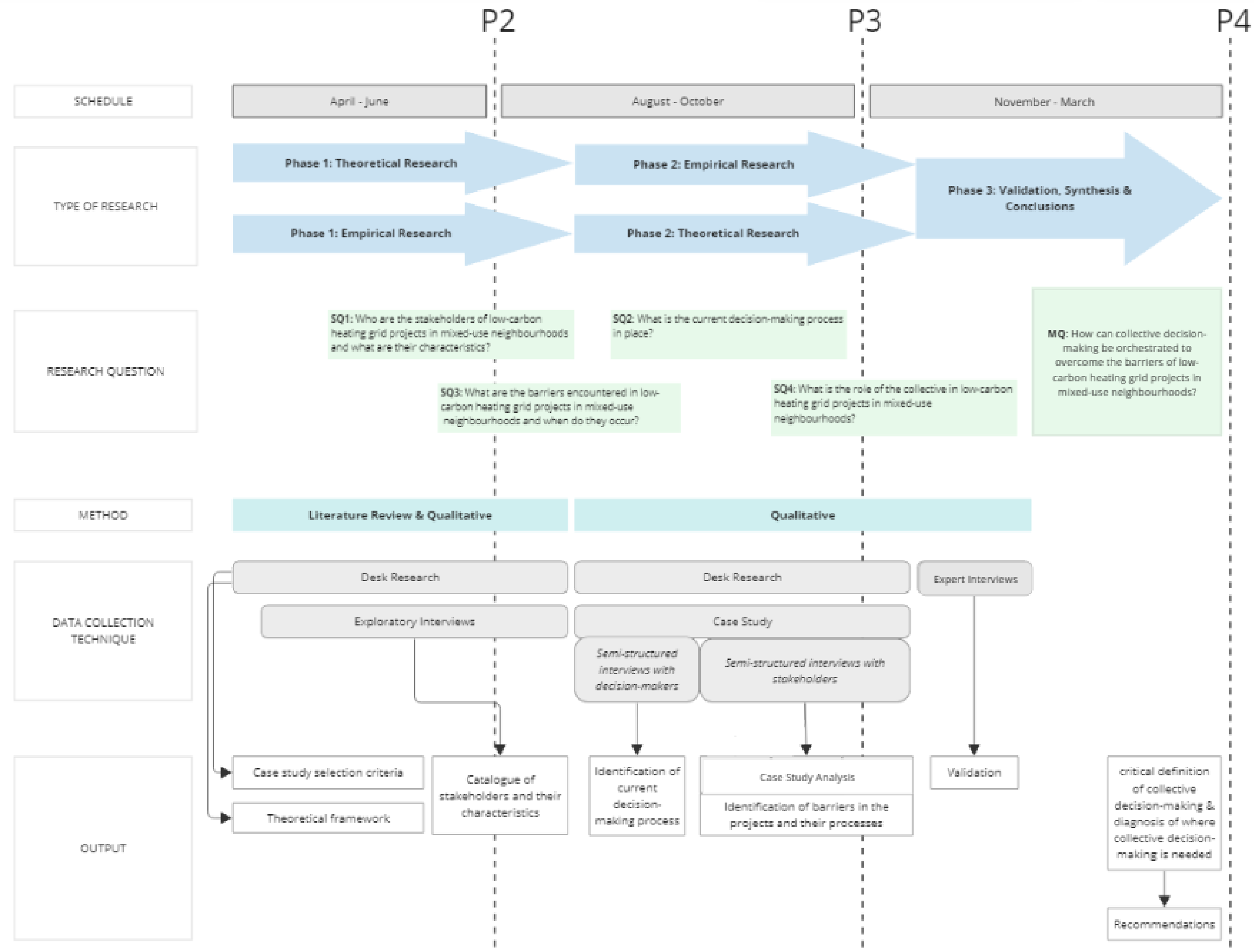


Figure 17: Research methodology framework (author)

<u>Phase 1</u>

Phase one is a combination of theoretical and empirical research and consists of both a literature review and qualitative research. The literature review will be undertaken on topics of collective decision-making, stakeholder involvement, sustainable heating grids, and the energy transition within mixed-use neighbourhoods. Additionally, in-depth literature review on the barriers, and in-depth research on current plans for the energy transition in the Netherlands will be undertaken. This includes local and district level energy transition plans and the regional energy strategy (RES) as well as proposals for heating grid implementations. Furthermore, explorative interviews will be conducted with an expert currently working in the field to further understand where the problems lie. Phase 1 will allow for the first research sub-question to be answered, and the generation of a theoretical framework, case study selection criteria, and catalogue of the involved stakeholders and their characteristics.

Phase 2

During phase two, semi-structured interviews will be conducted on stakeholders involved in heat grid projects in the Netherlands to gain direct insight into the field to better understand the current decision-making process in these projects, the encountered barriers, and their experiences with collective decision-making and how it impacts their work. During this process, a case study will be chosen to further analyse. The case study will be evaluated to offer perspective into the applicability of the results obtained from the interviews, while providing tangible examples and understanding of the parties involved in such projects, the decision-making process, the experienced barriers, and how the parties worked towards overcoming the encountered barriers during the process. The case will be chosen based on the following criteria:

- Fulfilment of mixed-use neighbourhood description such that it contains a variety of building typologies
- Current or planned sustainable heat grid project
- Availability of data

Furthermore, desk research will continue in parallel to evaluate whether literature substantiates or contradicts the statements obtained during the interviews. Phase 2 will allow for the second and third research sub-question to be answered and provide input for sub-question four.

Phase 3

The third phase of the research focuses on validation, synthesis, and generating conclusions. The outputs gathered from the previous phases will be used to develop solution paradigms to overcome the key encountered barriers that will require or encourage collective decision-making. These solutions will be validated be expert interviews with relevant industry stakeholders to determine the plausibility of the propositions and between which stakeholders. This will allow for the provision of feasible guidance on the arrangement of collective decision-making. Furthermore, phase 3 will allow for the fourth research sub-question to be answered as well as the main research question, which will lead to the creation of a critical definition of collective decision-making in the context of heat grid projects in mixed-use neighbourhoods, a diagnosis of where collective decision-making is needed to tackle project barriers, and the generation of recommendations for the orchestration of collective decision-making. Table 3 shows the research method that will be used to answer the sub questions.

Table 3: Research Methods (author)

Research Question	Literature Study	Interviews	Case Study
SQ1: Who are the stakeholders of sustainable heating grid projects in mixed-use neighbourhoods and what are their characteristics?	X	X	X
SQ2: What is the current decision-making process in place?		X	X
SQ3: What are the barriers encountered in sustainable heating grid projects in mixed-use neighbourhoods and when do they occur?	X	X	X
SQ4: What is the role of the collective in sustainable heating grid projects in mixed-use neighbourhoods?		X	X

3.2 Data collection

Given the nature of this research, a qualitative research method is adopted. Since qualitative research often encounters reliability and validity issues, data triangulation is adopted in this research. Triangulation occurs between the desk study, case study, and expert interviews. The general purpose of the desk study is to obtain existing data regarding the theory and status quo of the research concepts. The case study is needed after the explorative interviews to evaluate how the theory presents in practice and either supports or contradicts the theory and interview data. Due to the research's abductive approach where theoretical and empirical research occurs simultaneously, the desk study will be used to explain phenomena that may arise during the case study. Lastly, the expert interviews will serve as validation for the outcomes obtained previously. Figure 19 shows the triangulation of research methods.

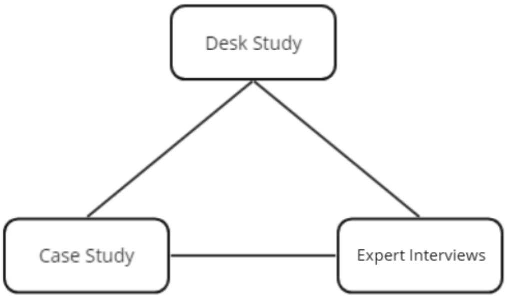


Figure 18: Research methodology triangulation (author)

3.2.1 Desk study

The desk study primarily consists of a literature review on the key concepts of this research and their interrelations. During the literature review, data is gathered through reading and analysing academic and scientific papers as well as grey literature consisting of dissertations, government reports, and conference papers (Paez, 2017). Through this technique, the theoretical background of this research was produced as well as the problem statement, allowing for further understanding of the concepts. Additionally, it helped generate the case study selection criteria. The documents used were found through the search engines Google, Google Scholar, the TU Delft Repository, and websites of the European Commission and Government of the Netherlands for governmental reports. The keywords used during the search included mixed-use neighbourhoods, communities, districts, sustainable neighbourhoods, collaborations, collective decision-making, decision-making, co-creation, energy transition, heat grids, and district heating. Furthermore, an exploratory interview was conducted with an expert in the field of this research to obtain first-hand knowledge into the complexities of the research topic.

3.2.2 Interviews & case study design

Following the literature review, interview questions are created for necessary data collection and potential interview participants are identified. The interviews address the current decision-making process and encountered barriers in heat grid projects in the Netherlands. Based on Section 2.3.1, key stakeholders were found whose perspectives are crucial for this research, namely housing corporations, local governments, grid operators, and residents. The interviews also provide direction regarding the case to be studied. Following the interviews, a case is chosen to analyse the stakeholder collaboration and pinpoint the problem areas of the district heating project. This analysis will allow for conclusions to be drawn regarding where collective decision-making can be implemented to allow for a more efficient project process. It has been decided for one case to be studied to provide tangible applications of the insight drawn from the interviews. The case study will collect data through interviews to obtain primary data from involved parties. The interviews and case will be analysed separately, followed by conclusions to be drawn from the synthesis of both, and the formulation of applicable recommendations.

3.2.2.1 Case study selection criteria

The case used for the case study was selected based on criteria in table 4.

Table 4: Case study selection criteria (author)

	Criteria	Reasoning
Required	District heating or heat grid project	Scope
	Renewable energy source connected to the grid to generate heat	Scope
	Located in the Netherlands	Scope
	Located in a mixed-use neighbourhood (minimum two different functions)	Scope
Desired	Currently being developed or is already completed	The project must be currently developed or already completed so that the research can look at the process of such projects and not focus on only one phase of the project, as would be the case if the project was only being conceptualized.
	Heat from the grid is sourced to multiple stakeholders	The consumers of the heat from the heat grid have a great impact on the barriers encountered in the project as the heat must be financially feasible for the users, therefore a mix of consumers is needed in the project to evaluate the impact of multiple stakeholders on the demand side
	At least one barrier was encountered that required a solution through decision-making	It is important to have access to information regarding at least one barrier or challenge that was encountered and how it was resolved. It is common for companies and project coalition to be reluctant to admit their faults or provide information that may put them in a negative light, however this is a crucial aspect of the research to be able to provide suggestions for other projects to adopt when they encounter challenges in the process.

Given that the main focus of this research is the stakeholder interviews to obtain a generalised and wholistic understanding of the research topics, the case study is adopted as secondary and will be chosen based on the data provided from the stakeholder interviews. Further detail is provided in Section 5.1.3.

3.2.3 Expert validation interviews

The expert interviews will be conducted with three key stakeholders of varying stakeholder categories as a validation technique for the results and conclusions obtained from the desk study, interviews, and case study. This was chosen to increase the credibility of the conclusions drawn and counteract the limitation of qualitative data collection regarding the possibility of differing data interpretation by varying researchers (Burnard et al., 2008). The three interviewees consist of representatives from a public heating company, regional government, and consultancy bureau. The public heating company representative was chosen due to the expected increase in their participation in these projects following the WcW law enactment, the regional government representative was deemed important due to their experience as a liaison between the national government and municipalities demonstrating a wide perspective and knowledge base, and the consultant provides a crucial perspective from their experiences as facilitator, project manager, and evaluator for a plethora of heat grid projects. All participants have many years of experience in the field of heat grids and in collaborating with all other stakeholders of these projects. Therefore, their validation interviews will provide deep insight from their respective perspectives which can be interpreted wholistically.

3.3 Data analysis

Data analysis consists of examining evidence to address the research's initial intentions (Yazan, 2015). There are several kinds of reasoning that can be used in order to do this, however this research will primarily use abduction and induction to draw conclusions. Abductive reasoning is strongly related to inductive reasoning and consists of grounding the theoretical understanding of the studied concepts into a broader meaning and perspective (Bryman, 2016). In other words, it consists of drawing conclusions from information and theory that is already known (Merriam-Webster, n.d.). Similar to induction, both reasoning approaches evaluate data that has little or no theoretical framework to develop an analysis structure (Burnard et al., 2008). Given that exploratory interviews are needed in phase 1 of the research to concrete the problem statement, and in-depth and expert validation interviews are carried out in the later phases, this reasoning approach is appropriate.

3.3.1 Interviews and case study

Data acquired during the stakeholder interviews will be analysed by the thematic content technique consisting of the analyzation of interview transcripts through an iterative process to identify themes that surge throughout the gathered data from the text (Burnard et al., 2008). This technique is chosen due to the importance of understanding the story expressed by interviewees and in their experiences with the topic to be able to draw conclusions and provide advice on how their experiences could be enhanced through an improved decision-making process. All rounds of interviews will be analysed through open coding which will allow for the identification of any themes throughout the interviews (Burnard et al., 2008). Then, axial coding will be used to connect data between the interviews (Delve, 2020). Following these data analysis methods for the interviews will allow for the concretion of the problem statement as well as for conclusions to be drawn regarding sub-research questions.

3.3.2 Expert interviews

As previously mentioned, expert interviews will be conducted to validate the previously collected data. Therefore, the content analysis approach will be adopted such that themes and patterns can be identified from the discussion to be able to interpret their underlying meanings (Hassan, 2022). The discussion points during the interviews will be based on conclusions drawn from the data analysis and case study.

3.4 Data plan

The data involved in this research will adhere to the FAIR guiding principles of scientific data management. These principles strive for data to be finable, accessible, interoperable, and reusable (Wilkinson et al., 2016). This research will ensure findability, the sources used in the research will be referenced using APA 7th, which follows the F3 principle stating "metadata clearly and explicitly include the identifier of the data it describes" (Wilkinson et al., 2016). Additionally, this research will be published on the TU Delft repository with a set of keywords relevant to the research to facilitate its finding. This follows the F4 principle stating "(meta)data are registered or indexed in a searchable resource" (Wilkinson et al., 2016). Similarly, to ensure accessibility, this research will have open access through the TU Delft repository, which follows the principle A1.1 that states "the protocol is open, free, and universally implementable" (Wilkinson et al., 2016). To ensure interoperability, the research and its data will be presented in formal English as it is a broadly used language in scientific research and will also adequately cite other scientific sources used during the research. This follows principles I1 and I3 which state "(meta)data use a formal, accessible, shared, and broadly applicable language for knowledge representation" and "(meta)data include qualified references to other (meta)data" respectably (Wilkinson et al., 2016). Lastly, to ensure reusability, the research will adhere to principle R1.3 stating "(meta)data meet domain-relevant community standards" (Wilkinson et al., 2016) by being published in the TU Delft repository which serves as indication that the research produced meets the masters level standard at a prestigious technical university. The Data Management Plan for this research is found in Appendix A.

3.5 Ethical considerations

In conducting this research, ethical considerations play a crucial role to ensure the protection and well-being of the participants involved. Given that the research focuses on the decision-making process from the perspective of different stakeholders, these ethical considerations are important as the stakeholders may have opposing or conflicting perspectives and opinions. To address these ethical concerns, anonymity will be maintained throughout the study. This approach aims to safeguard participants from potential risks and encourages them to provide genuine and unbiased responses. Therefore, the questions they will be asked will be focused on their knowledge and experiences. Furthermore, data collected during the interviews will be securely stored, with access limited to the primary researcher and thesis supervisors. This measure ensures confidentiality and protects the privacy of the participants. Additionally, prior to the interviews, participants will be provided with consent forms, which they will be asked to complete. These consent forms outline the purpose of the research, the voluntary nature of participation, and the rights of the participants. By incorporating these ethical considerations, the research aims to uphold the principles of integrity and responsibility in conducting research involving human participants.

Part 4

Research Outputs

CONTENT

4.1 Goals and objectives

4.2 Deliverables

4.3 Dissemination and audiences

4.4 Personal study targets

4.0 RESEARCH OUTPUTS

4.1 Goals and objectives

There are various goals that are being aimed for by performing this research. An overarching objective is to conduct research to further understand the role of stakeholders in the context of the energy transition. This includes understanding what stakeholders are involved, their roles and perspectives, and their decision-making governance. Additionally, due to the fact that collective decision making processes are not commonly used but are expected to be needed in energy transition project, especially for mixed-use developments, a key objective of this research is to obtain a more concrete and analytical definition of collective decision-making in general as well as an analytical definition of collective decision-making in the context of energy transition projects in mixed-use neighbourhoods, or more broadly in multi-stakeholder settings. Furthermore, this research aims to determine how collective decision-making is currently used and how it can be better utilized. Lastly, it is important for this research to gain a better understanding of how collective decision-making can be used to overcome the barriers encountered in sustainable heating grid projects in mixed-use neighbourhoods, and consequently help speed up the energy transition. Therefore, it is also a goal to inventorise the barriers of sustainable heating grid projects in mixed-use neighbourhoods.

4.2 Deliverables

The aimed deliverable of this research is threefold. Firstly, this research will provide a systematic overview of the stakeholders involved in sustainable heating grid projects in mixed-use neighbourhoods. Secondly, a critical definition of collective decision-making in the context of mixed-use neighbourhoods will be provided. Thirdly, guidance on how collective decision-making can be improved between the stakeholders and utilized to overcome encountered barriers will be provided. This includes the development of design principles for collective decision-making.

4.3 Dissemination and audiences

This research may be valuable for several audiences. This includes the key decision makers of low-carbon heat network projects such as government officials, policymakers and managers working in such projects by providing more information in compiling a critical definition of collective decision-making and pointing out the areas of this process that require more attention. Additionally, it will bring useful insight for the main stakeholders involved in such projects in mixed-use neighbourhoods as well as single-use neighbourhoods such as energy companies, developers, contractors, and other similar stakeholders. By providing novel information on the process of collective decision-making in the niche of sustainable heat grid projects within mixed-use neighbourhoods, this research can serve as useful knowledge for all stakeholders and actors involved in the energy transition including tenants.

4.4 Personal study targets

This research project is not only about acquiring the valuable insight on the topic at hand for academic, social, and scientific purposes, but it is also about achieving personal study goals throughout the process. Therefore, the below points delineate the key personal study targets that are aimed for during this research project:

- Improve time management and organization skills
- Further develop my understanding of the energy transition
- Gain insight into how appropriate and innovative management techniques can contribute to accelerating the energy transition
- Better understand the real-life impacts of stakeholder management and collective decision-making, rather than just theoretically speaking
- Learn to conduct research that is not simply literature based
- Discover the current challenges in the field and how I can contribute to overcoming them

Part 5

Analysis

CONTENT

5.1 Methods of analysis

5.2 Generic analysis

5.3 Case study – Groenoord, Schiedam

5.0 ANALYSIS

5.1 Methods of analysis

5.1.1 Interview contents and questions

Given the exploratory nature of the research and its desired outcomes, it was decided to interview individuals pertaining to each of the main stakeholder groups involved in heat grid projects in the Netherlands. This would allow for the perspectives of the key actors and stakeholders of such projects to be considered, to establish a strategy for ensuring collaboration for collective decision-making. By looking at publications online, several individuals were chosen that participated or were mentioned in these publications. Further research on these individuals was performed online and through LinkedIn to determine their suitability for this research. Through LinkedIn, more potential interviewees were found that could be categorized in the stakeholder groups of energy company, government, municipality, consultancy bureau, academics, energy cooperative, housing association, and homeowner association (VvE).

The interview protocol was created such that the questions could be adaptable to the role of the interviewed stakeholder. Its semi-structured nature also allowed for further questions to be discussed in a conversational manner as they arose. The interview questions were divided into five main categories: background, experience, decision-making process, barriers, and collective decision-making. The full interview protocol including the base interview questions can be found in Appendix B. The background and experience section gave the interviewees the opportunity to introduce themselves and their experience in heat grids, while allowing them to describe and introduce a relevant project that they are working on or are passionate about. Additionally, questions regarding the definition and implications of mixed-use neighbourhoods were also discussed.

Once the context of the interview was established and a particular project was chosen for further discussion, the decision-making process section was introduced, in which a basic decision-making diagram was shown used as a basis for the following questions. The aim was to identify the experience and views of the different stakeholders on the diagram and obtain their insight into how it is in practice. Given that an aim of the interviews was to generate a visual representation of the decision-making process, the diagram was adapted as the interviews progressed to be able to unfold a more detailed process with the acquired information.

The barriers portion served to validate barriers found in literature. While it was common for barriers to be discussed throughout the entire interview, this section was useful to pinpoint specific barriers, provide more clarity on said barriers, and determine when they typically occur during the projects. Lastly, the collective decision-making section allowed for interviewees to reflect on their current experience with collective decision-making and whether they believe that its occurrence should change and how.

5.1.2 Interview coding and analysis

Due to rates of responses, 12 participants were interviewed as shown in Table 5. The participants have been assigned codes to ensure anonymity.

Table 5: Interviews (author).

Code	Type of Organisation	Position in Organisation	Stakeholder Group
EC.1.BD	Energy Company	Business developer	Energy Company
HC.1.SA	Energy Company	Heat strategy advisor	Energy Company
G.2.PO	Regional Government	Policy officer	Regional Government
G.1.PL	Local Government	Heat transition project leader	Municipality
G.3.PO	Local Government	Policy officer energy transition	Municipality
C.1.C	Energy Transition Consultancy	Energy consultant	Consultancy Bureau
C.2.C	Energy Transition Consultancy	Consultant	Consultancy Bureau
C.3.C	Heat Transition Consultancy	Heat transition consultant	Consultancy Bureau
ECO.1.KD	Energy Cooperative Association	Heat knowledge developer	Energy Cooperative
NP.1.C	Non-Profit Citizen Initiative	Assistant manager	Energy Cooperative
HA.1.PM	Housing Association	Program Manager	Housing Association
M.1.PM	Housing Association	Process Manager	Housing Association

The key stakeholders of district heating networks in the Netherlands are local governments, grid operators, housing corporations, and tenants and/or homeowners (Bouw, 2015). As seen in Table 5, most of these key stakeholders are represented in the interview process: energy company (grid operator), municipality (local government), and housing association (housing corporation). Unfortunately, due to difficulties in identifying individuals to participate, tenants and/or homeowners are not represented in the interviews. Additionally, several interviews were conducted with consultancy bureau representatives, energy cooperative representatives, and a regional government representative. Although these are not included in the original list of key stakeholders, they each provide valuable insight into the topic. Consultancy bureau representatives are often hired to facilitate the feasibility phase of projects and therefore work with many key stakeholders, acquiring knowledge and experience into how different stakeholders interact during that project phase from a slightly external perspective. On the other hand, energy cooperatives in heat grid projects are growing thanks to the Programma Aardgasvrije Wijken (PAW) which is a program supporting municipalities to achieve natural-gas free neighbourhood projects (Nationaal Programma Lokale Warmtetransitie, 2023), as well as the SCE subsidy scheme for cooperative energy generation (Rijksdienst voor Ondernemend Nederland, 2021). Therefore, due to their growing involvement, their perspective must be considered as it may differ from the conventional ways of working for such projects. Given that most of the key stakeholders are represented twice each, with the exception of tenants/homeowners, as well as other stakeholders that are also deemed crucial, the findings of this research can be generalised and applied to other heat grid projects in the Netherlands.

After conducting the interviews, transcripts were generated and coded using the Atlas.TI software. A combination of inductive and deductive coding was used for the coding. The codes created were grouped into the topics of mixed-use neighbourhoods, project phases, barriers, and collective decision-making. The codes for mixed-use neighbourhoods were created deductively and split into building use and the issues regarding ownership and typology. These codes allowed for a determination of what constitutes a mixed-use neighbourhood to be able to generate a concise definition. Additionally, the codes of ownership issue and typology issue were created to find trends regarding stakeholders' opinions on which issue is most present in mixed-use neighbourhoods. The codes for project phases were created inductively as the transcripts were being processed such that the following phase codes were generated: initiation, feasibility, contracting, realisation, and operation. The codes for the barriers were first created deductively from the literature and theoretically-based interview questions. As the coding process evolved, some codes were determined inductively based on what arose during the interviews. Lastly, the collective decision-making codes included: who is the collective, negative view, and positive view. These codes were primarily used as an organizational tactic for the data gathered regarding opinions and perspectives on collective decision-making. These codes allowed for the generic analysis of the research topics.

5.1.3 Case study selection

During the interviews, three interviewees were found to have worked on the same project, hence making it an intriguing case to study. The criteria mentioned in Section 3.2.2 was used to determine the suitability of the project for the case study. Table 6 shows the case study selection criteria.

Table 6: Case study selection justification (author)

Case	Project Phase	Project Initiator	Heat Source	Building Typologies	Stakeholders Involved	Stakeholders Interviewed
Groenoord	Development	Housing Association & Municipality	Residual Heat from Biomass & Waste Incinerator	Residential (social and private), municipality-owned, leisure	Housing Association, Municipality, Energy Company, Residents, Consultancy Bureau, Regional Government	Housing Association, External Project Manager, Regional Government Representative

As can be seen, the Groenoord project discussed in three interviews fulfils all criteria from Table 4, hence being appropriate for the study. The case specific analyses provide a precise decision-making process while highlighting the key barriers encountered. This will allow for answers to be generated for the sub questions of the research as well as the main research question.

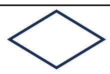
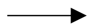
5.2 Generic analysis

5.2.1 Generic decision-making process

During the literature review of this research, it was clear that there is not a defined decision-making process scheme for district heating projects. Of course, there is an underlying decision-making process that is exercised during the development of such projects in practice, however, there has yet to be a scheme created demonstrating the key decisions that occur during the development of heat grid projects and when they occur. Therefore, one of the aims of this research is to create such a scheme by combining literature and empirical data from interviews.

As previously mentioned, the value chain of district heating projects includes the following stages: production, transport and distribution, and supply (ten Haaft, 2020). This was the basis used during the interviews for the development of the decision-making process scheme. Early on in the interview process, it was clear that this value chain was merely one part of a large, entangled matrix of decisions made during these projects. Therefore, by combining the data from the Greenvis Heat Pipeline and the interview findings, Figure 20 was generated. See Appendix C for enlarged diagram. Table 7 provides a legend for the diagram. The included phases are initiation, feasibility, and contracting due to the focus and scope of this research.

Table 7: Process diagram legend (author)

Symbol	Meaning
	Document
	Process
	Decision
	Action
	Direction of flow

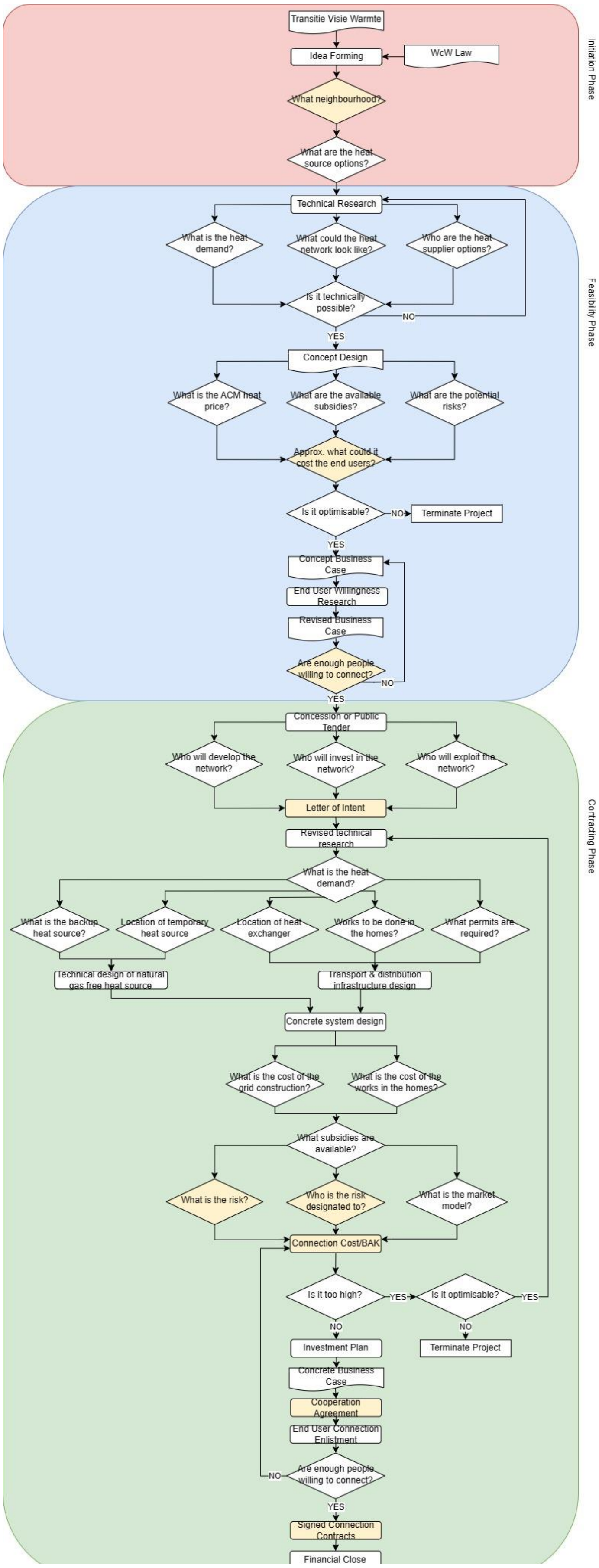


Figure 19: Generic decision-making process (author)

Initiation Phase

The initiation phase consists of a preliminary discussions of possible heat grid systems in an area and can be seen in Figure 21 with the key moments showed in yellow.

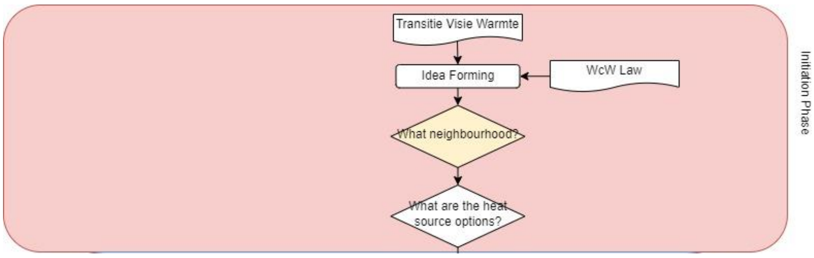


Figure 20: Generic initiation phase of decision-making process (author)

This phase can be commenced by different stakeholders such as the municipality, heat suppliers or energy companies, and building owners. Commonly, a municipality, energy company, and/or housing association will begin the initiation phase of district heating projects either individually or in combination with the other parties (Roos & Manussen, 2011). Additionally, there is an increase in citizen-led initiatives in the Netherlands in which the residents of a neighbourhood decide to initiate such projects (ECO.1.KD, 2023). Typically, a municipality's heat transition vision (transitievisie warmte) can provide input for the idea forming stage (HC.1.SA, 2023; Valk et al., n.d.), which is followed by the decisions on which neighbourhood could be selected for the implementation of a heat grid, and what are potential sustainable heat sources that are available and viable for the neighbourhood's grid (EC.1.BD, 2023; G.1.PL, 2023). These decision are heavily influenced by the Collective Heat Act (WcW Law) which is still pending and, among other points, states that the majority of heat infrastructure mut be owned by a public party or the local governments (Klimaat, 2023). Once these decisions have been made, the process continues onto the feasibility phase.

Feasibility Phase

The feasibility phase delves deeper into the technical and financial possibilities of the considered heat grid and is a combination of the Greenvis stages of investigation (onderzoeken) and design (ontwerpen) (Valk et al., n.d.). This phase can be seen in Figure 22, with the key moments showed in yellow, and begins with technical research being conducted on the heat production possibilities for the area in question (C.1.C, 2023; G.1.PL, 2023).

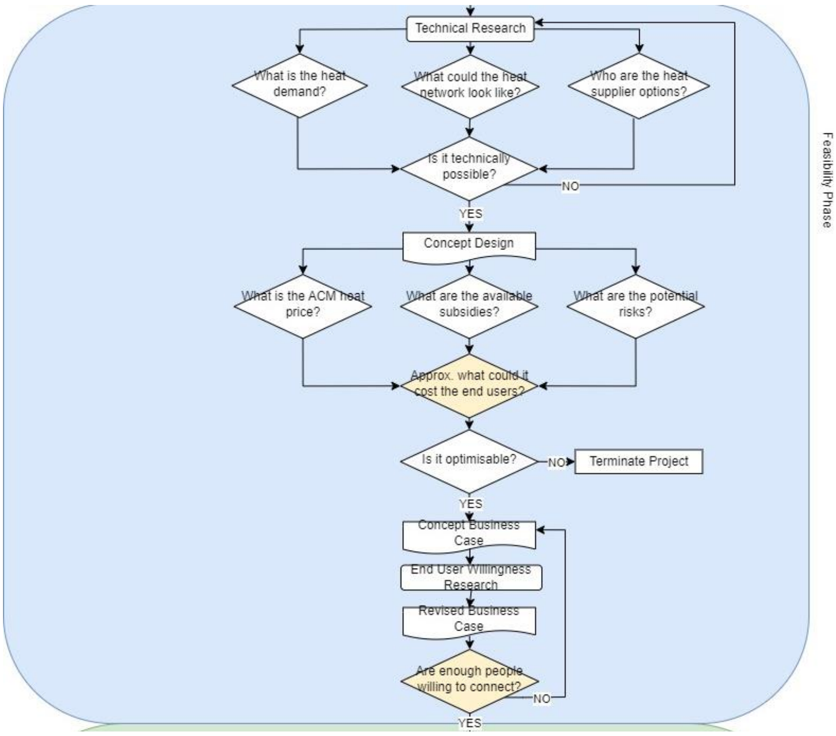


Figure 21: Generic feasibility phase of decision-making process (author)

This research sparks several questions requiring data to be collected and decisions to be made regarding the area's heat demand (Valk et al., n.d.), the possible design of the network and its infrastructure (C.1.C, 2023; G.1.PL, 2023), and potential supplier options (G.2.PO, 2023). These three decisions feed into one of the phase's key decisions: is it technically possible? If the grid is not technically possible, further technical research must be performed and the process circles back to that point. This is the first example of the iterative process experienced in the development of heat grid projects. If the grid is technically possible, the process continues such that the concept design is created. Following the conceptual design, various questions and decisions arise regarding the Netherlands Authority for Consumers and Markets (ACM) set heat price (C.1.C, 2023; G.2.PO, 2023), the available subsidies that could be acquired for this project (HC.1.SA, 2023), and the potential risks that may arise (Valk et al., n.d.). These three decisions feed into the phase's second key decisions: what is the approximate cost for the end users? Depending on the outcome of this moment, the cost must be evaluated to determine whether or not the obtained value is reasonable or optimisable: if no, the project is terminated given that the project is not feasible if the cost for the end users is not optimisable (C.1.C, 2023). If the cost is optimisable, the process continues to the creation of the concept business case which is generated from all the previously made decisions. Following the creation of the concept business case, research must be conducted on the willingness of the end users to connect to the proposed heat grid (G.1.PL, 2023). Based on the outcome of the research, the business case is revised a key question arises: are there enough people willing to connect for the business case to be feasible? If there is not enough people willing to connect, the concept design must be optimised, again demonstrating the process's iterative nature (C.3.C, 2023). If there is enough willingness to connect, the process continues onto the contracting phase.

Contracting Phase

The contracting phase can be interpreted as a combination between Greenvis' design (ontwerpen) and capture (vastleggen) phases and are characterized by the key milestones of signing the letter of intent, the cooperation agreement, the connection contracts, and finally arriving at the financial close. This is shown in Figure 23, with the key moments showed in yellow. This phase begins with announcing a concession or a public tender, depending on the initiators of the project (C.1.C, 2023; G.1.PL, 2023). As part of the concession/public tender process, decisions on the involved development parties are conducted to decide who will develop, invest, and exploit the network (G.1.PL, 2023).

Once this has been set, a letter of intent is drawn up and signed. The letter of intent is a formal agreement between all involved parties that state their intent of working together to develop the heat network (G.1.PL, 2023). After this milestone, the technical research is revised in order to create a more concrete system design, such that the heat demand is revised (Valk et al., n.d.), and multiple decisions must be made on the network's design. In order to create the technical design of the natural gas free heat source, the location of the temporary heat source (HC.1.SA, 2023) and the backup heat source must be determined (EC.1.BD, 2023). Additionally, to design the transportation and distribution infrastructure, the location of the heat exchanger must be determined (HC.1.SA, 2023) as well as the works that need to be done in the homes receiving the heat (C.1.C, 2023), and the required permits for the development and begin these processes (EC.1.BD, 2023). Once the concrete system design has been created, the financial matters must be considered including the construction cost of the grid, the cost of the works that need to be done in the homes (G.2.PO, 2023), the available subsidies and the processes for acquiring them (C.1.C, 2023), the risks and who is responsible for them (C.2.C, 2023; HC.1.SA, 2023), and the market model of the grid (Valk et al., n.d.). These decisions all make up the BAK or the connection cost of the system (C.1.C, 2023). This connection cost is a crucial outcome from this phase given that it highly impacts the end user's willingness to connect, and the overall development of the project. Once the connection cost has been established, it must be evaluated to determine whether it is reasonable for the end users. If the BAK is too high and cannot be optimised, the project is terminated. However, if the cost can be optimised, the technical research for this phase must be revised again and the process is continued from there. If no optimisation is needed, then an investment plan is created and a concrete business case is established (C.1.C, 2023). Once the concrete business case is created, an official cooperation agreement is signed between the parties involved in the project (C.1.C, 2023). After this, the end users must be enlisted to connect to the grid. If there are not enough people willing to connect to the grid, the connection cost must be revised. If there is sufficient willingness to connect, then connection contracts are presented and signed by the end users and the project reaches a financial close (C.1.C, 2023). Furthermore, once reaching the financial close, the realisation phase begins in which the heat grid is built and delivered, and finally begins to operate (Valk et al., n.d.).

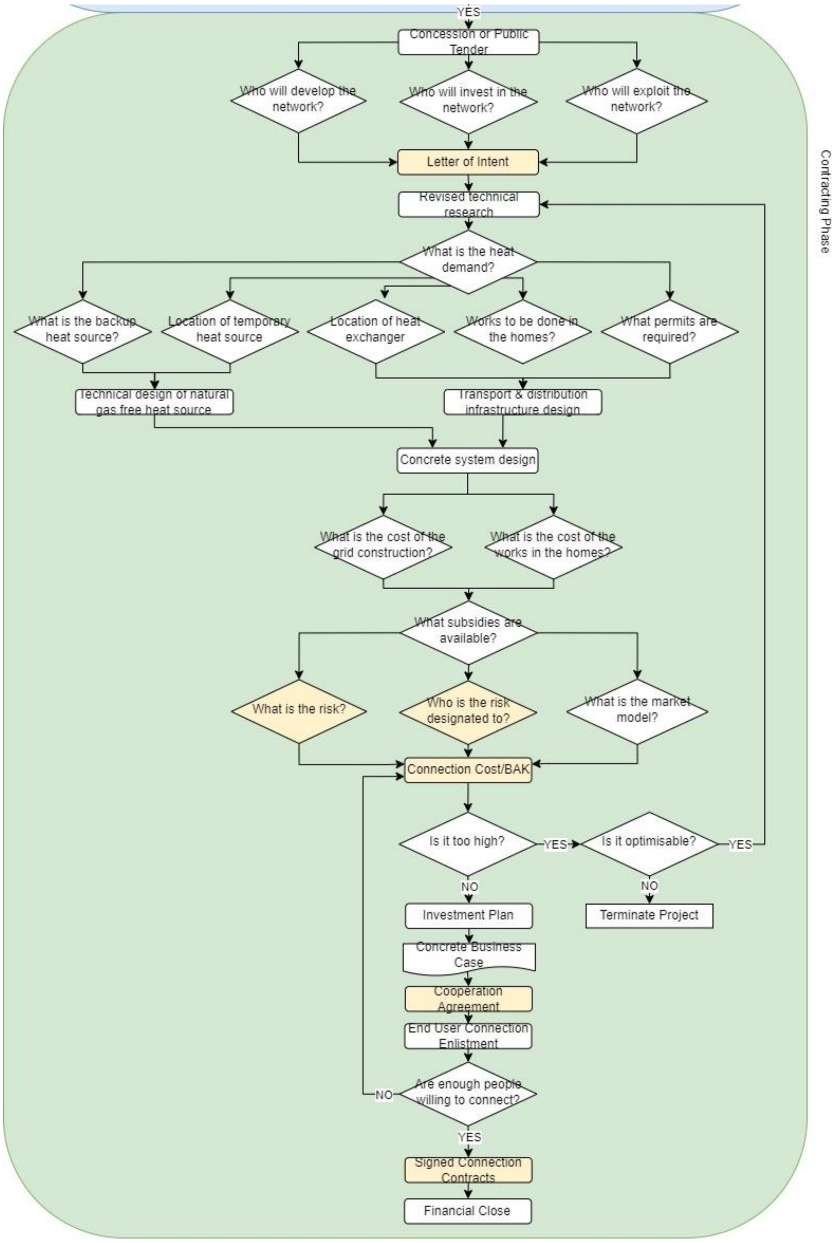


Figure 22: Generic contracting phase of decision-making process (author)

5.2.2 Generic analysis of barriers

In Section 2.4, a variety of literature regarding the barriers encountered in the energy transition, district heating projects, and Dutch district heating projects was combined discussed. From this catalogue, a barriers framework for this research was created against which to analyse the similarities and differences of experienced barriers of heat grid projects in the Netherlands, acquired through interviews, to those found in literature. In order to make this comparison, this framework will be used with an additional "Degree" column which denotes the frequency in which the interviewees mentioned the specific barrier. This serves as a general overview of the barriers experienced in practice from the combined perspectives of energy companies, policymakers, sector associations and consultancy bureaus, energy cooperatives, and building owners. After analysing the interview transcripts, several barriers were found that were not previously mentioned in literature, therefore these have been included in the framework and can be found in bold. This can be seen in Table 8.

Table 8: Barriers Framework (author)

Categorisation	Barrier	Degree	Totals
Informational	Lack of information	60	189
	Lack of expertise	40	
	Lack of experience in DHN	16	
	Lack of transparency and trust	63	
	Lack of experience with energy cooperatives	10	
Behavioural	Lack of awareness	47	257
	Perceived value of energy	12	
	Inertia	16	
	Ignorance	12	
	Social acceptance	6	
	Resistance to change	15	
	Negative perceptions of the energy transition	4	
	Lack of participation and cooperation	63	
	Willingness to connect	26	
	Interorganisational resistance	32	
	Individualism for collectivity	24	
Organisational	Monopolistic position of DHN operator	10	224
	Fragmented value chain	31	
	Unfavourable business case	8	
	Resource scarcity	10	
	Mismanagement	18	
	Difficulty in decision-making	25	
	Stakeholder conflicts	30	
	Lack of well-defined direction	43	
	Chicken & Egg scenario	9	
	Long project duration & changing actors	10	
	Iterative process & time	30	
Economic & Financial	Profitability	4	149
	Tax system	2	
	Market distortions	3	

	Market behaviour	3	
	Long payback times	3	
	Reduced long-term revenue for DHN operators	2	
	Low ROI	2	
	District heating prices uncertainty	18	
	High initial investment and risks	40	
	Connection fees	3	
	Cost efficiency vs flexible network design	7	
	Expensive transition costs	15	
	High capital costs	7	
	Sunk costs	2	
	High construction costs	1	
	Significant renovation costs for existing houses	6	
	High process costs	7	
	Ensuring affordability for all	7	
	Unreliable funding	17	
Technical	Perceived risks and uncertainties from immature technology	6	46
	Future demand uncertainty	25	
	Energy security	1	
	Complex construction in existing building stock	1	
	Complex energy systems	5	
	Organisation of infrastructure	8	
Legal	Regulatory risk and uncertainty	23	94
	Political-legislative uncertainty	71	

5.2.2.1 Discovered Additional Barriers

As mentioned, several barriers were identified and added to the framework including: lack of experience with energy cooperatives, willingness to connect, interorganisational resistance, individualism for collectivity, chicken & egg scenario, long project duration & changing actors, iterative process & time, high process costs, ensuring affordability for all, unreliable funding, and organisation of infrastructure. These barriers have not been mentioned in the predominant literature but have been addressed during the interviews which demonstrate their importance and provide a valuable contribution to the existing literature.

Added Informational Barrier

Given the rise and push for energy cooperatives in the district heating sector, there is a consequently inevitable lack of experience with energy cooperatives as described by the energy cooperative (80% of barrier degree), municipality (7% of barrier degree), and consultancy bureau (13% of barrier degree) stakeholders. This includes a lack of determined working procedures for collaborating with energy cooperatives, unlike those that are common when working with private companies, "with a cooperative it's a little bit of a different road because you do want to give them the chance to grow, and you want to create trust. So it's a new type of collaboration which asks for now ways of decision-making" (ECO.1.KD, 2023). This unclarity can often prevent or hinder the initiation of such resident initiative projects (Nationaal Programma Lokale Warmtetransitie, 2023).

Added Behavioural Barriers

The added willingness to connect barrier refers to the willingness that residents do or do not have to connect to the heat grid. This can be confused with the future demand uncertainty barrier however the willingness to connect refers to the frontrunning customers. Although not necessarily reflected in the barrier's degree, many stakeholders view the willingness to connect as the greatest risk and challenge in district heating projects (ECO.1.KD, 2023; G.1.PL, 2023; HC.1.SA, 2023). Additionally, the interorganisational resistance barrier was added to distinguish the difference between resistance to change. Interorganisational resistance refers to a resistance demonstrated by the value chain parties in collaborating with each other. This includes the resistance between different parties as well as within their own party, given that each party has its own organisational structure within their respective company in which different levels of power may have conflicting perspectives resulting in internal resistance (C.1.C, 2023; HC.1.SA, 2023). Lastly, the discovered barrier of individualism for collectivity is arguably the most interesting added barrier for this research and can be most clearly described by the following quote,

"it feels impossible to make a collective system based on individual choices" (C.3.C, 2023).

Given the nature of our society, it is common and normal for individuals to want what is best for their specific situation, however collective heating systems require everyone to be in agreeance with the proposed solution if it is going to work. Therefore, individualism poses many complications when aiming for a collective system.

Added Organisational Barriers

The chicken & egg scenario is one that causes many blockages in an array of projects, including district heating projects. In basic terms, this scenario occurs when there are multiple aspects that are dependent on each other in a vicious cycle such that you need A for B while you simultaneously need B for A. This scenario is present in several aspects of district heating projects and is often described as having to "play chess on many boards" which renders the decision-making process increasingly complex (G.2.PO, 2023). An example of this phenomenon can be explained by the following quote,

"it's really hard to say which goes first because you can only offer a contract saying it will probably cost roughly this, but you can really only say [the cost] if you know how much of a loan you're going to get from the bank and how much the build is actually going to cost. But the bank will only give you a loan and the interest rate once they know how many people have signed the contract… Same goes often with permits or getting the municipality involved because the municipality might say we will only join you when you get a loan from the bank and you have a financial close. But the banks will often have as a prerequisite for giving you a loan that the municipality has to be a guarantee for your loan" (ECO.1.KD, 2023).

Additionally, it was often mentioned that district heating projects have a long duration which results in changing actors (Nationaal Programma Lokale Warmtetransitie, 2023). These projects can last up to 10 years, therefore the personnel working on the projects from the different involved parties will inevitably change during that time, therefore requiring a rebuilding of relationships between the parties' members (C.3.C, 2023; EC.1.BD, 2023; M.1.PM, 2023). Similarly, the project process is of an iterative nature due to the various moving parts, hence being time consuming and increasing project duration.

Added Economic & Financial Barriers

The iterative process of heat grid projects results in high process costs, which pose a threat to these projects. Given the lengthy time of the process, the costs for these processes also increases, and consequently constitutes more financial strains to the parties involved. This stunts projects and incites resistance given the desire of obtaining concrete, tailor-made information but not wanting to pay for the costs of those processes (C.3.C, 2023). Another important financial barrier that was found is that of ensuring affordability for all. This is regarded as very important for municipalities as well as all other parties involved given that end-users will not be willing to connect if it is not affordable for them. However, the concept of affordability is complex because it means different things for different people depending on their situation. Therefore, value chain stakeholders struggle with determining how to approach affordability such that everyone in a neighbourhood is in agreement. This is also increasingly present in mixed neighbourhoods who's residents may have a wide range of financial backgrounds (HC.1.SA, 2023). Lastly, unreliable funding poses great uncertainty of the value chain parties. This funding can range between private investments, bank loans and funding, and government funding through subsidies. For established energy companies, the uncertainty of subsidy allocation slows down their processes as they are hesitant to invest in a project without the assurance that they will be granted the necessary subsidies to execute the project (HC.1.SA, 2023). Similarly, energy cooperatives face significant challenges in securing reliable funding from subsidies and banks, which often fails to align with their project ambitions and momentum. This can lead to project delays and, in some cases, project abandonment (ECO.1.KD, 2023; NP.1.C, 2023).

Added Technical Barrier

Although the technical barriers are not the core focus of this research, a technical barrier that was uncovered from the interviews that generates complications and uncertainty is the organisation of infrastructure. This encompasses the organisation in terms of extent of the grid and the project boundaries and how it may be adapted for future demand (HC.1.SA, 2023), and the issue that the Netherlands possesses that the grounds are already very full with piping that causes challenges for the underground piping design for heat grids (C.2.C, 2023).

5.2.2.2 Key Barriers Analysis

As can be seen, the barriers have been categorised as either informational, behavioural, organisational, economic & financial, technical, or legal barriers. This classification was determined based on the previously discussed literature as well as by identifying patterns and grouping similar barriers. In the literature, the taxonomy of barriers included personal, social, economic, technological, and political. However, after consideration of all the mentioned barriers literature and the creation of the framework, the personal and social barriers have been characterised as either informational or behavioural barriers, the political barriers have been characterised as either organisational or legal barriers, while the economic and technological barriers have remained in their attributed characterisation. It can be seen in Table 8 that informational, behavioural, and organisational barriers are the most prevalent as per the conducted interviews.

It was found that the most reoccurring informational barrier was lack of transparency and trust with every interviewed stakeholder mentioning the barrier at least once during the interview. This barrier was often discussed simultaneously with the barriers of lack of participation and cooperation, and stakeholder conflicts, which demonstrates that the level of transparency and trust between stakeholders and throughout the project has a direct correlation with the amount of participation and cooperation and stakeholder conflicts. This was expressed by several stakeholders that pertained to the groups of energy company and consultancy which stated that although communication is present between actors, it appears that they do not understand each other nor "speak each other's language" (C.2.C, 2023). Interviewee EC.1.BD explained "it's not that we're not talking to each other, we are talking to each other, but we hear things and we cannot place them very well. We perceive all the parties to behave very awkward” (EC.1.BD, 2023). Additionally, there is a strong correlation between interorganisational resistance and the lack of transparency and trust, as stated by interviewee G.1.PL “we do not want commercial companies to take the cherries” (G.1.PL, 2023). This also links to the monopolistic position of district heating network operators which also pose resistance from residents as explained by interviewee G.2.PO: “[the] heat company often is a private owned entrepreneur, of which you are very dependent and which doesn’t feel really comfortable. Those are reasons against choosing for heat grid” (G.2.PO, 2023). This lack of trust and transparency does not appear to be merely attributed to a specific party, but more as an industry standard which is one of the most problematic that must be overcome or alleviated in order to strive for project success. It is interesting to note that there is an imposed institutionalised distrust due to European Union anti-monopoly rulings that constrain the cooperation between private companies as well as between public parties (G.2.PO, 2023). Interviewee C.1.C stated the importance of transparency and trust within the decision-making process, “if you want to make a decision together, then you need to be able to look at each other’s hands, look at what cards we are dealing with.. I think the problem here is you also need to trust that they really show you all the cards and they don't have a few up their sleeves. So trust is a very big base here” (C.2.C, 2023).

In addition, the greatest behavioural barrier was determined to be a lack of participation and cooperation. As previously explained, there is a direct correlation between participation and cooperation, interorganisational resistance, and stakeholder conflicts. Closely following, there is an evident relationship between a lack of participation and cooperation and a lack of well-defined direction.

A lack of well-defined direction is the greatest organisational barrier and whose definition is multifaceted. It can be described as an uncertainty in the roles of different actors in the value chain of heat grids and a lack of standardisation of the forms of collaboration and way of working between the different parties (Nationaal Programma Lokale Warmtetransitie, 2023), which consequently impacts the assignment of risks and responsibilities for the project. This is closely tied with the fragmentation of the value chain in the heat grid industry. Additionally, it encompasses the fact that there is a risk of unclear goals of each involved party which impacts the prioritisation of different aspects of the project, which can cause a loss of focus on crucial decisions and a shift to prioritising noncritical tasks (Nationaal Programma Lokale Warmtetransitie, 2023). This has been explained by interviewee C.2.C in the following manner “what's very important is that [the involved parties] feel responsible to make the project work. So we always advise to make this one liner or the goal of this team, like what are we working on together. Because for a municipality it can be we want sustainable heat, but for a housing corporation it can be I want to match my goals that I have and nothing more. So also the ambitions have to line up to one goal to say then we're going to realise this” (C.2.C, 2023). Therefore, it is understandable that a lack of participation and cooperation from different parties can result in a lack of well-defined direction and vice versa.

Moreover, the greatest economic and financial barrier is the high initial investment and risks of such projects, which was mentioned by every stakeholder group. This barrier arguable presents the largest issue for heat grid projects given that not only is the cost of the initial investment high creating a burden or impossibility for many actors, but the associated risks, such as a lack of connections rendering the grid obsolete, also halt projects since the financial risk is too large that parties do not want to or cannot cover them (C.2.C, 2023). This risk allocation is a great barrier as expressed by interviewee ECO.1.KD, “what we see in a developmental stage, you get some contractors building something, you have someone who owns the source, someone who owns the infrastructure, someone who owns the supply or is responsible for the supply. And then where you allocate the risks, that is a very difficult decision to make because nobody wants to have the most risks… That's a difficult decision making process" (ECO.1.KD, 2023). This ties into the detection that this barrier has a high correlation with future demand uncertainty, political-legislative uncertainty, difficulty in decision-making, and fragmented value chain. This conflict for heating companies of evaluating the tradeoff between the high investment and risks, the future demand uncertainty, and political-legislative uncertainty that can be attributed to a fragmented value chain and results in difficulty in decision-making is best demonstrated by the following quote:

"if you say, I have say 5,000 [connections] that are really certain but have the perspective of 10,000 [connections], so our company decision is we will invest ahead in getting from 5 to 10,000 [connections]. So that will not be in the connection cost [for the consumer]… and that's one of the difficulties in certain cases, so we try to make [guarantee] agreements [with] municipalities. [We] say we think we can go to 10,000 connections in the heat system, but it's uncertain if they will come. We have to invest 4 million more to be ready on those numbers for heat supply, which [getting from 5,000 to 10,000] costs say 2 million. Can you guarantee us 2 million euros if we don't make the jump from 5 to 10? So [the municipality] have to make us some kickback fee kind of deal to build [that extra] connection or transport... That's one of the main challenges, the heat system always has to be able to provide enough heat for the people the same like an electricity distribution, we do not allow a lot of blackouts" (HC.1.SA, 2023).

Additionally, it is interesting to note that most, if not all, stakeholders stated that financial barriers are the most problematic, "the biggest challenge is always money" (G.3.PO, 2023). However, from Table 8 it can be seen that economic and financial barriers can be classified as having the second to last degree out of the six barrier categories. A potential explanation for this observation is that given the fact that the interviewees stated multiple times their strong beliefs that the financial aspects are most troublesome, they did not elaborate as much on them as other barriers, and their mentions were not inductively found during the coding process.

Furthermore, the greatest technical barrier is the future demand uncertainty which refers to uncertainty in the connection of those customers that could join later on when the heat network has already been established, as well as uncertainties regarding the future heat demand due to applied energy efficiency measures. This barrier typically occurred in connection with the barriers of high initial investment and risks, difficulty in decision-making, and willingness to connect. This can be explained as the uncertainty of future demand triggered more risks for the involved parties and caused struggles in the decision-making process regarding whether or not to invest in the project. Also, the future demand uncertainty and willingness to connect barriers are typically mentioned in the same context. Although different, both the current willingness to connect as well as the future connection potentials and use are both topics that generate risks, uncertainties, and difficulties for the involved parties.

"It's really complicated and it's also interesting now because we see that we follow this process and then at the end there's still no decision made because we see a lot of risks…In this decision you have, a technical part and a financial part. So is it technically possible and how much should it cost. But then you also have responsibilities and risks… [so] what will happen if the plan doesn't work out?" (C.2.C, 2023).

It should be noted that the technical barriers had the lowest combined degree, however this does not automatically mean that technical barriers do not impact district heating projects. This low degree could simply be attributed to the fact that the majority of interviewed stakeholders were not necessarily technical experts. Additionally, the main focus of this research is not the technical aspects of heat grids, therefore the emphasis and drive of the interviews were primarily skewed towards the non-technical barriers that arise.

Lastly, the greatest legal barrier is the political-legislative uncertainty that is currently present in the industry's landscape. It is imperative to note that this barrier possesses the greatest degree overall out of all of the explored barriers, with every interviewee mentioning this barrier at least three times throughout the interview. This uncertainty is primarily attributed to the uncertainty surrounding the proposed Wet Collectieve Warmtevoorziening (WCW) law and has a strong correlation with the lack of well-defined direction barrier. The WCW law states that 51% of heat infrastructure is owned by a public party, however the law is not in place yet but it is anticipated (EC.1.BD, 2023). However, it has not been decided who that public party will be nor what categorizes entities as a suitable public party for such projects, however it is certain that they will be the owner of the heat grid infrastructure (G.1.PL, 2023). Therefore, parties are struggling to make decisions and are therefore stagnant on pursuing projects due to this uncertainty (EC.1.BD, 2023). The panorama has been described as conflicting for several involved actors, "because of what the minister has decided, it's kind of a difficult position that we're in now… Because we are taking a large financial risk if we now say there must be a heat grid. And the commercial companies have said, if you want a public heat grid, then I'm not going to invest anything. So it's kind of like a standoff at the moment because of this uncertainty with the new law and stuff" (G.1.PL, 2023).

5.2.2.3 Barriers of Mixed-Use Neighbourhoods

Mixed-use neighbourhoods provide their own opportunities and challenges in district heating projects. However, it is debated whether the core of the challenges stem from the differing building ownerships or from the building functions and typologies present. From the interviews, it was found that 76% of the difficulties of mixed-use neighbourhoods are attributed to the building ownership, while the building typology accounts for 24%.

The issue of ownership primarily regarded the fact that an increase in owners mean an increase in decision makers for whether or not to connect to the heating grid. This makes the decision-making process increasingly complex and lengthy, consequently jeopardizing the speed of connections to the grid (G.1.PL, 2023). Therefore, housing associations are key in this regard because they own a large number of apartments in certain areas for which they can essentially decide for a whole street or area to be connected because they own the property (C.1.C, 2023; G.1.PL, 2023). Housing associations are in charge of getting their tenants to connect to the grid, while to the greater value chain of heat grids the other stakeholders only work with one stakeholder for those homes, the housing association. Technically speaking, apartment buildings are also simpler to connect given that you only need to connect one pipe to the heat distribution system, typically in the basement, to connect the entire building. This results in low costs and high income because the association will pay for each of these households to connect them to the heat grid, and the amount of piping is minimal (C.1.C, 2023). However, connecting utility or other types of buildings becomes more complex given that each owner will need to decide for themselves whether to connect or not. Additionally, it often occurs that the owner of non-residential buildings are not the user, making it more difficult to get the building's decision-makers to agree to connect to the grid (G.1.PL, 2023). This complexity can be described as, "the difficulty increases exponentially with more people having to decide. So [having] more different owners is way [more difficult] than [having] one or two organisations that own most or all of the properties in a certain area" (C.3.C, 2023). For this reason, the main focus for heat grid projects is to connect with housing associations as much as possible (C.1.C, 2023; C.3.C, 2023; G.1.PL, 2023).

Nonetheless, there are some complications with including non-residential buildings to heat grids due to their typology. Commercial buildings, specifically those consuming a lot of heat, get charged lower gas prices than residential users, and therefore want lower heat prices as well if joining the grid. However, this rapidly damages the business case if heat companies need to sell heat for lower prices, making it increasingly difficult to be profitable if commercial users are included in the system (C.3.C, 2023; G.2.PO, 2023). This is due to the regressive tax system on energy tax in the Netherlands, where energy tax is based on how much is used in a year (C.1.C, 2023; Belastingdienst, n.d.). Additionally, large commercial buildings, such as a school for example, require large amounts of piping as compared to an apartment building, adding to the costs of the system while requiring lower energy costs. Although large non-residential buildings can be useful to to level out heat demand over time and provide constant heat supply for the heat grid (C.1.C, 2023), large non-residential building with high energy demands will be less willing to connect to the heat grid unless they also receive a large discount on their heat price (C.3.C, 2023).

Therefore, it is clear that both typology and ownership are areas that bring complications to the feasibility of a heat grid in a neighbourhood, resulting in a strong focus on recruiting housing associations with large apartment buildings to get the systems off the ground. Additionally, several barriers were found specifically occuring in mixed-use neighbourhoods. These are shown in Table 9.

Table 9: Barriers in mixed-use neighbourhoods (author)

Categorisation	Barrier	Degree	Totals
Informational	Lack of expertise	1	2
	Lack of information	1	
Behavioural	Willingness to connect	1	2
	Cooperation	1	
Organisational	Fragmented value chain	1	3
	Mismanagement	1	
	Iterative process & time	1	
Economic & Financial	Connection fees	1	7
	High initial investment and risks	2	
	Reduced long-term revenue	1	
	Tax system	2	
	Unreliable government funding	1	
Technical	Organisation of infrastructure	1	1
Legal	Political-Legislative uncertainty	1	4
	Regulatory uncertainty	3	

As can be seen, economic and financial barriers is the most predominant barrier category experience in mixed-use neighbourhoods specifically, while regulatory uncertainty is the greatest barrier present.

5.2.2.4 Barriers per Stakeholder Group

In order to better understand the position of the involved stakeholders and their primary concerns in district heating projects, it is necessary to analyse the validated barriers from the above framework per stakeholder group. Figure 24 shows the distribution of barrier categories per stakeholder group.

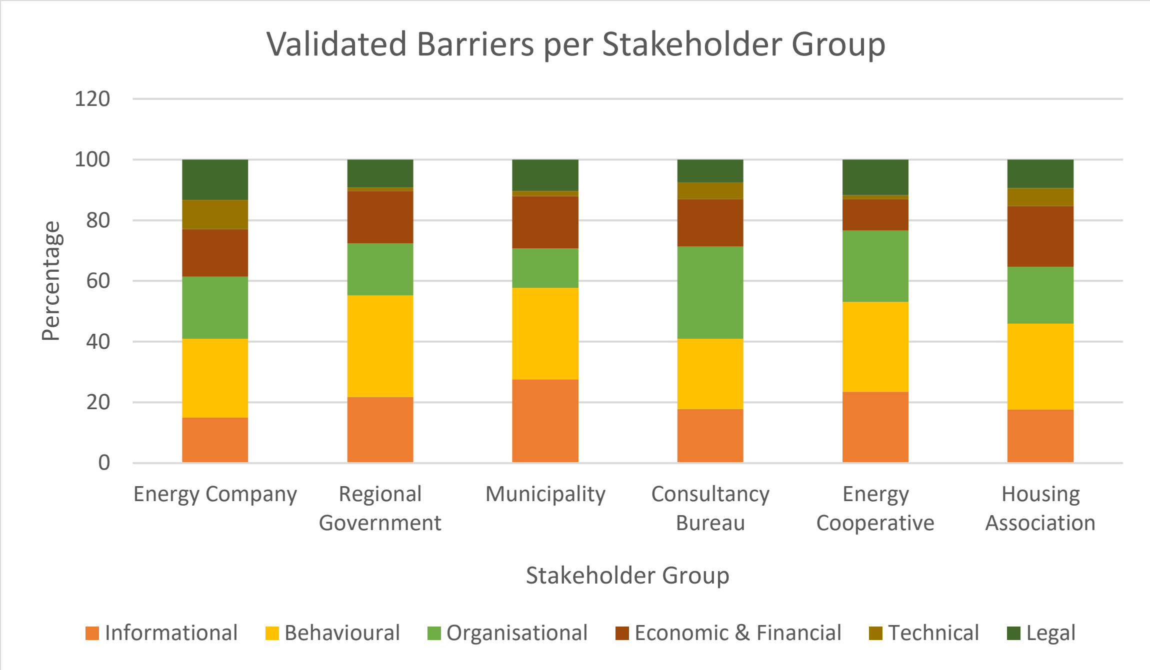


Figure 23: Validated barriers per stakeholder group (author)

From the figure, it can be seen that when comparing the barriers encountered by the stakeholders, all but the consultancy group primarily experience behavioural barriers, with the regional government expressing the most (33%). Additionally, consultancies experience the most organisational barriers (30%), while municipalities encounter the most informational barriers (28%), and housing associations are burdened with the most economic and financial barriers (20%). Furthermore, energy companies experience the most legal and technical barriers, 13% and 10% respectively. It is also interesting to note that the regional government rank the organisational and economic and financial barriers equally (17%), while energy cooperatives rank their organisational and informational barriers equally (23%). These barrier rankings per stakeholder group are important to note as they provide a basis for the priorities and concerns of each stakeholder group and how these may clash between the parties. For example, housing associations will have the strongest stance on economic and financial topics and may show a strong priority to those topics. This is logical given that housing associations are essentially representatives of their tenants and have an inability by law to raise their rents, hence prioritizing economic aspects. Additionally, almost all parties will be greatly threatened by behavioural barriers, while consultancies may be more threatened by organisational barriers. This could be due to the nature of consultancy work of having more of a facilitator and organisational role in such projects.

5.2.2.5 Barriers per Project Phase

The phases of heat grid projects have been designated in a variety of ways. The Greenvis Heat Pipeline suggests four phases: investigation, design, commitment, realisation (Valk et al., n.d.). However, through the interviews, it was found that there are other variations of the phase categorizations, such as initiation, development, contracting and exploitation phases (C.3.C, 2023; ECO.1.KD, 2023; G.1.PL, 2023). Therefore, by combining the Greenvis Heat Pipeline and the data acquired from the interviews, the following phases were concluded to be used for this research: initiation, feasibility, contracting, realisation, and operation. Hence, it becomes interesting to evaluate during which phases the barriers occur in order to determine which phase poses the most complications during the project. Figure 25 presents the barriers per phase of heat grid projects.

It can be seen that the contracting phase experiences the most barriers, with the feasibility closely following. When evaluating the initiation phase, it is found that the top barrier categories experienced in this phase are behavioural and informational barriers. More specifically, the top experienced barrier

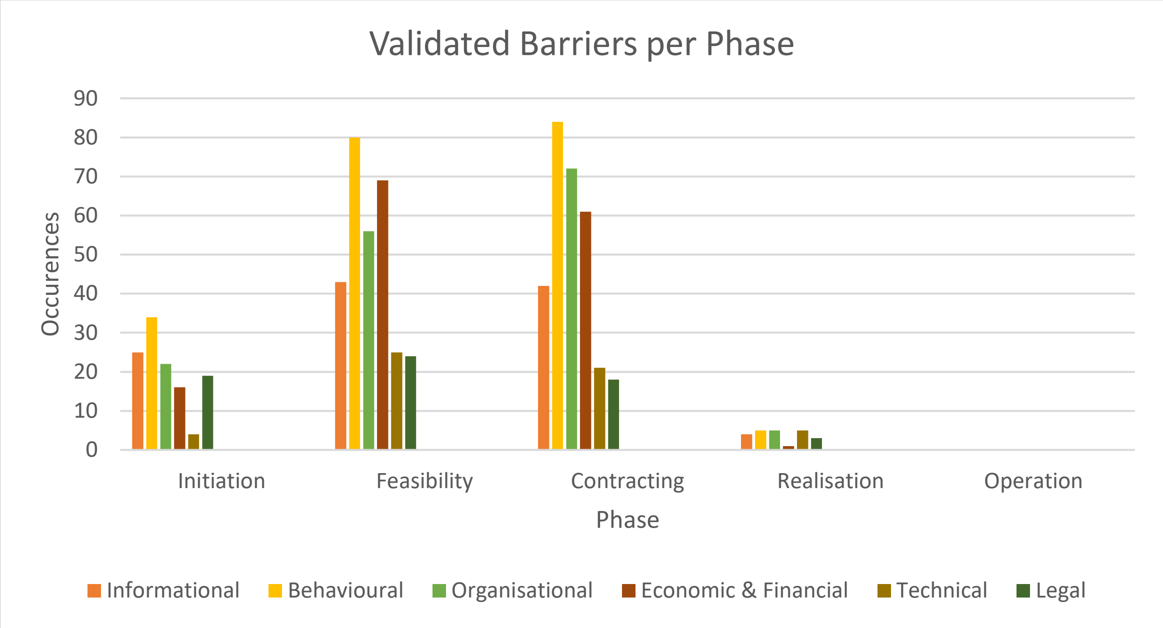


Figure 24: Validated barriers per phase (author)

is political-legislative uncertainty, the top behavioural barrier experienced is lack of participation and cooperation, and the top informational barrier experienced is lack of information which is tied with a lack of well-defined direction. As for the feasibility phase, the top barrier categories experienced include behavioural and economic barriers, with greatest overall barrier being the behavioural barrier of lack of participation and cooperation, and the greatest economic barrier being high initial investment and risks tied as second greatest overall barrier with lack of information.

Additionally, the contracting phase faces the most behavioural and organisational barriers, with the highest-ranking overall barrier being the behavioural barrier of lack of participation and cooperation, and the second greatest barrier being lack of transparency and trust. It is interesting to note that the third highest ranking included a tie between the barriers lack of information, high initial investment and risks, lack of awareness, and willingness to connect which shows their importance during this phase. In addition, the greatest organisational barrier faced is fragmented value chain. Moreover, the realisation phase's top barrier categories tie between behavioural, organisational, and technical barriers, which the highest-ranking barrier being the organisational barrier iterative process & time. It is clear that the realisation phase shows the least number of barriers while there are no present barriers in the operational phase. This must be interpreted with caution given that the technical aspect of such projects is not greatly evaluated during this research and these aspects are predominant in the realisation and operation phase. However, it can be understood that the process leading up to the construction and operation of the heat grid are currently hindering the projects most.

5.2.2.6 Barriers per Project Phase per Stakeholder

In order to understand the perspectives of the involved stakeholders on the barriers of heat grid projects, it is necessary to evaluate when their perceived barriers occur. Therefore, Figures 26, 27, 28, 29, 30, 31 have been created to demonstrate the stakeholders' barriers per project phase.

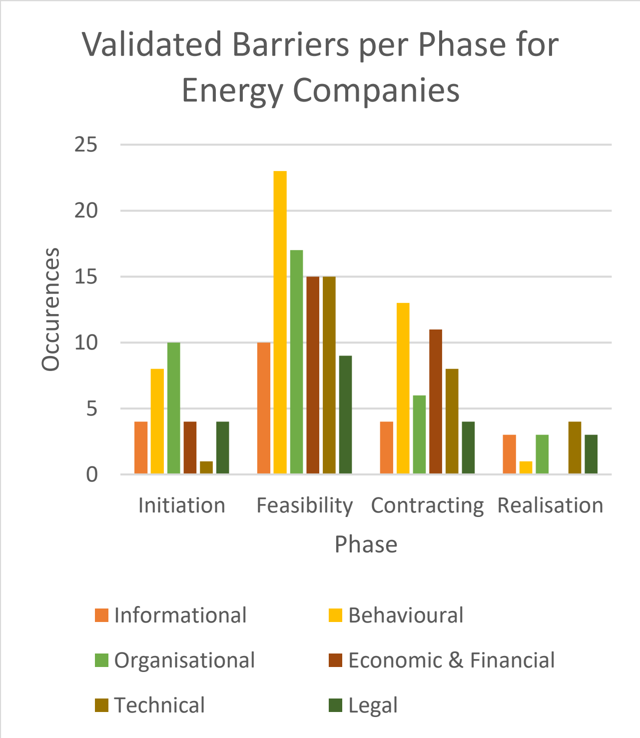


Figure 25: Validated barriers per phase for energy companies (author)

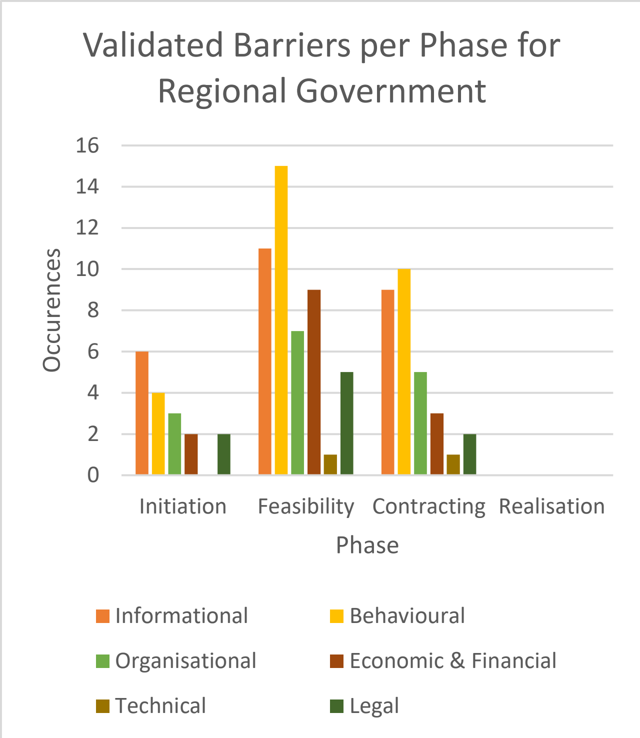


Figure 26: Validated barriers per phase for regional government (author)

Figures 26 and 27 show the barriers per phase for energy companies and the regional government respectively. It can be seen that energy companies perceive the feasibility phase as possessing the most barriers, with behavioural barriers prevailing in this phase. The top three barriers and when they occur are:

1. Political-legislative uncertainty in the feasibility phase
2. Lack of participation and cooperation in the feasibility phase
3. Interorganisational resistance in the feasibility phase

Similarly, the feasibility phase is perceived by the regional government as the phase with the most barriers, with behavioural barriers being the most dominant. The three most common barriers and when they occur are:

1. Lack of awareness in the contracting phase
2. Lack of information in the feasibility phase
3. Lack of transparency and trust in both the feasibility and contracting phases

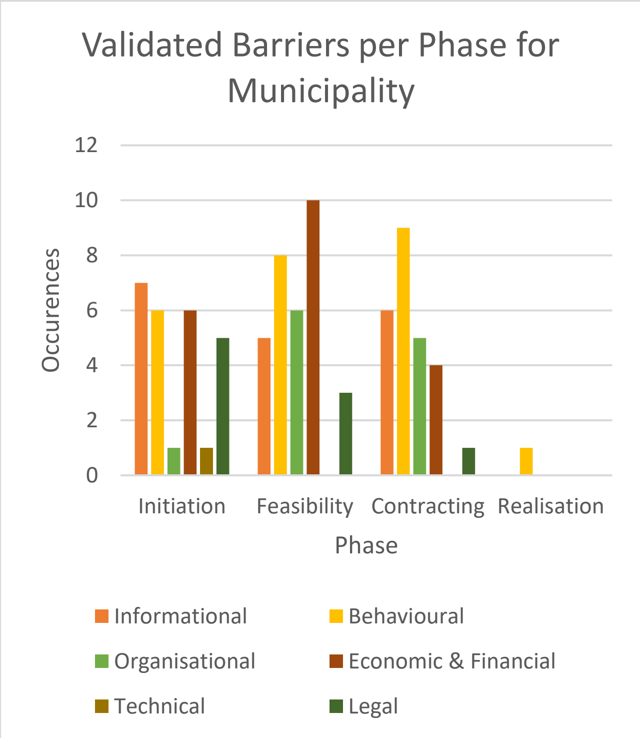


Figure 28: Validated barriers per phase for municipality (author)

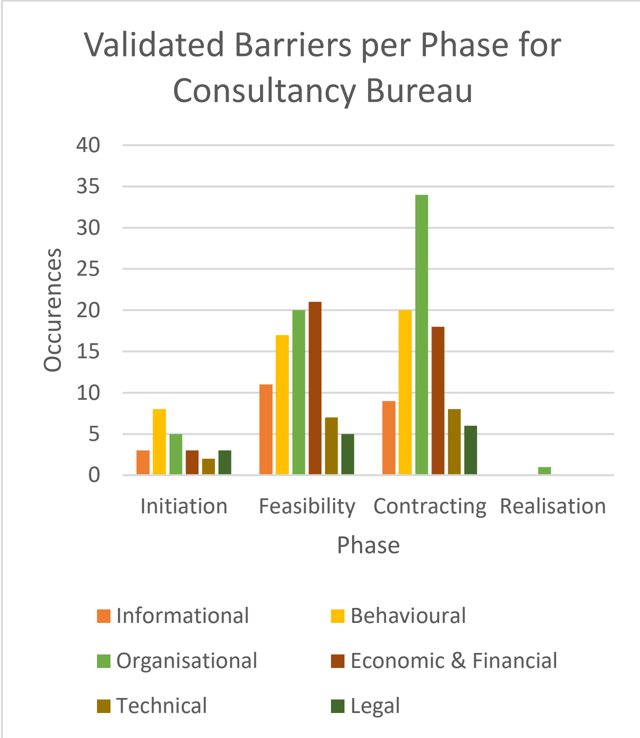


Figure 27: Validated barriers per phase for consultancy bureau (author)

Figures 28 and 29 show the barriers per phase for municipalities and consultancy bureaus. As shown, municipalities consider the feasibility phase to be the most challenging, with economic and financial barriers being the most widespread. The three most common barriers and their phase occurrence are:

1. Lack of information in both the feasibility and contracting phases
2. Lack of awareness in the contracting phase
3. Political-legislative uncertainty in the initiation phase

On the other hand, municipalities perceive the contracting phase as the most difficult, with organisational barriers being the most prevalent. The three primary barriers and when they occur are:

1. Political-legislative uncertainty in the contracting phase
2. Lack of information in the feasibility phase
3. Lack of well-define direction in the contracting phase

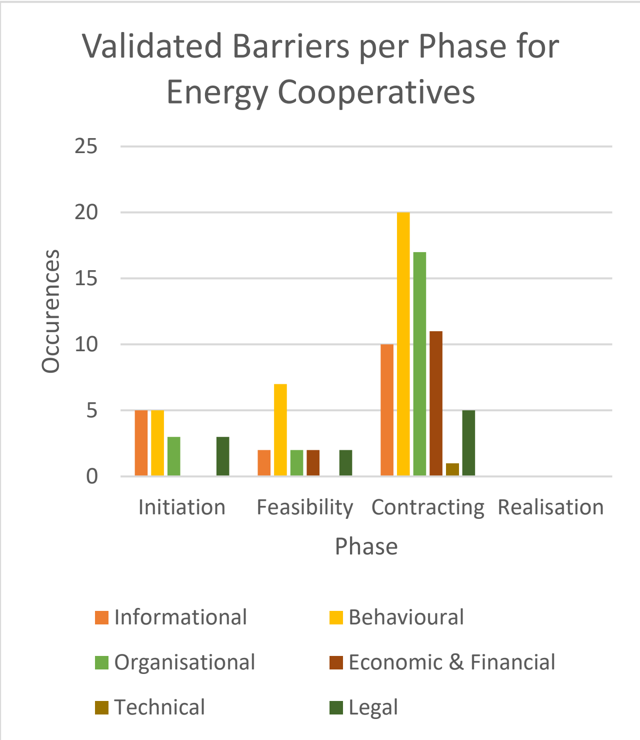


Figure 30: Validated barriers per phase for energy cooperatives (author)

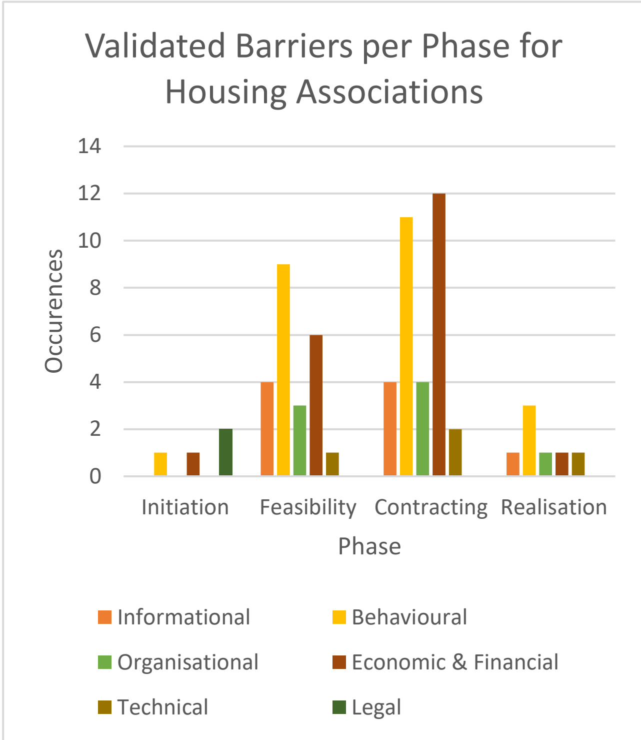


Figure 29: Validated barriers per phase for housing associations (author)

Figures 30 and 31 present the barriers per phase for energy cooperatives and housing associations. Energy cooperatives perceive the contracting phase as the most difficult, with behavioural barriers being the most predominant. The two most widespread barriers and their respective phases are:

1. Lack of participation and cooperation in the contracting phase
2. Lack of transparency and trust in the contracting phase

The third ranking barrier is tied between stakeholder conflicts, regulatory uncertainty, and unreliable funding all in the contracting phase. Lastly, housing associations consider the contracting phase to be the most challenging, with economic and financial barriers being the most widespread. The three most common barriers and their phase occurrence are:

1. Lack of transparency and trust in both the feasibility and contracting phases
2. Lack of participation and cooperation in the contracting phase
3. Political-legislative uncertainty in the initiation phase

These top three barriers per stakeholder group and when during the project they occur demonstrates the main concerns of each stakeholder group and when this is most problematic for them.

5.2.3 Generic collective decision-making views

In this thesis, collective decision-making has been defined as the participation of multiple stakeholders in the decision-making process such that the decisions of the project are made as a team or collective to ensure maximal benefit for all project stakeholders. Therefore, this thesis hypothesizes that an increase in collectivity with the involved stakeholders of heat grid projects will lead to a decrease in the severity of the encountered barriers and therefore allow for a smoother project process. In order to evaluate this, the views of all the stakeholders interviewed must be analysed in order to determine their perspectives, experience, and willingness to adopt collective decision-making and evaluate how a collective decision-making approach can be formulated to overcome project barriers.

Figure 32 gives an overview of the general sentiments that the stakeholder groups expressed towards collective decision-making throughout the interviews.

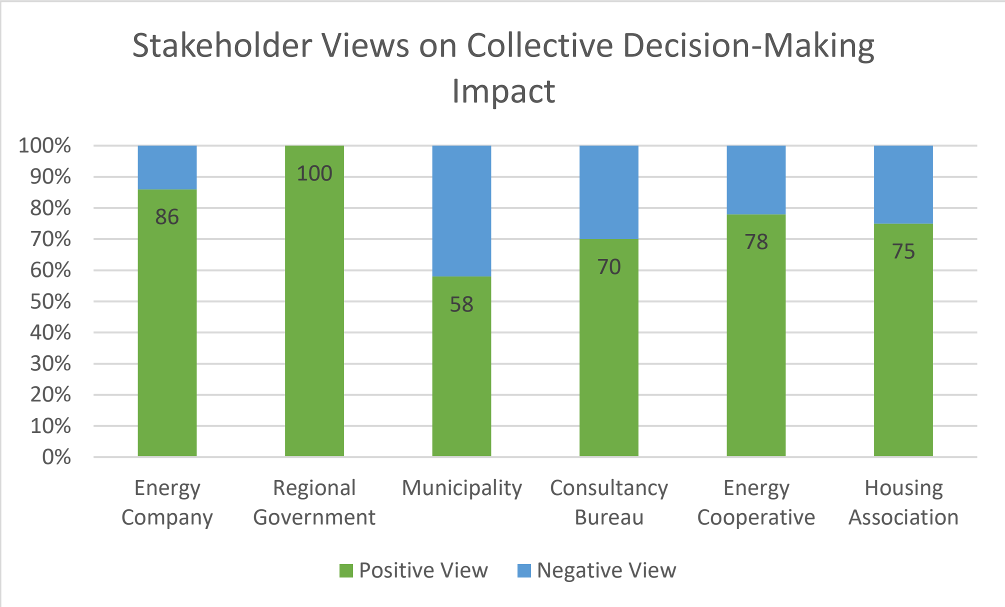


Figure 31: Stakeholder views on collective decision-making impact (author)

It is clear that all stakeholder groups demonstrate a positive view on collective decision-making. Additionally, Figure 33 shows the views of all stakeholder groups per project phase. It can be seen that the discussions on collective decision-making primarily related to activities that occur in the feasibility phase. Therefore, it is interesting to analyse the specific views expressed by the stakeholder groups.

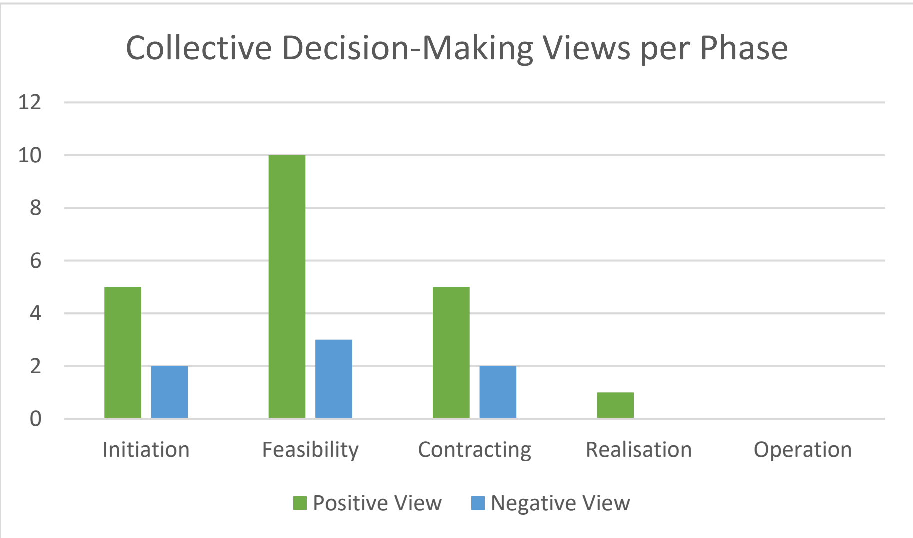


Figure 32: Collective decision-making views per phase (author)

5.2.3.1 Energy Company

From the perspective of energy companies, collective decision-making can positively impact the outcome of a project, with 86% of moments of discussion on collective decision-making being positive. It is expressed that collaboration between end-users, municipalities, and housing companies is essential for successful project implementation, although it is a time-consuming investment but it is understood to be necessary upfront in order to accelerate the heat transition as a whole (EC.1.BD, 2023; HC.1.SA, 2023). This cooperation is based primarily on a building positive relationships between parties to allow for effective collaboration and establish a mutual understanding of stakeholders' concerns, needs, and perspectives (EC.1.BD, 2023). More specifically, understanding the household owners' needs and perspectives is crucial for successful implementation, and creating partnerships with municipalities and housing associations allows to address barriers and strive for a smooth transition from current heating systems (HC.1.SA, 2023). This is typically done by engaging in extensive communication with stakeholders through information sessions, creating newsletters for diverse audiences, offering casual coffee conversations, providing "speed dating" opportunities to facilitate information exchange and interaction between parties, and asking for feedback (EC.1.BD, 2023). These approaches can create an essential shared understanding of the project needs and stakeholder perspectives among all parties.

Additionally, an emphasis on public opinion is seen as important as public sentiment against a project can hinder its progress, while support for the project can drive its success (EC.1.BD, 2023). Therefore, energy companies actively seek partnerships to foster support, engage with end-users, and understand what is necessary for the project (EC.1.BD, 2023; HC.1.SA, 2023). By emphasizing mutual understanding, acknowledging diverse viewpoints, and actively addressing concerns, the path to successful implementation becomes clearer. However, the issues of changing actors and long process time of incorporating collective decision-making are downsides of such collaboration (EC.1.BD, 2023). Additionally, the number of individuals included in the collective decision-making process must be chosen adequately given that a too large group will require too many resources to organise and consider all opinions, while a too small group can also result in delays in the project by causing conflicts later on in the project process. Similarly, choosing the right timing for involving end-users is imperative such that they are not involved too early nor too late. Ideally, conversations about neighbourhood preferences for energy systems including discussions about options, costs, and whether a collective heat system or individual electricity solutions is the best route, should occur early on in the project process before development (HC.1.SA, 2023).

5.2.3.2 Regional Government

During the regional government interview, all discussion moments regarding collective decision-making pointed towards the positive impact of such on heat grid projects. The interviewee expressed that the heart of collective decision-making lies in prioritizing collective decisions over individual interests. It is imperative to emphasize the impact on the broader community rather than focusing solely on personal background or representing specific groups. It involves many individuals coming together to move forward as a cohesive whole, transcending their own group affiliations. This collective decision-making is crucial, however requires more room and freedom for cooperating as a whole while being open to disregard the narrower interests of one's own background and prioritizing the interests of all individuals, municipalities, and inhabitants. Without such a collective approach, the project will become increasingly difficult and result in eventual delays or even termination. Additionally, collective decision-making on a multi-municipal level was presented. It was explained that decisions made within one neighbourhood significantly impacts the options available to other neighbourhoods. For instance, if a neighbourhood opts out of a heat grid, it will consequently affect the feasibility of developing a grid for other areas. Collaborating with multiple municipalities becomes crucial, especially when considering large-scale infrastructure like a heat transportation system. Moreover, collective decision-making ensures optimal conditions, cost-effectiveness, and successful transitions (G.2.PO, 2023).

5.2.3.3 Municipality

Interestingly, it was found that between the municipality interviews, the distribution of views regarding collective decision-making were 58% positive and 42% negative. Although it was agreed that good connections and relationships between all parties is necessary to increase the possibility of the project's positive outcome, it was also emphasized that the greater the number of stakeholders involved, the lengthier the project process will be and the greater the risks and possibility of negative influence on decisions.Therefore, while the inclusion of stakeholders is necessary, reducing their number can streamline project processes and increase the likelihood of a positive outcome. For instance, a neighbourhood with only one social housing company tends to facilitate smoother projects rather than those involving multiple housing corporations (G.1.PL, 2023).

However, the importance of involving end users early on in the decision-making process was made clear. It was explained that when people are informed from the beginning, they gain a deeper understanding, however ensuring that end users are taking in the information provided remains a challenge. Therefore, continuous communication during the initiation process of such projects is crucial, otherwise citizens will likely feel that decisions are already made without their input or interests in mind, leaving the government on step behind. Although this may be a time-consuming feat, it is more beneficial to reserve more time in the early stages to involve the end users rather than rushing ahead and consequently being delayed much more due to unacceptance of the project by the public and the end users (G.3.PO, 2023).

Additionally, the motivations of municipalities was made clear to be ensuring an afforable heat price for their citizens, while being influenced by legal opportunities. This affordability is also strongly tied to the speed of connection of the homes to the grid. Furthermore, the preference for full ownership of the heat system was expressed due to the ability of the municipality to gain more possibilities to maintain affordability, and directly engaging a company to implement the system allowing for an easier process (G.1.PL, 2023).

5.2.3.4 Consultancy Bureau

With a 78% positive view of collective decision-making in heat grid projects, consultancy bureaux express the importance of transparency betweem all parties, "if you want to make a decision together, then you need to be able to look aat each other's hands, look at what cards you are dealing with" (C.1.C, 2023). Although potentially resulting time-consuming, in order for effective collective decision-making, complete access to all information and transparency from all parties is crucial to ill foster mutual understanding and shed light on internal organizational dynamics (C.1.C, 2023; C.2.C, 2023). Interviewee C.1.C suggests that transparency can be better achieved without the involvement of commercial parties in heat grid projects (C.1.C, 2023), while interviewee C.2.C suggests implementing a bouwteam approach such that the municipality collaborates closely with a specific company to engineer the project in greater detail to develop the grid's appearance and cost to enhance collective collaboration (C.2.C, 2023). Separately, interviewee C.3.C suggests that establishing a shared vision for the next few years to align the various stakeholders is crucial given that many individuals do not view the heat transition as urgent. Once consensus is reached, collective choices will make more sense within a unified system (C.3.C, 2023). If parties were more aligned and participated in collective decision-making, everybody would benefit from a shorter decision-making process including financially due to their large costs (C.1.C, 2023). Additionally, involving heating companies in the process could be beneficial by allowing them to provide input on system design based on stakeholder priorities, to then streamline decision-making and facilitate subsequent office work and calculations. Furthermore, it would be beneficial if collective decisions involving end users, the heating company, and the main municipality could be streamlined. Finding a way to bypass or simplify certain steps while still obtaining concrete information would encourage thoughtful consideration (C.3.C, 2023).

Although it is said that collective decision-making is quite common for heat grid projects in the existing building stock (C.2.C, 2023), others believe that collective decision-making is not being practiced truly, although it should, due to a lack of trust between parties. For example, it has been found that a heating company can be entirely owned by the municipality, there can still be a lack of trust between the municipality and the company. The issue persists because each party still operates independently, prioritizing their own interests (C.1.C, 2023). This discussion can be framed as a tension between individualism and collectivism within the current societal landscape. District heating projects require substancial collective trust and decision-making, and the prevailing individualistic mindset of society may not align well with these requirements (C.3.C, 2023). Public involvement might not necessarily resolve this trust deficit, as everyone involved aims to secure favorable outcomes for themselves. In essence, the challenge lies in aligning individual goals with the collective well-being of the community (C.1.C, 2023). This highlights the following dilemma: should individual choice be prioritized, allowing everyone to select from a wide array of options, or opt for a more limited, collective decision for the greater good? The latter ensures that at least everyone in the neighborhood receives an acceptable solution. However, achieving an optimal solution for all remains elusive. While collective decision-making would be ideal, organizing it proves challenging. People tend to focus on their own homes, sometimes overlooking the broader system benefits. Additionally, when engaging stakeholders in the collective decision-making process, it has been found that although some individuals may express appreciation for their attempted involvement, they find it lacking in concreteness which hinders their ability to make informed decisions (C.3.C, 2023).

Although progress is attempting to be made, clarity regarding individual responsibilities would significantly enhance this. While initial enthusiasm fuels collaboration, eventually, the need for discussions on challenging topics arises, where typically uncertainty prevails. For this reason, it is necessary for designated individuals to facilitate these discussions, ensuring the important subjects are addressed and resolved. Such proactive management would greatly benefit the project. However, caution must be taken when assembling a large group of individuals for the collective decsion-making process due to the necessity of ensuring uniform knowledge levels, availability of time, and effective collaboration among participants. Given the time-crunch for achieving the 2050 heat transition goals, efforts on this topic must be expedited (C.2.C, 2023).

5.2.3.5 Energy Cooperative

From the perspective of energy cooperatives, collective decision-making can positively impact the outcome of a project, with 78% of comments on collective decision-making being positive. A strong sentiment was demonstrated regarding the interconnection of collective decision-making and collective ownership in order to achieve a more democratic energy system. The heat transition is an opportunity for democratizing the entire energy infrastructure by reimagining roles and moving away from profit-drive models, while fostering local values and strengthening social bonds. Cooperatively owned heating systems, in particular, offer a chance to build community cohesion and a sense of ownership. This transformation isn't merely technological; it's an invitation to drive social change through promoting self-organization and prioritizing local value over international gains. By redefining ownership structures and distributing decision-making power, true collective decision-making emerges, making shared responsibilities, shared power, and a collective say possible (ECO.1.KD, 2023). In the case of the KettlehuisWG energy cooperative, whether through hiring or specific roles, a sense of ownership is maintained. Although bonds have beeen forged and perhaps some independence sacrificed, the project remains distinctly of the community and all stakeholders recognize that success centres on the collective efforts of residents (NP.1.C, 2023). Therefore, to achieve genuine collective decision-making, a different governance model is essential, such as having a cooperative formed by all residents in a neighbourhood, where the community and municipality jointly own and manage the system. This demonstrates the important interconnection between shared ownership and influence with collective decision-making.

Although collective decision-making has immense potential to garner support for heat grids and foster willingness among people, it is imperative to be clear with whom the legal responsibility for tasks lies. For instance, a municipality tasked with achieving CO2 targets may involve stakeholders in decision-making, but they ultimately hold the legal power. Therefore, clarity is crucial: defining what's open for collective decision and what is not, otherwise participants may believe they influence outcomes, only to find decisions overridden by those with ultimate authority. In essence, decision-making power determines the course of action, and equitable division of this power is what ensures a fair and effective process. Currently, municipalities often organize events to seek input from residents regarding their preferences for heat grids. However, it is necessary to recognize that this process is not true decision-making, but rather it's advisory. While stakeholders provide advice and input, the ultimate decision lies with the municipality or the contracted company. While other organizations participate in the process, they lack decision-making authority. The municipality shapes the tender procedure and sets criteria for commercial parties, thus holding significant power (ECO.1.KD, 2023).

Furthermore, the core of collective decision-making lies in the trust between stakeholders, trust in the project, and the certainty that everyone is committed to cooperative efforts. This trust is fuelled by a shared drive—a collective purpose. It's not about personal gain or using knowledge elsewhere; it's about mutual trust, knowing that each contribution serves the project. To achieve this, it was found that organizing initial meetings with diverse perspectives prove immensely helpful. As subsequent meetings unfold, some participants express their views and depart, leaving a dedicated core group to propel the project forward. However, this may present the issue of questionable diversity and lack of representation of particular groups. Nevertheless, having a larger, driven team is advantageous given that when a few individuals juggle multiple tasks, efficiency declines. Starting with a robust group, distributing tasks, and creating efficient working groups yield better productivity. Additionally, having a reliable anchor is crucial. For this reason, creating working lines has shown to provide stability (NP.1.C, 2023). Nonetheless, the transition will require time for people to adapt to new procedures. While initial investment in participatory processes may seem time-consuming, it ultimately accelerates the overall process. Without such involvement, projects face legal challenges and resistance. By investing more time upfront, a smoother execution and faster realization is likely, avoiding obstacles down the line. It's a case of slowing down initially to speed up later (ECO.1.KD, 2023).

5.2.3.6 Housing Association

The distribution of views within housing associations were 75% positive and 25% negative, demonstrating their support of collective decision-making in heat grid projects. Transparency and working together is needed from the start when adopting such a process due to the importance in knowing the interests and relevant issues of each party, including tenants, the district, and the housing association, very well in order to effectively progress (HA.1.PM, 2023; M.1.PM, 2023). Typically, a trio is formed in the early stages of heat grid projects between housing association, municipality, and energy company such that there is constant collaboration between parties to identify issues and resolve them, however a practical approach is taken such that in instances only two parties participate if the third is not essential for resolving a specific issue. Additionally, it was stated that collective decision-making may be the only way to work in such complex projects given that each party must contribute something in order for all three to benefit more. Furthermore, local residents hold significant importance due to their direct experience of decisions' consequences. Therefore, their input must be considered in the decision-making process, although the optimal timing of their involvement remains debatable (HA.1.PM, 2023). Nonetheless, the inclusivity of all interested participants is crucial in neighbourhood decision-making in order to provide the individuals with the opportunity to engage voluntarily with the project. Initiating invitations from the start is essential, even if some individuals do not attend**.** Exclusion is unnecessary, and when information reaches everyone effectively, they can decide whether to participate. This approach minimizes the risk of later complaints about lack of involvement (M.1.PM, 2023). However, the challenge arises that due to the number of residents, how to ensure that their voices are effectively heard is uncertain. Therefore, it is common for housing associations to interact and engage consistently with a select group of individuals that represent the totality of tenants. However, the question of how truly representative the group arises. Hence, achieving the right balance and granting them a meaningful role in the decision-making process remains complex (HA.1.PM, 2023; M.1.PM, 2023).

5.3 Case study – Groenoord, Schiedam

The Municipality of Schiedam and the housing corporation Woonplus decided on December 2020 that a heat grid would be developed for the Groenoord neighbourhood. This heat grid would connect Groenoord to Eneco's already installed heat transportation pipeline, the Leiding over Noord, that runs from Rozenburg to Rotterdam, and provides the heat network with residual heat from biomass and waste incineration from the waste management company AVR. Additionally, the Groenoord heat station incorporates a heat transfer station and auxiliary heat station in one building (Eneco, n.d.-b). The construction of the heat network and heat station will be carried out by Eneco, commissioned by the Municipality, between 2022 and 2024. The first pile was driven in November 2022, and currently works are underway for the construction of the heat station, as well as the heat pipe laying within Groenoord and from the station to the district. Figure 34 shows the Groenoord heat grid and highlights that phases in which the pipes are to be laid (Eneco, n.d.-c).

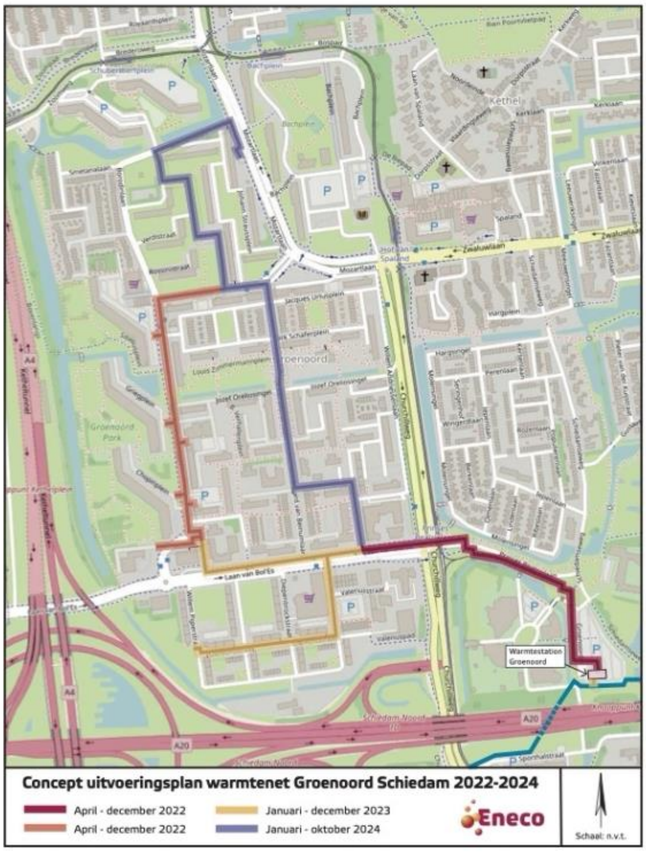


Figure 33: Groenoord heat grid
Source: Eneco. (n.d.-c). *Werkzaamheden Groenoord.* Retrieved 4 March 2024, from https://www.eneco.nl/duurzame-energie/warmte-koeling/projecten/werkzaamheden-groenoord/

The municipality of Schiedam in collaboration with Woonplus and the province of Zuid-Holland, deemed a heat network in Groenoord to be optimal for making the neighbourhood natural gas-free, and allow the residents to be able to save up to 68% of carbon emissions as opposed to a natural gas run home. This decision aims to simultaneously improve the neighbourhood's quality of life and greenery while presenting the residents with and affordable and feasible proposal that they will be able to accept (Eneco, n.d.-b). Approximately €120 million will be allocated to Groenoord to development the new energy infrastructure and provide home enhancements. This investment also presents possibilities for improving various social opportunities, including those related to education and employment (Woonplus Schiedam, 2020).

5.3.1 Mixed-Use in Groenoord

Groenoord is made up of buildings of varied functions and ownership, including:

- 4 schools (Google Maps, n.d.)
- various leisure facilities such as a sauna, sports complex, fitness centre, and bowling alley, 2 shopping centres (Schiedam Partners, n.d.)
- some medical practices (Schiedam Partners, n.d.)
- 2500 social housing homes owned by the housing association Woonplus (HA.1.PM, 2023)
- 2500 privately owned homes that are part of the homeowners association (VvE) (HA.1.PM, 2023)

This demonstrates the Groenoord inhibits at least 4 different building functions and owners, therefore being considered a mixed-use neighbourhood.

The buildings in the neighbourhood were primarily constructed after the Second World War around the 1960s and 70s, with the majority of the homes in the area being part of high-rise buildings typically of 6 to 7 floors, while just 7% of homes are single-family detached homes (G.2.PO, 2023; HA.1.PM, 2023). The fact that 93% of homes were part of high-rises served beneficial given that numerous of these flats already had collective gas systems in place, making the transition to the heat grid more straightforward to initiate (HA.1.PM, 2023). The residents of Groenoord come from diverse backgrounds and cultural origins, including people with limited income, proving the great importance of ensuring affordability in the project and its ambitions of improving living conditions while addressing environmental targets (G.2.PO, 2023). The special aspect of this project lies in its holistic approach to not only connect the housing association's properties but striving for a neighbourhood-wide solution. Whether the houses are owned by the housing company, other private owners, or commercial investors, the goal is to provide a comprehensive solution for all to create a collective effort toward a sustainable future (G.2.PO, 2023; HA.1.PM, 2023).

5.3.2 Barriers

From the interviews conducted, it was found that many of the barriers discussed in Section 5.2.2 arose in the Groenoord project. Appendix D shows the full table of barriers and their degree of occurrence within the interviews. From this table, the top three barrier categories for this project include behavioural, informational, and economic and financial. Additionally, the top three barriers were found to be:

1. Lack of transparency and trust in the feasibility and contracting phases
2. Lack of participation and cooperation in the contracting phase
3. Political-legislative uncertainty in the initiation and feasibility phase

(G.2.PO, 2023; HA.1.PM, 2023; M.1.PM, 2023). It is interesting to note that these three barriers follow the theoretical framework of the barriers of heat grid projects as show in Section 5.2.2 and are the overall top three barriers discovered in the general analysis of barriers including all interviewed stakeholders.

A notable explanation of a remarkable situation that occurred during the Groenoord project was given by interviewee M.1.PM which demonstrates the extent of the lack of transparency and trust, as well as the lack of participation and cooperation that developed in this project. In the beginning of the project, the democratic vote regarding the implementation of a heat grid in Groenoord was tight with 17 votes for and 16 votes against the project. One week after the ruling for, discussions between Woonplus and the tenants of the first building commenced such that Woonplus explained their goal of making the building natural gas-free ready through renovations. Some people agreed with the associations, however many rejected the proposals due to their fear that the cost for the works was too uncertain. This strong sentiment resulted in negative news about the project being spread through the media. Therefore, Woonplus revisited their proposed renovation plans to enhance then to better serve the tenants. However, the absence of trust between tenants and the housing association were too great and needed improvement first before being able to continue. As the project expanded and continued to other buildings, their successful renovations gradually built trust within the community. Tenants saw tangible improvements in their homes and recognized Woonplus' commitment to deliver improved homes at an affordable price. Additionally, concerns were addressed through FAQs and direct communication to help dispel misinformation. Furthermore, customer satisfaction was monitored during and after the renovations which contributed to positive outcomes. Therefore, although challenging and threatening to the project, this situation showed that the informal chats between people and having tangible proof of proposed plans increased trust and allowed for the project to move forward. This occurred during the feasibility phase of the project, specifically during the end-user willingness research moment (M.1.PM, 2023).

Additionally, the lack of participation and cooperation has proven to be a reoccurring barrier in the Groenoord project. Although Woonplus has invited residents to engage in the project by organizing walk-in sessions, creating and sharing newsletters, and hosting other events, attendance remains sparse with only a handful of people showing up to the events. However, despite the lack of participation, it can be argued that this is not a major issue in the initial phases of creating the heat grid, the initiation and feasibility phases of the project. During these phases, the project remains distant for the residents, however as 2028 or 2030 approaches – streets will open, pipes will be laid, and residents will have a concrete connection date – residents will become more interested in the project. When that moment comes, the housing association will need to make personal connections with the residents and explain precisely what the works mean for their households (M.1.PM, 2023).

Furthermore, the lack of participation and cooperation spans further to the housing association residents to the VvE (Verenigingen van Eigenaren, or Owners' Associations) buildings, which arguably presents a larger barrier. The challenge lies in the uncertainty regarding their decisions to connect to the heat grid. Each VvE must independently decide on their connection status, and currently a mixed response has been observed with some VvEs willing to join the proposed heating system, while others remain undecided. It is hoped that more VvEs will express interest over time, further benefitting the system's business case and functionality, however this remains uncertain (HA.1.PM, 2023).

5.3.3 Decision-Making Process

As previously mentioned, the Groenoord heat grid project was initiated by the Municipality of Schiedam and Woonplus combined due to the Municipality's desires of making steps in the energy transition, and Woonplus' goals of making their real estate ready for the future (HA.1.PM, 2023). Hence, they worked together on the idea forming stage. Then, an external consultancy party was approached to propose an initial business case including an initial idea of how the heat grid could be design and the approximate costs. However, it was known that Eneco already had pipes laid near

Schiedam which could be a financially attractive and logical approach to the project. Therefore, the Municipality decided to appoint Eneco as the heating company that will develop the grid and create the connection between the grid and the neighbourhood (HA.1.PM, 2023). Hence, the three parties joined in a letter of intent. Initially, the housing corporation intended for a different location to be connected to the heat grid, however after discussions between the Municipality, Woonplus, Eneco, and a representative from the Province of Zuid-Holland parties about the project, Groenoord was chosen as the neighbourhood to be connected due to its large amount of high-rise buildings with collective heat systems (G.2.PO, 2023). The three institutions then made a deal and joined in a three party contract to collaborate on this project (HA.1.PM, 2023). Following this, end user willingness research was conducted by the Municipality, Woonplus, and the involvement of the residents in order to create a revised business case (G.2.PO, 2023; M.1.PM, 2023). This moment was pinpointed as a troublesome moment in the decision-making process in which trust and transparency play a large role resulting in the end-users' unwillingness to connect (M.1.PM, 2023). Eneco continued by conducting revised technical research and determining specifics regarding the required infrastructure, while Woonplus provided input into the decision most specific to the homes. This resulted in the creation of the BAK or connection cost, where Woonplus and Eneco made an agreement on the price for the tenants such that the cost must be the same as the residents were paying before (HA.1.PM, 2023). From this, an investment plan was created, and the business case was concreted. This was followed by an end user connection enlistment lead by Woonplus (HA.1.PM, 2023), leading to signed connection contracts between Eneco and the residents, and finally the financial close. It is important to note that the financial close made by the board of directors of Eneco, Woonplus, and the Municipality of Schiedam.

Based on the information gained from the interviews and using the framework created in section 5.2.2, a decision-making process has been generated specific for the Groenoord project shown in Figure 35. This diagram also shows in which moments the different project stakeholders were involved as shown by the circles. This highlights that the key stakeholders of the Groenoord project include the housing association (Woonplus), the municipality (Gemeente Schiedam), an external consultancy bureau, the energy company (Eneco), the regional government (Province Zuid-Holland), and the residents of the neighbourhood. Additionally, it is clear from the decision-making process diagram that the main decision-makers of the project include the municipality, the housing association, and the energy company. It can be seen that the energy company primarily makes decisions on the technical and design aspects of the system, while the municipality and housing association are greatly involved in the connection with and decisions affecting the residents. Furthermore, due to the nature of the initiation of this project, it is evident that the decision-making process differs from the generic decision-making process presented in Section 5.2.1.

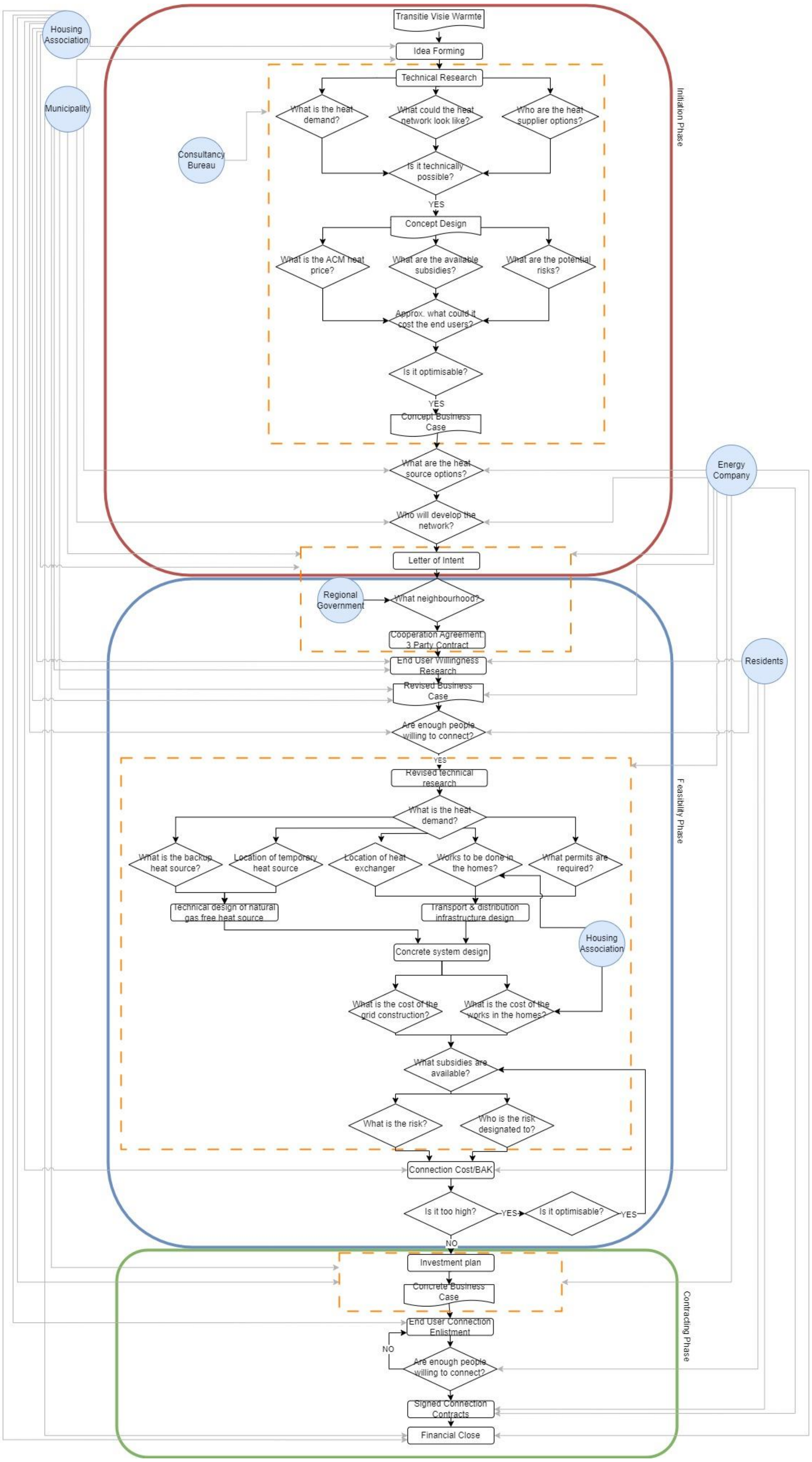


Figure 34: Decision-making process in Groenoord (author)

Additionally, it is important to evaluate the organisation of the parties. In this project, there were three main hierarchical groups within the municipality, housing association, and energy company. Figure 36 shows the organisation of the groups.

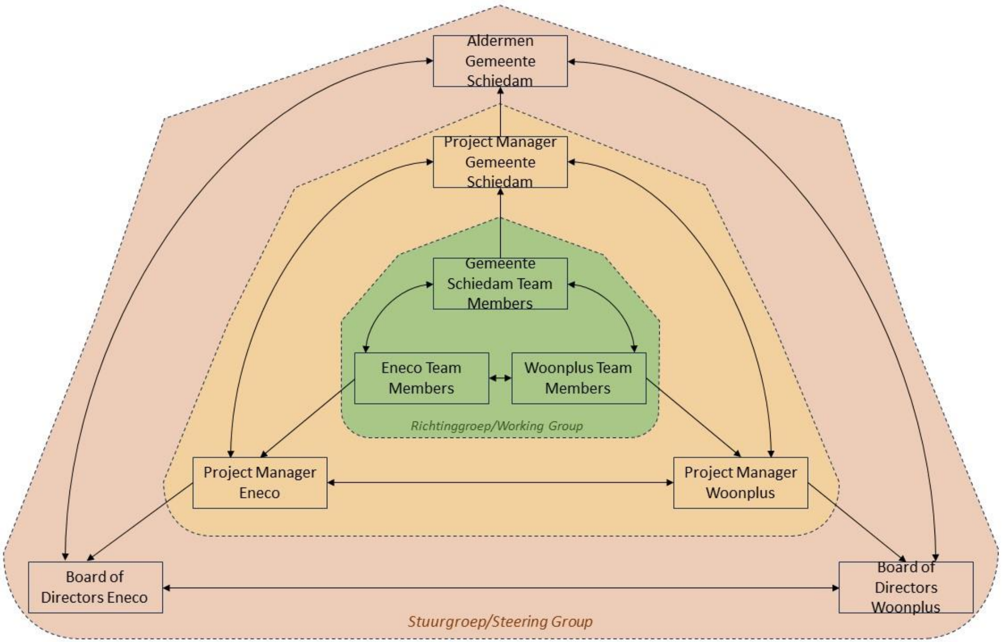


Figure 35: Governance structure in Groenoord case

As can be seen, the richtinggroep or working group includes the team members of the three organisations which all work together on producing the required work for the project (HA.1.PM, 2023). These team members report back to the project manager of their respective organisation who represents their organisation when making deals and work together with the other organisations' representative project managers. They are also involved in jointly making the intermediate decisions within the project (M.1.PM, 2023). The project managers are also responsible for reolving conflicts that may arise, and when this is not possible or a large and final decision must be made, they communicate with the stuurgroep or leading group made up of the municipality aldermen, and the board of directors of the housing corporation and energy company (HA.1.PM, 2023; M.1.PM, 2023). This group is in charge of making the final decision of developing a heat grid in Groenoord together. Additionally, it should be noted that the municipality adopted the role of chairman for this project (M.1.PM, 2023).

5.3.4 Conclusion

From this case study, several conclusions can be generated and expressed in terms of the research questions of this thesis.

***SQ1**: Who are the stakeholders of low-carbon heating grid projects in mixed-use neighbourhoods and what are their attributes?*

Table 10 shows the stakeholders involved in Case study – Groenoord, including their case-specific stakeholders, and their attributes as expressed by the interviews conducted for this case. Additionally, the stakeholders have been categorized as primary, secondary, internal, and external stakeholders as per the framework presented in Section 2.3. To reiterate that section, primary stakeholders directly contribute to the economic and operational aspects of the project, while secondary stakeholders impact the project but are only involved when needed during the development process (Hamdan et al., 2021a). Additionally, internal stakeholders are directly associated or involved with the project, for example through employment, investment, or ownership, while external stakeholders are affected by the actions taken and their outcomes but who can also influence its success (Maqbool et al., 2022). Therefore, it should be noted that although end-users are greatly influential in heat grid projects due to their acceptance to joining the grid being the determining factor for ultimate project execution, they are categorized as external stakeholders. This is due to their experienced consequences of the project being the leading influence for their eventual connection decision.

Table 10: Groenoord stakeholders and their attributes (author)

Stakeholder	Case-Specific Stakeholder	Stakeholder Type	Attributes
Municipality	Gemeente Schiedam	Internal, Primary	Gemeente Schiedam was one of the project initiators, and adopted the role of project chairman (M.1.PM, 2023). Their approval of the project is crucial both financially and politically. Not only do they invest in the project itself, such as by covering engineering fees and communication means to the neighbourhood, they also bear the costs of post-project pavement restructuring and other similar required actions (G.2.PO, 2023). Additionally, they are tasked, in collaboration with the housing association, with the role of informing the neighbourhood residents about the heat grid and why it has been decided to implement one in Groenoord (HA.1.PM, 2023). Furthermore, within the municipal government itself, various political parties may seek to benefit from the situation and the project, therefore negotiations arise when the mayor requires approval from the entire group of political parties to ensure majority support (G.2.PO, 2023). In the Groenoord project, the municipality agreed to participating in the project due to their desire to make steps towards the energy transition (HA.1.PM, 2023). Additionally, the municipality was the party to decide on Eneco's appointment as energy company (HA.1.PM, 2023), and had to ensure Eneco that there are indeed enough households willing to connect to the network (M.1.PM, 2023).
Housing Association	Woonplus	Internal, Primary	Woonplus was one of the initiators of the project. Their motive for initiation was the desire to render their real estate ready for the future, and their primary responsibility is to manage the project's consequences for their tenants and themselves. Additionally, Woonplus decided to be involved in the heat grid project given that it was the cheapest and most effective way to get the tenants off their natural gas connection. They were then confronted with the question: can we come to an agreement with our tenants? Therefore, their roles include providing information to the residents about the project's consequences on their home and building and making the homes ready to connect to the grid (in terms of insulation and renovations). Additionally, it was necessary for them to make a deal with Eneco regarding the costs for the residents and the definite number of houses that would connect to the grid upfront (HA.1.PM, 2023).

Energy Company	Eneco	Internal, Primary	Eneco is the appointed energy company to develop and invest in the Groenoord heating grid. They are the decision-maker on how the grid will be in the area, including the infrastructure and costs of development (HA.1.PM, 2023). Additionally, given that they derive their revenue from supplying households with heat, and their cost of investing in laying the pipes in the street is significant, they experience a great risk regarding the uncertainty in the number of connections to the grid. This must be monitored given that if the risks are perceived as too high, they may choose not to invest at all (HA.1.PM, 2023; M.1.PM, 2023).
Consultancy Bureau	External Party	Internal, Secondary	The external consultancy bureau was hired only during the initiation phase of the project in order to provide the initiators with an initial sketch of what the proposed idea of a heat grid in Schiedam could look like, including its approximate cost and a concept business case (HA.1.PM, 2023).
Regional Government	Province Zuid-Holland	Internal, Secondary	The Province Zuid-Holland was involved in the feasibility phase of the project to provide technical knowledge and arguments in favour of a heat grid implementation in Schiedam, to aid in determining the most adequate location for this. Additionally, they provided support to get as many things in place as possible in order for the project to proceed through the feasibility phase and the following phases (G.2.PO, 2023).
End-User	Residents of Groenoord	External, Secondary	The residents of Groenoord have an impactful influence on the project given that they have to say whether or not they will connect to the grid and adapt their home to be suitable for the connection (G.2.PO, 2023; M.1.PM, 2023). These residents understand that there is a heat transition in the Netherlands and that eventually they will not be using their natural gas system. Additionally, they express satisfaction with the project's integration of home improvements and insulation efforts to enhance the overall comfort within their homes. However, their lack of freedom to select their preferred energy company to develop the project is resisted by the tenants who desire more autonomy in their choices, in this case in the decision for Eneco to be the involved energy company (G.2.PO, 2023).

***SQ2**: What is the current decision-making process in place?*

During the initiation phase, the Municipality of Schiedam and Woonplus initiated the Groenoord heat grid project such that they worked together on the idea forming stage and then contracted an external consultancy party to propose an initial business case. Given that Eneco had pre-existing pipes in the area, the Municipality appointed Eneco as the heating company that will develop the grid, and the three parties joined in a letter of intent. The feasibility phase began with determining the neighbourhood for the project along with the Province of Zuid-Holland, followed by the three institutions joining in a three-party contract to collaborate on this project. Following this, end user willingness research was conducted by the Municipality, Woonplus, and the involvement of the residents, which was pinpointed as a troublesome moment in the decision-making process, to create a revised business case. Eneco continued by conducting revised technical research, while Woonplus provided input into the decision most specific to the homes, which resulted in the creation of the connection cost. From this, the contracting phase began with an investment plan leading to the concrete business case. This was followed by an end user connection enlistment lead by Woonplus, leading to signed connection contracts between Eneco and the residents, and finally the financial close (Figure 35).

It is evident that the decision-making process demonstrated by this case differs from that generated by the generic analysis in Section 5.2.1. This is primarily due to the way in which this project was initiated such that the feasibility and initiation phase moments shown in Section 5.2.1 were combined into the initiation phase of this project. Additionally, the initiation process also showed a lack of tender procedure and hence an earlier letter of intent and cooperation agreement. Nonetheless, the contracting phase followed a similar process as the generic process, and the key decision makers were deemed to be the municipality, housing association, and energy company which matches literature.

SQ3*: What are the barriers encountered in low-carbon heating grid projects in mixed-use neighbourhoods and when do they occur?*

Case study – Groenoord primarily experiences behavioural, informational, and economic and financial barriers, with the top three barriers being a lack of transparency and trust in the feasibility and contracting phases, lack of participation and cooperation in the contracting phase, and political-legislative uncertainty in the initiation and feasibility phase. Therefore, this validates the barriers discussed in the generic analysis Section 5.2.2.
Additionally, it was explained that the end user willingness research and end user connection enlistment were the moments in the decision-making process that were the more difficult due to the large number of barriers experienced and their significance on the project.

SQ4*: What is the role of the collective in low-carbon heating grid projects in mixed-use neighbourhoods?*

In Case study – Groenoord, the core collective consists of the municipality, housing association, and energy company which collaborated to make the decisions necessary for the project, and occasionally involve the other project stakeholders for their input as needed. The role of this collective is to work on all of the aspects necessary for realisation to happen. Within the three parties, there is three levels of hierarchy: the working group consisting of team members from their respective organisation, the project management group consisting of one representative project manager per organisation, and the leading group consisting of aldermen and boards of directors from their respective organisation. The working group is responsible for producing the necessary work and tasks for the decisions, the project management group facilitates the works and works on negotiations with each other to reach necessary deals and decisions, while the leading group is the highest hierarchical level responsible for making the final financial close decision and stepping in when necessary. Therefore, the final decision for the project is always made by the leading group together.

During the initiation and feasibility phases, much of the decision-making process occurs behind closed doors, such that the decisions are made solely between the three parties or only two out of three organisations if one is deemed unnecessary to make a specific decision. Once a decision is reached, the residents are informed that their neighbourhood will undergo a transition from natural gas to a heat grid system, which will include home renovations. It is at this point that tenants express reluctance due to their lack of involvement earlier on (M.1.PM, 2023). Therefore, the municipality and housing association is responsible for connecting with the residents and ensuring that they are onboard with the proposed project. Additionally, during the decision-making process, the stakeholders typically do not always convene in the same room simultaneously, but instead different decision-making and discussion groups are created to tackle the different project aspects such that as one group concludes their discussions, the next group takes over, and the cycle continues. This demonstrates that the decision-making process is ongoing with multiple subgroups working together to reach the next steps, phases, and investment decisions (G.2.PO, 2023).

***MQ**: How can collective decision-making be orchestrated to overcome the barriers of low-carbon heating grid projects in mixed-use neighbourhoods?*

In order to improve the process of collective decision-making, effective and transparent communication and clarity of interests from the start of the project are key (G.2.PO, 2023; HA.1.PM, 2023). This requires stakeholder groups, regardless of the hierarchical level, to meet frequently to foster open dialogue and strong connections by ensuring that all team members have accurate information to be able to navigate different areas successfully. This approach is vital for collective progress, and can be facilitated by an independent process manager, as was the case in Groenoord. Additionally, clarity in the contracts between parties by outlining specific responsibilities assigned to the relevant parties is necessary for smooth collaboration and effective task execution (HA.1.PM, 2023).

Furthermore, early participation is crucial to address the specific concerns of tenants, the housing association, and the municipality due to the uncertainty faced by the energy company regarding the number of tenants willing to connect to the heat grid. For example, households hold opinions regarding whether the heat grid is the optimal choice for their property and if it aligns with their budget, which consequently poses a significant risk for the energy company, making it necessary to consider these opinions. However, it is common for not every party to be interested in participating throughout the entire process. For example, residents typically engage more actively when decisions directly impact them. Nevertheless, involving as many neighbourhood participants as possible is essential, and initiating the process with invitations promotes transparency. While not everyone may engage, it’s crucial to facilitate opportunities for community engagement from the beginning of the project. Exclusion should be avoided, and proper communication empowers participants to decide whether they want to engage. This approach minimizes the risk of complaints arising later on in the process from a lack of involvement. Therefore, the municipality and major asset owners, such as the housing association, must be involved from the start due to the substantial financial stakes and risks they bear (M.1.PM, 2023).

For collective decision-making to prove truly successful, collective decisions must transcend individual backgrounds or personal interests in order for many people to move forward together for the greater good, rather than merely representing their own group’s interests and concerns (G.2.PO, 2023).

Part 6

Discussion

CONTENT

6.1 Validated decision-making process

6.2 Barriers in the decision-making process

6.3 Solutions to barriers in low-carbon heating grid projects

6.4 Collective decision-making approach

6.0 DISCUSSION

Following the analysis of the relevant research topics, expert interviews were conducted with industry stakeholders, each pertaining to a different category, in order to validate the conclusions drawn from the analysis. The interviewees pertained to the following stakeholder categories: energy company, regional government, consultancy bureau. One expert interview provided validation for the proposed decision-making process developed in the analysis section, and three expert interviews provided validation for proposed barrier solutions.

6.1 Validated Decision-Making Process

Following the analysis of the relevant research topics, three expert interviews were conducted with industry stakeholders, each pertaining to a different category, in order to validate the conclusions drawn from the analysis. One expert interview served to provide validation input about the decision-making process created in Section 5.2.1 from the culmination of literature, online industry sources, and collected qualitative data. The generated process diagram was shown to the interviewee to obtain their opinions on its representation of practice. Although in agreeance with most moments that appeared in the process, the interviewee pointed out that the order in which many moments occur was not accurate. Figure 37 shows the adapted decision-making process. The created diagram is a combination of the pre-existing process diagram with adaptations based on the expert interview.

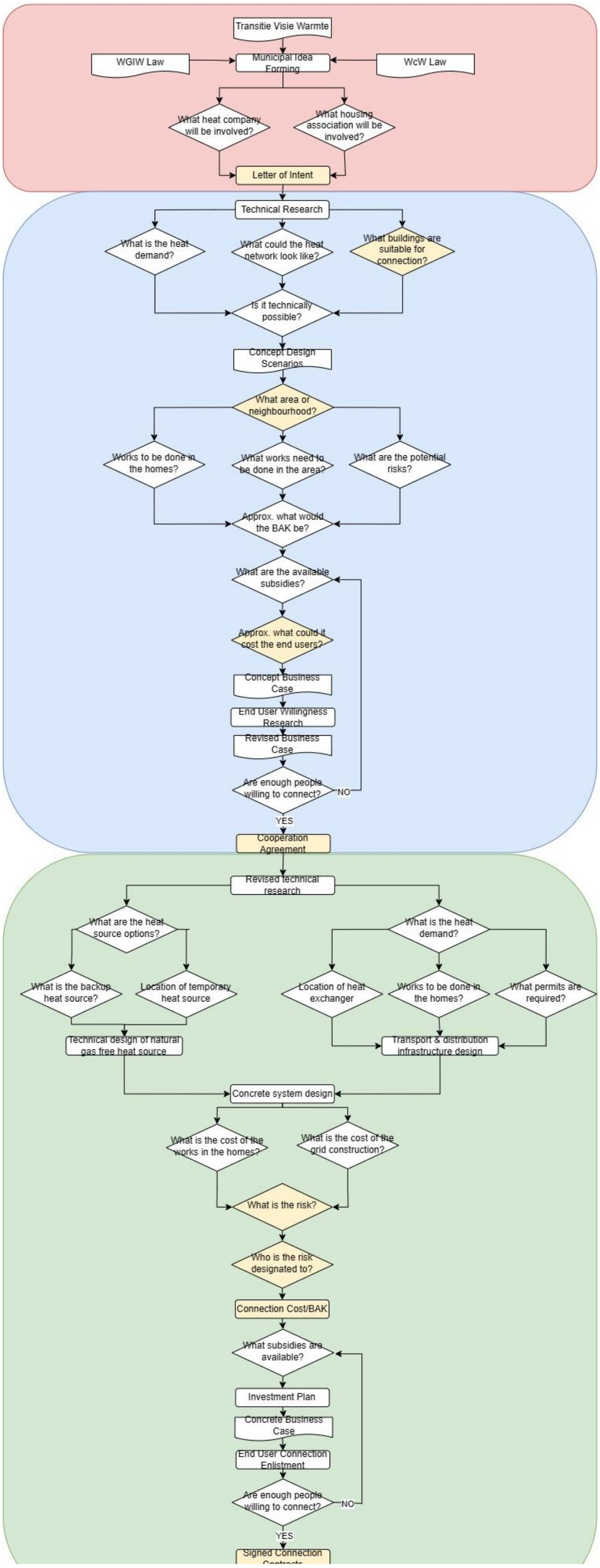


Figure 36: Validated decision-making process (author)

Initiation

The initiation phase commences with the idea forming lead by the municipality, and impacted by the Transitie Visie Warmte, WcW law, and the WGIW law. The latter is missing from the original diagram but it important given that the WcW and WGIW laws work in tandem. From the idea forming stage, the municipality decides what heat company and housing association will be appointed for developing the project, followed immediately by the creation of the letter of intent by the three parties. The letter of intent provides an initial commitment by the parties to explore the feasibility of a heat grid for an area together, and the requirements of the project are stated, including sustainability and affordability goals (EI.1.HC, 2024). This differs from the original process, as a tender or public concession is made at the beginning of the contracting phase followed by the letter of intent occurs which all occurs after initial technical and social research is conducted. In this case, a formal tender is not made, but the appointment by the municipality appears to be similar to a public concession although less formal.

Feasibility

Similar to the original, the feasibility phase beings with technical research, however the heat supplier options are not considered at this stage, and instead emphasis is placed on research the suitability of buildings for their connection to the heat system. This has been deemed as one of the greatest challenges of this phase. This research is followed by the creation of scenarios upon which the decision on the area or neighbourhood for the grid implementation is based. The works required in the homes is then determined, as well as well as any infrastructure adaptation in the area and the potential project risks. The connection cost (BAK) value is approximated from these points (EI.1.HC, 2024), followed by research on available project subsidies, to determine the approximate cost for the end-users. This contrasts from the original in which the BAK is only calculated in the contracting phase after the design has been finalised. This is followed by a similar structure than the original such that a concept business case is made, followed by conduction of end-user willingness research, and the development of the revised business case. From the revised business case, it is evaluated whether enough people are willing to connect to the system: if yes, the process continues to the cooperation agreement between the three development parties and the feasibility phase ends (EI.1.HC, 2024); if no, the subsidies are revised. This differs from the original process such that the cooperation agreement occurs much earlier, and the question regarding end-user willingness is not of great concern at this stage. This may be due to the fact that there is the possibility of convincing residents later on one-by-one to join the grid by providing them with increased benefits (e.g. increased double glazing in their homes) (G.2.PO, 2023).

<u>Contracting</u>

During the cooperation agreement, the three parties agree to specify engineering and financing aspects further, so the technical research is revised in which the heat source is considered (EI.1.HC, 2024), unlike the original process in which the heat source is considered earlier in the initiation phase. This leads to the concrete system design creation followed by calculation on the home improvement and grid construction costs, and the evaluation and designation of the risks. These points provide input for the final BAK calculation. Then, the necessary subsidies are determined, and their obtainment process begun, which leads to the creation of the investment plan and the concrete business case. Once the concrete business case is completed, the end user connection enlistment begins. If there is a lack of willingness to connect, the subsidies are revised, “I don’t think we are going to recalculate a BAK because if you say it’s too expensive for us at the moment, it’s not always possible for us to be cheaper because it’s the sum of what we need to do with all the uncertainties during the time. So we are going to look into other ways of financing” (EI.1.HC, 2024). This differs from the original process in which the BAK is revised if faced with a lack of willingness to connect. Nonetheless, once the number of connections is met, the signed connection contracts are fulfilled, leading to the achievement of the financial close. Appendix E shows the original process next to the validated process to be able to compare.

While this new process diagram provides fruitful insight into the decision-making process carried out in practice, it should be noted that this is merely the perspective of one stakeholder group. The individual interviewed represents the perspective of a public heating company in the Netherlands. Therefore, this process is not representative of other stakeholder perspectives who may experience the decision-making process in a different way. Nonetheless, given that the looming WcW law requires the involvement of a public party to develop and deliver the heat grids, this decision-making process gives insight into what the process may look like for projects in the Netherlands once the law is established.

6.2 Barriers in the Decision-Making Process

As previously discussed in Section 5.2.2, there are various barriers that arise depending on the phase of the heat grid project. Now that the decision-making process has been presented delineating the main events, decisions, and productions of each phase, the main barriers per phase can be mapped onto the decision-making process in order to understand what moments present barriers and hardships. Figure 38 shows the decision-making process with the mapped barriers, and can be interpreted as the most problematic moments per phase. Although a different decision-making process was presented in Section 6.1 as a result of the validation process, the original decision-making process from Section 5.2.2 was considered for this discussion. This was chosen due to the fact that the proposed validated decision-making process was a result of only one expert interview, hence presenting the perspective of a specific stakeholder group which is not representative of the perspectives of all stakeholder groups involved in heat grid projects. Given that the original decision-making process was generate from a combination of literature and interviews with stakeholders of various categories, this process was chosen upon which to base the continuation of discussion topics.

In the initiation phase, the predominant barriers include the political-legislative uncertainty, lack of information, lack of participation & cooperation, and lack of well-defined direction. Based on the interviews, the decision-making moments in which the barriers are present have been deduced and shown in Table 11. The color of the font for the barriers serve as a key for the shades used in the diagram.

Table 11: Barriers in the initiation phase (author)

Phase	Barrier	Decision-Making Moment
Initiation	Political-legislative uncertainty	- WcW Law
	Lack of information	- WcW Law
	Lack of participation & cooperation	- Idea forming
	Lack of well-defined direction	- Idea forming - WcW Law

In the feasibility phase, the principal barriers include the lack of participation & cooperation, lack of information, and high initial investment & risks. Based on the interviews, the decision-making moments in which the barriers are present have been deduced and summarized in Table 12. It can be seen that the moments incurring the most barriers are the decisions regarding the potential project risks, the available subsidies, and the approximate cost for the end users, which all feed into the concept business case and consequently make it a barrier-encountering moment. Additionally, the end user willingness research is impacted by several barriers.

Table 12: Barriers in the feasibility phase (author)

Phase	Barrier	Decision-Making Moment
Feasibility	Lack of participation & cooperation	- Concept design - What are the available subsidies? - What are the potential risks? - End user willingness research
	Lack of information	- What is the heat demand? - What are the available subsidies? - What are the potential risks? - Approx. what could it cost the end users?

		- Concept business case - Are enough people willing to connect?
	High initial investment & risks	- What are the potential risks? - Approx. what could it cost the end users? - Concept business case - Revised business case - End user willingness research

Lastly, in the contracting phase the most reocurring barriers include the lack of participation & cooperation, lack of transparency & trust, lack of information, high initial investment & risks, lack of awareness, and willingness to connect. Table 13 summarizes when in this phase the key barriers are experienced. It can be seen that the end user connection enlistment experienced the most barriers, followed by the letter of intent, the investment plan, and the following decisions: Who will develop the network? Who will invest in the network? Who will exploit the network? What works need to be done in the homes?

Table 13: Barriers in the contracting phase (author)

Phase	Barrier	Decision-Making Moment
Contracting	Lack of participation & cooperation	- Letter of intent - What works need to be done in the homes? - What permits are required? - What subsidies are available? - Who is the risk designated to? - Investment plan - Cooperation agreement - Signed connection contracts
	Lack of transparency & trust	- Who will develop the network? - Who will invest in the network? - Who will exploit the network? - Letter of intent - Investment plan - Cooperation agreement - End user connection enlistment
	Lack of information	- Who will develop the network? - Who will invest in the network? - Who will exploit the network? - Letter of intent - What works need to be done in the homes? - What is the cost of the works in the homes? - End user connection enlistment
	High initial investment & risks	- What is the cost of the grid construction? - What subsidies are available? - What is the risk? - Who is the risk designated to? - Investment plan - Concrete business case - End user connection enlistment
	Lack of awareness	- Who will develop the network? - Who will invest in the network? - Who will exploit the network? - What is the heat demand? - Location of heat exchanger - What works need to be done in the homes?

		- End user connection enlistment
	Willingness to connect	- What is the cost of the works in the homes? - Connection cost/BAK - Concrete business case - End user connection enlistment - Signed connection contracts

These conclusions provide crucial information for the actors and decision-makers of these projects as it highlights the areas which can be most difficult in the process of developing a heat grid, hence providing an opportunity for the involved stakeholders to plan accordingly in order to be able to efficiently tackle such barriers.

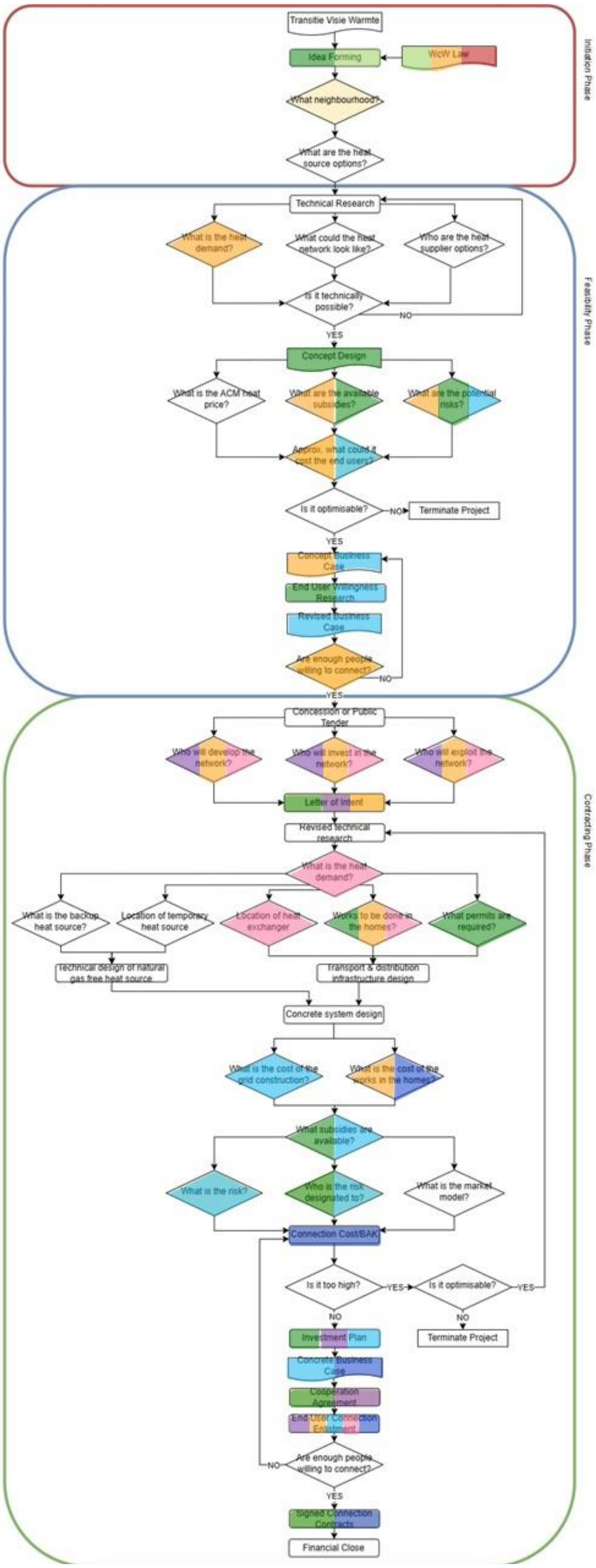


Figure 37: Decision-making process with mapped barriers (author)

6.3 Solutions to Barriers in Low-Carbon Heating Grid Projects

In order to determine the applicability of collective decision-making in low-carbon heat grid projects, it is crucial to evaluate potential solutions to the barriers encountered in such projects. Given the extensive list of barriers found in Section 5.2.2, solutions have been found for the most reoccurring barrier per category as well as the added barriers that were found during the interview process. Table 14 shows the barriers for which solutions were found.

Table 14: Key barriers (author)

	Barrier	Category
1	Lack of transparency & trust	Informational
2	Lack of experience with energy cooperatives	
3	Lack of participation & cooperation	Behavioural
4	Willingness to connect	
5	Interorganisational resistance	
6	Individualism for collectivity	
7	Lack of well-defined direction	Organisational
8	Chicken & Egg scenario	
9	Long project duration & changing actors	
10	Iterative process & time	
11	High initial investment & risks	Economic & Financial
12	High process costs	
13	Affordability for all	
14	Unreliable funding	
15	Future demand uncertainty	Technical
16	Organisation of infrastructure	
17	Political-legislative uncertainty	Legal

Due to the variety of barriers considered, a large number of solutions were found that could mitigate the occurrence or effects of the evaluated barriers. The solutions were validated by three expert interviews, each pertaining to a different stakeholder group, namely regional government, heating company, and consultant. When evaluating the solutions found, it was determined that most solutions could tackle several barriers. For this reason, a Sankey diagram was created to demonstrate how the different solutions can be applied for mitigating various barriers, shown in Figure 39. As can be seen, the barriers tackled by the most solutions are the lack of participation & cooperation, lack of transparency & trust, and interorganisational resistance. Additionally, the solutions that counter the most barriers include risk assessment and contingency planning, implementing formal and informal knowledge sharing moments, and having simple contracts with long-term planning.

Figure 38: Barriers and their corresponding solutions (author)

The generated solutions have been grouped into 6 themes as can be seen in Figure 40.

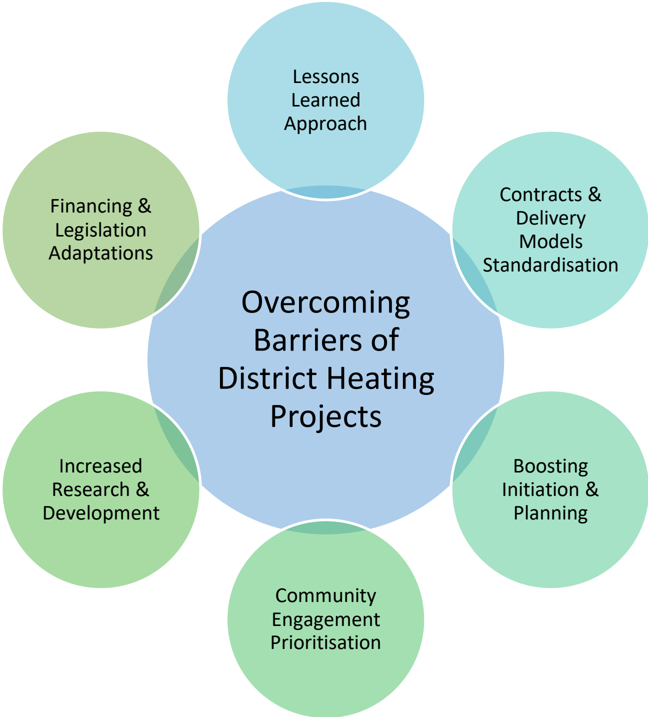


Figure 39: Solutions strategy (author)

Furthermore, Table 15 provides a condensed summary of the Sankey diagram by expressing the proposed solutions per theme, the barriers that they mitigate, and the phase(s) in which they should be implemented.

Table 15: Solution to barriers in heat grid projects (author)

Approach Theme	Proposed Solution	Barriers that it mitigates	I	F	C
Lessons Learned Approach	Knowledge governance strategy	1, 2, 8, 9, 10, 11, 12	X		
	Formal & informal knowledge sharing moments	1, 3, 5, 7, 8, 9, 10, 16, 17	X	X	X
	Encourage stakeholder feedback from all	1, 3, 4, 5, 6	X	X	
	Data-driven decision-making	1, 2, 7, 10, 12	X	X	X
	Pilot projects or phases	3, 4, 5, 6, 7, 8			
Contracts & Delivery Models Standardisation	Alliance delivery model	1, 2, 3, 5, 7, 11,		X	X
	Contractual & relational governance	1, 2, 3, 5		X	X
	Decouple heat transportation & delivery	1, 4, 5, 8, 10, 11,	X		
	Exhaustive & separated business case	3, 5, 7, 11		X	X
	Simple contracts with long-term planning	1, 3, 5, 7, 9, 11, 15, 17	X	X	X
Boosting Initiation & Planning	Appoint a PM	1, 3, 5, 8, 10, 12	X		
	Invest in team alignment	1, 2, 3, 5, 7, 9	X		
	Develop detailed & representative roadmap	2, 7, 8, 9, 10	X	X	
	Scope frozen	7, 9, 10	X		
	Resource procurement & allocation plan	3, 7, 8, 9, 10, 12, 15	X		

	Risk assessment and contingency plan	1, 2, 3, 5, 7, 8, 10, 11, 12, 14, 17	X	X	
	Plan of approach with policy makers & experts	1, 3, 5, 7, 8, 9, 17			
	Keep team motivated	3, 5, 6		X	X
Community Engagement Prioritisation	Invest in community building	1, 2, 3, 4, 6	X		
	Build partnerships with community organisations	1, 2, 3, 4, 6	X		
	Involve end-users in initiation (through goal-setting, feedback, etc.), keep informed in feasibility	1, 2, 3, 4, 6, 7, 10, 12	X		
Increased Research & Development	Collaborate with research institutions	2, 8, 10, 11, 15, 16	X		
	Increase R&D for flexible systems and demand forecasts	8, 15, 16	X		
Financing & Legislation Adaptations	Political-legislative uncertainty impact assessment	3, 5, 11, 15, 17	X		
	Increase government interventions	3, 4, 5, 11, 12, 13, 14	X		
	Improve heat price regulations: price DH advantages	1, 5, 11, 13, 15, 17	X		
	Reorganisation of heat costs for end-users: transition from fixed price model to more flexible	4, 13	X		
	Improve heat market policies to encourage heat storage and favour scaling up	4, 11, 15, 16	X		
	Monitor split incentives and aim for shared incentives	1, 3, 5, 11, 14	X		

<u>Lessons Learned Approach</u>

1. *Knowledge governance strategy*

By implementing a knowledge governance strategy, a specific plan of approach is created for knowledge governance within that project, in addition to the typical project documents, such as the letter of intent or the business case. This document should outline several aspects, including learning goals, responsibilities for learning and development, and how knowledge sharing will be organised. This allows for the collaborating organisations to establish a pattern of processes for sharing, applying, creating, and enabling knowledge identification (Pemsel et al., 2014). Additionally, this strategy should encourage and facilitate a reflection process in order to learn from projects and avoid reoccurring issues which can cause a waste of time and money (EI.3.C, 2024). Nonetheless, given that heat grid projects are relatively new in the Netherlands, often stakeholder are confident that although knowledge may be available on a national level, they must experience the processes themselves to get accustomed the such project, "sometime you will still need to take time to feel it in your veins what is needed to make such a change in energy system" (EI.1.HC, 2024).

2. *Formal & informal knowledge sharing moments*

Establishing formal and informal knowledge sharing moments into the schedule of the project creates an opportunity to enhance cooperation, and build individual and interorganisational knowledge while simultaneously creating a team environment (Ipe, 2003). Informal knowledge sharing is also referred to as 'messy talk' which allows for tacit knowledge to be generated between and after the scheduled topics have been discussed in the formal information sharing moment. Messy talk can provide the opportunity to share, discuss, and debate different topics and experiences however, for messy conversations to be productive, it is important for teams to be well-organized, structured, and willing to interact with each other (Dossick & Neff, 2011). Therefore, in order to establish fruitful interactions, it is crucial for stakeholders to be transparent in such conversations and to trust each other, although building trust takes time (EI.1.HC, 2024; EI.3.C, 2024). For this reason, efforts are being made to address possible hesitancy from people in openly discussing issues or failure that occurred in a project due to potential scrutiny by other parties, including local political representatives (EI.2.G, 2024). However, from a consultant's perspective, people are typically willing to share the successes and failures of projects in order to determine their reasonings (EI.3.C, 2024), although the regional government's perspective differs. In the Netherlands, there are currently attempts to boost learning between stakeholders of heat grid projects. At the provincial level, stakeholder sessions and events are hosted aiming to provide knowledge-sharing. Additionally, at the national level, the Programma Aardgasvrije Wijken (PAW) provides a learning program aiming to disseminate lessons learned between parties (EI.2.G, 2024). However, dissatisfaction remains among several parties regarding the level of support and information provided by the national government, including adequate formats, clarity for effective subsidy implementation, and the role of the municipality when initiating a heat development project (EI.1.HC, 2024). While this approach is promising to overcome several barriers encountered in heat grid projects, it must be further encouraged between parties and clarity must be given to the information yearned by the different stakeholders from each other. Furthermore, focus must be given to establishing a safe environment for meaningful conversations to occur.

3. *Encourage stakeholder feedback*

Encourage feedback from all stakeholders to increase transparency, sense of ownership and collectivity between stakeholders (Shortall et al., 2022)(Caramizaru & Uihlein, 2020). While this suggestion may be beneficial on a variety of aspects, in practice it results more complicated to standardize due to the potential explosive nature of such conversations in the industry, specifically if outcomes or feedback is of a negative or sensitive nature, due to the risk of blaming others (EI.2.G, 2024). This demonstrates that a lack of accountability for things that have gone wrong in projects may impede the willingness of participating in such a strategy.

4. *Data-driven decision-making*

In the initiation and development of heat grid projects, it is common for people to discuss actions and ambitions without understanding the specific data related to the circumstances. Therefore, data is crucial to assess costs and benefits, such as financial implications and carbon reductions, rendering data-driven discussions beneficial for focusing on reality rather than speculation and hypotheticals (EI.3.C, 2024). By adopting the technique of data-driven decision-making, relevant data is collected and analysed throughout the project to provide real-time optimised results in the medium and long-run. This can provide the necessary information to guide decisions, optimize resource allocation and provide clarity of project direction (Kabeyi & Olanrewaju, 2022).

5. *Pilot projects or phases*

By establishing pilot projects or phases, the collaborating organisations can demonstrate success and build confidence with stakeholders, while making it easier to scale-up in the future (Moser & Jauschnik, 2023). Pilot projects are common in the Netherlands, specifically through the PAW pilot programme. However, some stakeholders believe that the way in which pilots are carried out currently are in fact a waste of time and money due to the fact that each pilot is different and the learning opportunities they provide are limited. Furthermore, there seems to be a lack of reflection after developing the pilots, further diminishing the benefits obtained from them. Therefore, it has been suggested to discourage the adoption of pilot projects in the Netherlands in the future (EI.3.C, 2024).

Contracts & Delivery Models

1. *Alliance delivery model*

Adopting an alliance delivery model promotes collaboration and information exchange by having multi-party agreements between entities to cultivate equitable risk-reward distribution, unanimous decision-making, a blame-free environment, and trust-based relationships—all aimed at benefiting the collective (Moradi & Kähkönen, 2022).

2. *Contractual & relational governance*

Establishing contractual governance and relational governance through informal relationships and formal contracts to enhance project performance and inhibit willingness to learn from each other. Extensive legal agreements can hinder information exchange due to fear of revealing knowledge (Hamel, 1991), therefore informal relational contracts built on trust can facilitate knowledge exchange by encouraging open sharing (Musawir et al., 2020). However, parties have demonstrated a slight resistance to the feasibility of this implementation due to the formalities required in the tender procedure in the Netherlands. Given that municipalities typically must put out a tender for such a project, the relationships between involved parties and stakeholders only begin after a contract has been signed. Many individuals express their desire for greater freedom to choose with whom they will collaborate in the project (EI.3.C, 2024). This initial frustration towards the tender procedure may result in complications or frictions with adopting relational governance.

3. *Decouple heat transportation & delivery*

Decoupling heat transportation and heat delivery into distinct legal entities allows for more autonomous management of their respective activities, and enhances the attractiveness of these entities to external investors (Osman, 2017). However, all three interviewed experts displayed resistance towards the possibility of decoupling heat grid component. Although it could provide benefits during the development of a heat grid is parties collaborate adequately, a key argument against the decoupling is it may in fact worsen the barrier of a fragmented value chain, “a heating system must operate as if it is one system, like it is a heart that has to deliver blood to every vein in your body” (EI.2.G, 2024). Additionally, compared to electricity, heat is more difficult to decouple given the need for larger sources. Therefore, in the current and expected law, this separation is not possible given the encouragement of heat companies being the party that builds the transportation system, delivers the heat, and bills the end-user (EI.1.HC, 2024; EI.3.C, 2024).

4. *Exhaustive & separated business case*

Ensure the business case includes clearly defined stakeholder responsibilities, investment plan, and billing strategy separately, as well as the costs to all involved parties, to ensure transparency within the collaborative parties (Instituut voor Warmtetransitie, 2022; Moser & Jauschnik, 2023). This could provide more uniform standards within the industry, by providing a sort of framework for what must be considered when collaborating with the other main stakeholders and parties of heat grid projects, and that allow for local concerns to be implemented. However, the extent to which this is done must be monitored to ensure it is not too complex to serve useful in a local setting (EI.1.HC, 2024).

5. *Simple contracts with long-term planning*

Ensure the contracts between parties are simple while including: specification of stakeholder responsibilities, frequency and channels of communication, renegotiation clauses to allow for flexibility and alleviation of risks given the project's long-term nature, and detailed mitigation strategies for handling difficulties (Lygnerud et al., 2019). In the proposed WcW, the contract for heat grid projects can be between 20 to 30 years, however the price for the heat is to be determined yearly by the heating company and checked by the ACM (EI.3.C, 2024). Hence, accommodating for renegotiations in the contract would be beneficial for businesses as well as for the government (EI.2.G, 2024).

Boosting Initiation & Planning

1. *Appoint a project manager*

Appointing a project manager to mediate the process, facilitate open and honest communication and push the project forward has been demonstrated to be beneficial. In order to foster unbiased mediation, an external mediator such as a consultant can be brought in to facilitate the conversations and aim to promote transparency and trust between the parties and contribute to the project's direction. This role could be adopted by the municipality (Edmondson, 1999; Ipe, 2003; Osman, 2017). Whether an internal or external project manager is appointed, all expert interviews agreed to the need for the municipality to take responsibility for this process. Given the municipality's wide-spreading obligations, allocating resources for this role is crucial as an independent external project manager can effectively handle project responsibilities and takes charge, otherwise a lack of this clear leadership presents too many obstructive challenges throughout the project development. However, the government views that having the role be internal can ensure effective leadership, while an external party can provide comfort to all project stakeholders due to their independent nature as sometimes having the municipality take this role has encountered resistance from end-users. Nonetheless, frequent changes in external project manager may hinder long-term progress and should be taken into consideration when appointing someone for this role (EI.1.HC, 2024; EI.2.G, 2024; EI.3.C, 2024).

2. *Invest in team alignment*

By encouraging knowledge sharing and encouraging open, honest, and regular communication to ensure alignment between stakeholders, a team culture will begin to evolve and consequently improve levels of transparency and trust. Therefore, investing in team alignment by collaborating with all relevant stakeholders to generate distinct goals, objectives, project scope, and a systemized way of working to define a clear vision will allow for the creation of a high performance team that aligns towards the same direction with a unified understanding of the project's objectives (Alaskar, 2013; Instituut voor Warmtetransitie, 2022; Kabeyi & Olanrewaju, 2022). Keeping alignment between individuals and organisations presents a main challenge, however this aspect requires focused attention in order to progress to the project's realisation phase and can be integrated into pre-existing moments such as the letter of intent, collaboration agreement, and financial close. When working together over an extended period, alignment and motivation are essential to tackle the project collectively (EI.2.G, 2024; EI.3.C, 2024), "it is not my system or your problem, we have a large challenge to do it together or else it is not going to work. It's shared responsibility" (EI.1.HC, 2024). Additionally, while broadening horizons and involving other stakeholders within a safe space is helpful, a lack of trust in energy companies can make this process difficult. Nonetheless, it is known that when faced with challenging tasks, it is better to work together to find solutions. On a regional scale, it has been found that partnerships involving the different project stakeholders allows for their understanding of each other to become more profound over time, fostering successful results (EI.1.HC, 2024).

3. *Develop a detailed & representative roadmap*

Develop a detailed and representative roadmap outlining the project's milestones, timelines, and key deliverables (Kabeyi & Olanrewaju, 2022), which considers aspects such as the time it might take to readjust to changing actors in the future. Additionally, responsibilities and leading parties of tasks must be clearly distributed depending on the determined deliverables, with the project manager overviewing (EI.3.C, 2024).

4. *Scope frozen*

Implement a scope frozen moment: a stakeholder agreement that at a chosen point in time, the project scope is said to be well-defined and any change from that point onwards will affect other project aspects (Alaskar, 2013). This puts more pressure on determining a concrete direction for the project and allow for smoother incorporation of new team members. However, when implementing this concept, it is necessary to also establish a procedure for handling unexpected issues within the scope that may arise, given that it is rare to create a scope at the beginning of a project which remains the same until the end. This is typically overseen by the project manager to ensure consistency (EI.3.C, 2024).

5. *Resource procurement & allocation plan*

Create a realistic resource procurement & allocation plan including time, skills, money, tools to ensure best use of team resources (Asana, 2022). This can consider tasks outsourced to external parties (EI.3.C, 2024). Additionally, regular reporting is crucial to keep track of project and monitor alignment or potential attention areas (EI.3.C, 2024). Adapting continuously and responding in real-time to project requirements ensures resource allocation optimization (Asana, 2022).

6. *Risk assessment & contingency plan*

Produce a risk assessment and contingency plan early on in the projects to be used as a proactive approach to help manage uncertainty and have a strategy to minimizes disruptions (Kabeyi & Olanrewaju, 2022). Additionally, it should ensure an adequate risk allocation such that there is a balance between risk and reward for all parties (Moser & Jauschnik, 2023). This is necessary at the beginning of the project, and a yearly re-evaluation is essential in longer projects (EI.3.C, 2024).

7. *Plan of approach with policy makers & experts*

Engage with policymakers, and legal and regulatory experts to ensure real-time alignment with regulations and policies and create a clear plan of approach to be followed by all parties to reduce uncertainty, foresee potential shifts, and adjust practices accordingly (Kabeyi & Olanrewaju, 2022; Stowe, 2022). More specifically to the current Dutch context, establishing a roadmap regarding how projects should be approached while waiting for the implementation of the WcW law and establishing a distinction between the law's impacts on existing, in development, and new projects. However, while desirable, it is likely not feasible nor useful. When a project is initiated, the existing legislation is known, and in the absence of specific guidelines, such as the WcW, parties operate based on the established norms and understand the inherent minor risks. Therefore, despite investing significant effort into a roadmap, the outcome remains uncertain. Having a foundational level of information accessible to everyone might help, but trust in that information and subsequent actions remain uncertain (EI.2.G, 2024; EI.3.C, 2024). This demonstrates that in the current political-legal landscape of heat grids in the Netherlands, risk and uncertainty is unfortunately inevitable.

8. *Keep team motivated*

Due to the length process of heat grid projects, celebrating achievements of small tasks as well as big ones to keep the team motivated and keen to work towards the end goal is needed (Alaskar, 2013). When conflicts arise among team members, it can jeopardize project progress. Therefore, when an opportunity arises to celebrate, it should be embraced wholeheartedly to foster positive (EI.3.C, 2024).

It should be noted that a challenge persists with this solutions category. The proposed actions demand extensive information in much detail during the early project phase when uncertainty prevails. In order to generate and document these in the desired level of detail is resource-intensive both financially and in terms of needed personnel (EI.1.HC, 2024), meaning it will likely cause resistance when proposed to the varying stakeholders.

Community Engagement

1. *Invest in community building*

Invest in building a community environment in the area where the project will take place, if not already present, to stimulate collectivity (Shortall et al., 2022). This is essential in heat grid projects, however the proposed WcW fails to incorporate it into the legislation. It should be imposed on development parties to invest in community building early on in the project. This should be the responsibility of both the municipality and the housing corporation, and would be beneficial for the heating company to also contribute (EI.2.G, 2024). However, although understood to be important, heating companies are hesitant to invest in such activities due to their uncertainty in being appointed to the project and place the responsibility on the municipality (EI.1.HC, 2024)

2. *Build partnerships with community organisations*

Build partnerships/relationships with other community organisations to create a shared sense of responsibility for the project and ensure it is supported by a broad range of stakeholders, while enhancing community trust for the project (Caramizaru & Uihlein, 2020). Currently, this is pursued by municipalities who engage with neighbourhoods. The investment of heating companies in such activities is resisted (EI.1.HC, 2024).

3. *Involve end-users in initiation (through goal-setting, feedback, etc.), keep informed in feasibility*

Involve end-users in the decision-making of the initiation phase via creative workshops to stimulate communication and information exchange in a managed way, while maintaining them informed during the feasibility phase can reduce the risk of conflicts between the project team and the end-users in the long-run (Emmitt et al., 2005; G.3.PO, 2023; Lindahl & Ryd, 2007). Holding focus groups about goal setting and feedback, training sessions, and public meetings builds a sense of community and social learning, while engaging end-users in the project and creating a sense of shared ownership of the project to promote collectivity (Caramizaru & Uihlein, 2020; Shortall et al., 2022). An approach to enable this is for the municipality to hire an independent member to represent inhabitants and the community by facilitating the development of their ideas and representing their interests to other project parties. This has been done in a few projects in the Netherlands and has proven beneficial, especially now that district heating remains relatively novel (EI.2.G, 2024).

Given the importance of end-user willingness connect in the realisation of heat grid projects, it is not possible for this heat transition to be a surprise for the end-users of a project as they will immediately be against connecting. It is necessary to help them grow into the idea and its importance, requiring constant communication during the multiple years of development prior to realisation. This way, end-users will be relieved for its eventual implementation when the time comes rather than reluctant (EI.2.G, 2024). In the Netherlands, a distinction is made between participation and communication, such that communication entails information spreading while participation entails the actual involvement of end-users into the decision-making and idea development process of the project early on and considering their inputs into the outcomes (EI.3.C, 2024). This is necessary for community acceptance which is one key factor for success of heat grid projects.

<u>Increased Research & Development</u>

1. *Collaborate with research institutions*

Collaborate with research institutions and industry partners to cooperatively explore innovative solutions and technology, exchange best practices, and verify project assumptions (Kabeyi & Olanrewaju, 2022). This should be organised separately from a project such that focus is given to reflecting and evaluating work that has been done for improvement implementations to occur in following phases or projects such that it does not clash with active project operations (EI.3.C, 2024).

2. *Increase R&D for flexible systems and demand forecasts*

Increase research and development into flexible systems, increasingly efficient piping design and energy demand forecasts (Van de Graaf & Sovacool, 2014).

<u>Financing & Legislation Adaptations</u>

1. *Political-legislative uncertainty impact assessment*

Assess potential impacts of political-legislative uncertainty on operations and decision-making processes and adopt scenario planning for contingency to prepare and adapt (Laker & Roulet, 2019).

2. *Increase government interventions*

Increase government interventions (quota schemes, soft loans, tax incentives, subsidies, etc.) to mitigate the investors' risks and foster societal and institutional momentum for district heating, and allow for such projects to compete with other renewable technologies (Lygnerud et al., 2019; Mazhar et al., 2018). Although attempts are being made in this aspect, it is not enough and remains complex. Therefore, the government must simplify the access to funding for all parties as the existing complexity presents challenges in achieving necessary subsidies. Not only are increased financial interventions and a streamlined process required, but equity in heating costs must also be facilitated through a national norm or subsidising mechanism. Currently, district heating presents a local challenge with significant cost variations, such that for an almost identical system, one neighbourhood may pay significantly more than another (EI.1.HC, 2024). In Denmark, a similar system is implemented with varying pricing, however due to the urgency of achieving the heat transition insufficient municipal support is not possible, with compelling reasons for the national government to invest in expanding the heat network such as the lack of capacity of the electricity grid to handle additional heat demand. If government intervention is not rapidly improved, people may resort to adopting individual heat pumps, further increasing strain on the electricity grid. Therefore, to ensure speed, it may be necessary for the government to accept some risk or cost inefficiency at a national level. While some returns may be financial, earned back over 10 or 30 years, others may be intangible with the true return on investment lying in successfully transitioning to heat networks, guaranteeing public satisfaction, and enabling the broader energy transition (EI.2.G, 2024). This ties into the proposal of reorganising costs such that heat costs are socialised, given the requirement for increased government intervention for this. Additionally, the government must simplify the access to funding for all parties as the existing complexity presents challenges in achieving necessary subsidies. Such an approach would facilitate better access to financial resources, and enable similar and less strenuous solutions within and between neighbourhoods (EI.2.G, 2024).

3. *Improve heat price regulations: price DH advantages*

Improved regulation on heat prices is necessary to enable district heating to compete with the status quo, either through government intervention or sector-specific policies, as occurs in Scandinavia (Mazhar et al., 2018). Currently, the cost of heating is composed of the "vastrecht" (a sunk cost) and the cost per gigajoule (GJ) of heat consumed. The vastrecht is a yearly fee paid my consumers that includes management and maintenance costs for the grid (Eneco, n.d.-a). Due to a lack of inadequate heat price regulations, users are confronted with the vastrecht costing more that the GJ cost of heat used, and the vastrecht is expected to increase significantly in the coming year although the amount of heat used remains the same. This situation arises in the Netherlands because commercial companies are considering exiting the heating business and transferring the system back to local communities due to the imminent law, hence aiming to maximize their financial gains prior to this transition (EI.3.C, 2024). For this reason, the implementation of more stringent heat price regulations is vital in order to protect end-users and other project parties.

Low-carbon heat grids possess various advantages, such as providing CO2 reductions, that are not currently valued in their business case. Therefore, pricing their advantages in the business case or modifying the energy tax scheme to reflect the benefits of district heating would be beneficial. Additionally, socialising the cost of heat grids is being conversed withing the industry (Osman, 2017). This would mean that the price for connecting to a heat grid would be lower given that the infrastructure for the grid would be paid by all Dutch citizens through taxes. This is currently the case for gas and electricity networks, therefore providing an unfair disadvantage to heat grids due to their lack of socialisation (Osman, 2017; EI.3.C, 2024). This is a result of an illogical political decision made a few years ago, “it’s silly because when we started building gas pipes in the 50s, we never had the same discussion” (EI.3.C, 2024). Considering this review of district heating pricing is necessary given that current heat regulations are not well developed resulting in a lack of protection for the end-users (EI.3.C, 2024). In terms of pricing advantages into the business case, the concept is promising, however practical implementation may only be possible for certain aspects, such as accounting for the benefits of not expanding the electricity grid (EI.2.G, 2024).

4. *Reorganisation of heat costs for end-users: transition from fixed price model to more flexible*

Reorganisation of heat cost for end users can prove beneficial for financial stability. There are various examples of how the reorganisation can be such as by charging end-users based on the kilowatt-hours used (Moser & Jauschnik, 2023), or by the heating company setting a tariff per heat unit. In Sweden, there is a case where the heating company does not charge a fee when the outside temperature is above 7°C. In another Swedish case, the heat is supplied free of charge in the summer while a fixed fee per unit is imposed during the winter (Lygnerud et al., 2019). The Swedish approach could be mirrored in the Netherlands by differentiating prices based on demand, such that higher rates are charge during peak times and lower rates during off-peak (EI.2.G, 2024). In the Netherlands, certain electricity providers offer similar cost structures such as providing free electricity during weekends from April to September. However, the constant availability of heat presents a challenge for such a structure given that a high baseload persists throughout the year (EI.3.C, 2024). Another approach to consider is offering users two pricing options for heating: low monthly flat rate with higher heat cost per megawatt (MW) to align with the existing gas pricing model, or a higher flat rate (independent of the connection rate) with lower heat price per MW to take advantage of the benefits of the heating system (EI.2.G, 2024). Although interesting, such a system may take 5 to 10 years, if ever, to become feasible (EI.3.C, 2024). Regardless of the approach, effective communication of the options is imperative to ensure informed decision-making by the end-users (EI.2.G, 2024).

Transitioning from a fixed price model to a more flexible model can redistribute the risk from customers to district heating providers (Lygnerud, 2018). This focuses on the varying vastrecht mentioned in the heat price regulations improvement. It would be beneficial for financial security to establish a fixed vastrecht for consumers, however this is a lengthy legislative process given that the ACM is currently facing challenges regarding the prompt understanding of heating system costs, making this proposition troublesome in the current landscape. To expedite this, the political chambers must set a two-year deadline for the ACM to determine these costs, and if this cannot be achieved, then a separate law should be considered (EI.3.C, 2024). Otherwise, end-users will continue to bear the financial burden of ACM’s uncertainty. Additionally, in the Netherlands, similar to the Denmark system, there are differing prices per kilowatt of heat within the same heat grid. This should be adapted to mimic the structure of gas pricing such that the cost per GJ of heat used, the vastrecht, and the price per kilowatt is fixed. If a system is very expensive due to design and engineering limitations but remains the best option for the affected area, the necessary funding must be secured by the government and other involved project parties such that the price for consumers does not differ based on proximity to the grid or access to cheaper heat. This ties into the proposal of socialising heat such the this fixed price approach can ensure equitable access to the heat grid through funding from taxpayers or the national government (EI.2.G, 2024).

5. Improve heat market policies

Given that Europe is facing shrinking energy demand, heat market policies should be improved to encourage heat storage and alternative applications, such as cooling, to provide flexibility for heating grid investments (Van de Graaf & Sovacool, 2014). Additionally, adapt policies to favour scaling of existing projects instead of new construction (Moser & Jauschnik, 2023) is needed. Larger heat systems tend to be more cost-efficient, however in Denmark, numerous small systems are community-owned without commercial company involvement such that transparency is maintained by actively managing expenses, including decisions on the director's salary. While expensive, the transparent approach ensures efficient system operation. A similar approach could be considered in the Netherlands, therefore it is necessary to establish an efficiency scale for such systems (EI.3.C, 2024).

6. Monitor split incentives and aim for shared incentives

Closely monitor split incentives and work towards shared incentives (Lygnerud et al., 2019). This is important given that split incentives are more difficult to organise and deal with, however the source of such incentives in heat grid projects is not yet immediately apparent (EI.3.C, 2024)and requires further research

6.4 Collective Decision-Making Approach

Given the multitude of barriers present in heat grid projects in the Netherlands, it is evident that the decision-making process in such projects is challenging and could benefit from a collective approach. In order to integrate collective decision-making into the process, it is necessary to identify the key decisions that should be made collectively, by whom, and who should lead the process. The points of tension in the decision-making process for which collective decision-making can provide benefit can evaluated from two lenses: the barrier intensive decisions and the stakeholder intensive decisions.

The barrier intensive decisions can be extracted from Section 6.2 (Figure 38) which maps the barriers that occur in the process. A barrier intensive decision or moment was deemed to be one that experiences two or more barriers. The stakeholder intensive decisions can be derived from the case study in Section 5.3, particularly the decision-making process (Figure 35) which shows which stakeholders are involved at each moment. So, Table 16 was formed to highlight the barrier and stakeholder intensive moments in the decision-making process. The moments in bold are those which are both barrier and stakeholder intense, hence demonstrating the most strenuous moments which must be approached by collective decision-making (CDM) and must be given special attention to. Additionally, the table identifies which stakeholders must engage in collective decision-making during the respective decisions and moments, as well as the party who must lead the collective decision-making process at that time. The following shorthand was used for the stakeholders: NGov (National Government), RGov (Regional Government), M (Municipality), HA (Housing Association), EC (Energy Company), CB (Consultancy Bureau), E-U (End-Users).

It should be noted that the stakeholders mentioned during this discussion omit private homeowners who are not part of a housing association, including VvEs. However, their involvement can be considered simultaneously with that of the housing association. Additionally, energy cooperatives have been omitted, as it is currently more common to implement heat grids through the municipality, especially in light of the WcW law. Nonetheless, energy cooperatives can be involved whenever the municipality is engaged and would take the lead in those instances.

Table 16: Collective decision-making during the decision-making process (author)

Phase	Decision or Moment	Barrier Intensive	#	SH Intensive	#	CDM Among Who	Lead
Initiation	WcW law	X	3			NGov, RGov, CB	NGov
	Idea forming	X	2			E-U, HA, M	M
	What neighbourhood?			X	4	RGov, M, HA	M
	What are the heat source options?			X	2	RGov, M, CB	M
Feasibility	What are the available subsidies?	X	2			RGov, M, HA, CB	CB
	What are the potential risks?	X	3			M, HA, CB	CB
	Approximately what could it cost the end-user?	X	2			M, HA, CB	CB
	Are enough people willing to connect?			X	2	M, HA, CB	CB
	Concept business case	X	2			M, HA, CB	CB
	End-user willingness research	X	2	X	3	M, HA, E-U	HA
	Revised business case			X	3	M, HA, CB	CB
Contracting	**Who will develop, invest, exploit the system?**	X	3	X	2	RGov, M, HA	M
	Works to be done in the homes?	X	2	X	2	HA, EC, E-U	HA
	What is the cost of the works in the homes?	X	2	X	2	HA, EC	HA
	What subsidies are available?	X	2			M, HA, EC	M
	Who is the risk designated to?	X	2			M, HA, EC	M
	Letter of intent	X	3	X	3	M, HA, EC, CB	M
	Connection cost/BAK			X	2	M, HA, EC, CB	M
	Investment plan	X	3	X	3	M, HA, EC, CB	M
	Concrete business case	X	2	X	3	M, HA, EC, CB	M
	Cooperation agreement	X	2	X	3	M, HA, EC, CB	M
	End-user connection enlistment	X	4			M, HA, EC, E-U	HA
	Signed connection contracts	X	2	X	2	M, HA, EC, E-U	HA
	Financial close			X	3	M, HA, EC, CB	M

<u>Initiation Phase</u>

During the initiation phase, the barrier intensive moments include the influence of the WcW law and the idea forming moment. Given that stakeholders are awaiting the WcW law implementation, uncertainty prevails. Unfortunately, there is little solution for this given that the national government must simply finalise and implement the law. Nonetheless, the national government should work with the regional governments, as a representative of their relevant municipalities, and consultancy bureaus, as a representative of the public and market parties involved in such projects. By collaborating with these stakeholders and facilitating real-time concrete spread of information will allow the barriers cause by the looming law to be mitigated. Additionally, during the idea forming moment of this phase, while the municipality should lead via an appointed project manager, they must involve end-users into this moment as well as housing associations. Although at this moment the specific neighbourhood and involved housing association may be unknown, it would be beneficial to engage in conversations with the different housing associations and inhabitants of the district in order to develop ideas for the heat grid implementation with their input.

Furthermore, the stakeholder intensive decision of this phase includes the decisions of which neighbourhood to implement the grid, and the heat source options. The former decision should be made by the regional government, municipality, and housing association due to the specific input that each can provide. The regional government can provide insight into the impact of connecting a neighbourhood to other regional heat grid projects, while the housing association can provide understanding on their real estate's suitability for heat grid connection. Additionally, the municipality can provide municipal-specific opinions regarding the location and will be required to lead this decision by the WcW law, hence the appointed project manager should organise the collective decision-making process for such. Similarly, the municipality must lead the discussion regarding heat source options, with the involvement of the regional government and a consultancy bureau which can provide expert advice on the possibilities for such a project.

Feasibility Phase

During the feasibility phase, the barrier intensive decisions include: What are the available subsidies? What are the potential risks? Approximately what could it cost the end-user? The barrier intensive moments include the concept business case and the end-user willingness research. Additionally, the stakeholder intensive decision is: are enough people willing to connect? While the stakeholder intensive moment is the revised business case. All but the willingness research have been assigned the consultancy bureau as the lead given that this will allow for alleviation of work from the municipality during this uncertain period. Additionally, the leading external party can produce a detailed feasibility study for the proposed project upon which the internal parties can decide on the next steps.

The topic of available subsidies has been highlighted as difficult due to the lack of ease in accessing them. Therefore, the regional government, as a liaison with the national government, should collaborate with the municipality to provide clear direction and guidance for which subsidies are available for heat grid projects and their acquisition procedure. Additionally, the housing association should provide input into real estate related topics to analyse the applicability of certain subsidies, for example for home insulation. Similarly, the housing association must provide such input for the decisions on risks and end-user costs, while the municipality must provide input into the legal, regulatory, and political aspects of the project. By being the lead, the consultancy bureau can serve as an organiser of information and documents, while also providing input as to the effects of an energy company from their experiences with the stakeholder and other heat grid projects. However, their involvement not necessary for the end-user willingness research such that the housing association should be the lead to give end-users a sense of security in the process given that the housing association is tasked with having the residents' best interests in mind. The municipality should also provide support during this moment, however due to possible distrust in the government, they should not hold a leading role at this time to avoid unnecessary resistance to the project. It is during this time that an independent party can be brought in by the housing association to represent and push for the views of the residents. This moment is both barrier and stakeholder intensive, therefore requiring special attention and efforts. Furthermore, the evaluation of the number of people willing to connect to the system must be carried out by the municipality and the housing association given their experience with the willingness research, and the consultancy bureau bridging the outcome with the impact on the business case, and hence creating the revised business case.

Contracting Phase

During the contracting phase, there are various decisions and moments which are barrier intensive and that should be led by either the municipality or the housing association. Regarding the decisions of who will develop, invest in, and exploit the grid, the collaboration of the regional government, municipality, and housing association is needed for similar reasons as they are needed to decide the project location. The regional government can provide insight into how certain proposals or energy companies may align with other regional projects, while the housing association can represent the views of the end-users and can involve the independent representative in this decision to ensure that the residents perspective is considered. Additionally, the WcW will require the municipality to lead this decision, hence the appointed project manager should organise the collective approach to this decision. However, when deciding on the works to be done in the homes and their costs, the housing association must lead given their expertise and responsibility towards their real estate. Additionally, they must incorporate the technical knowledge provided by the energy company while considering the end-users input and ensuring that the costs are reasonable. It is important to involve the end-users at this moment given that they are the ones living in the homes and must agree to the works being done, hence they can provide valuable insight into their requirements and experience, and other renovation area can be tackled simultaneously to improve their living conditions such as mould improvements or other similar issues. These decisions are both barrier and stakeholder intensive, therefore requiring thorough consideration and efforts in collective decision-making.

When further evaluating the available subsidies and risk designation, the municipality-appointed project manager must lead. Given the initial evaluation during the feasibility phase by the consultancy bureau, the involved parties can look deeper into the available subsidies and begin the process of achieving them. Additionally, the project manager must reevaluate the work already done on these topics and manage the input of the housing association and energy company to ensure equitable risk assessment and allocation and provide conflict resolution as necessary. Similarly, the project manager must conduct the generation of the letter of intent, investment plan, concrete business case, cooperation agreement, and financial close between the development parties to enable cooperation between parties and facilitates dispute resolution when needed. All but the financial close are barrier and stakeholder intensive, requiring specialized attention. Additionally, the consultancy bureau may be involved for administrative purposes if desired by the project manager. Similarly, the municipality and consultancy bureau will adopt the same roles to support the housing association and energy company in collaborating on the connection cost determination. The energy company must calculate their costs of installation, equipment etc. to connect the properties to the grid, while the housing association can evaluate its alignment with their financial capabilities and whether optimisations are possible. Furthermore, similar to the end-user willingness research of the feasibility phase, the housing association should lead the end-user connection enlistment for the same reason. Support and input from the other parties is needed by providing information about the project, however the main alliance should lay between the end-users and the housing association to enhance trust. Similarly, the housing association should lead the signed connection contracts moment, with the municipality's support, between the end-users and the energy company to provide security to the end-users who may distrust energy companies. This moment is another that is both barrier and stakeholder intensive, requiring specific attention to the effective implementation of collective decision-making.

Part 7

Conclusion

CONTENT

7.1 SQ1: Who are the stakeholders of low-carbon heating grid projects in mixed-use neighbourhoods and what are their attributes?

7.2 SQ2: What is the current decision-making process in place?

7.3 SQ3: What are the barriers encountered in low-carbon heating grid projects in mixed-use neighbourhoods and when do they occur?

7.4 SQ4: What is the role of the collective in low-carbon heating grid projects in mixed-use neighbourhoods?

7.5 MRQ: How can collective decision-making be orchestrated to overcome the barriers of low-carbon heating grid projects in mixed-use neighbourhoods?

7.0 CONCLUSION

This research aimed to provide an overview of key barriers in heat grid projects in mixed-use neighbourhoods, and an approach for effective collective decision-making across the involved stakeholders for project execution and realization. To achieve it, the following main research question was formulated: "How can collective decision-making be orchestrated to overcome the barriers of low-carbon heating grid projects in mixed-use neighbourhoods?". This research addresses four main notions to answer the main research question, through an explorative qualitative data analysis employed by interviews and a case study. First, the stakeholders of heat grid projects in mixed-use neighbourhoods and their attributes were identified. Second, the decision-making process for such projects was mapped. Third, the barriers encountered in such projects were identified. Lastly, the role of the collective in such projects was considered. The following sections present the conclusions for each sub-question and ultimately provide a comprehensive answer to the main research question.

7.1 SQ1: Who are the stakeholders of low-carbon heating grid projects in mixed-use neighbourhoods and what are their attributes?

One of the aims of this research is to further understand the role of stakeholders in the energy transition, particularly in heat grid projects in mixed-use neighbourhoods, including their perspectives and decision-making governance. From the literature study (Section 2.3), four key stakeholders of heat grid projects arose including: housing corporations, tenants/homeowners, local governments, grid operators. During the qualitative research, these stakeholders were translated for the Dutch context as: housing associations, end-users, municipalities, and energy companies. Additionally, several other stakeholders were found including national governments, regional governments, consultancy bureaus, and energy cooperatives which are all involved in the rollout of the heat transition in the Netherlands.

From the data analysis and case study evaluation (Section 5.2 and 5.3 respectively), several conclusions can be drawn regarding the ambitions and decision-making governance of these stakeholders. The national government's main impact consists in the finalisation of the WcW law and providing financial and regulatory mechanism to encourage the heat transition to prioritize heat grids. The regional government is typically only involved in the initiation and/or feasibility phase, by contributing technical and regulatory expertise into the implementation of a heat grid in a particular area and helping the municipality to identify its most suitable. They also provide support to ensure all necessary elements are in place for the project to progress through the subsequent phases. The municipality is a common project initiator that participates and invests in heat grid projects to align with their energy transition goals. They work with the housing association to inform residents about the heat grid and its implementation, while balancing the various internal political parties and appointing the energy company that will develop the project.

The housing association is another typical initiator aiming to future-proof their real estate, while maintaining their main responsibility of managing the project's impact on tenants and themselves. They actively participate in heat grid projects when deemed as a cost-effective way to transition tenants away from natural gas. Their roles include informing residents about project consequences, preparing homes for grid connection, and negotiating costs and participation with the energy company. Their primary challenge includes reaching an agreement with tenants. The energy company is a significant decision maker that determines the grid's design, infrastructure, and development costs. Their investment in the grid construction is substantial, however the uncertainty surrounding the number of grid connections poses a considerable risk that if perceive as too high, may lead to a reconsideration of their investment. The consultancy bureau contributes to determining project feasibility by providing the initiators with initial sketches of the desire heat grid including infrastructure design, approximate costs, and a concept business case. They may also be contracted to support in the revision and finalisation of these steps, and the agreements and contracts between parties.

Energy cooperatives encourage local ownership of such projects through creating community-owned heat grid system that provide affordable energy to the community. By prioritizing local decision-making, transparency takes precedence to ensure the development of a system that aligns with community needs and wants. Lastly, end-users decide whether to connect to the heat grid and adapt their homes accordingly, which is necessary for project realisation. They tend to be aware of the Netherlands' eventual shift away from natural gas and appreciate when the project focuses on home improvements and insulation to enhance overall comfort. However, some tenants desire more autonomy in choosing the energy company involved.

7.2 SQ2: What is the current decision-making process in place?

This question aimed to map how the decision-making process in heat grid projects is currently taking place in the Netherlands. To evaluate this, theory on the value chain of such projects was combined with stakeholder theory to create a preliminary decision-making diagram. This was discussed and adapted throughout the interview process, such that the final decision-making process presented in Section 5.2.1 demonstrated a combination of qualitative empirical data, theory, and online industry sources (Figure 20). The process diagram was applied to a specific case in Section 5.3.3, which demonstrated various similarities and differences attributed to the initiation process and stakeholders of the case project (Figure 35). Additionally, the process diagram was further validated through an expert interview (Section 6.1), which provided perspective into what the process looks like when specifically initiated by a public heating company. This is valuable insight given that the awaited WcW law will require a public entity to develop all heat grid projects in the Netherlands, therefore the proposed decision-making process (Figure 37) may be the process that will be adopted once the law is implemented. The key differences between the process elaborated during the analysis and that from the expert interview lays in the initiation of the project and the lack of tender procedure in the latter. This consequently leads to a longer feasibility phase with early agreements between parties, including the letter of intent and cooperation agreement, and a shorter contracting phase. Furthermore, it is crucial to recognise that the decision-making process can differ depending on the project initiator and the location's already present infrastructure and real estate. However, given that the WcW law will require the municipality to initiate the projects, the main deviation will lay on whether or not an energy cooperative is involved in the project.

7.3 SQ3: What are the barriers encountered in low-carbon heating grid projects in mixed-use neighbourhoods and when do they occur?

This research question aimed to identify the barriers that arise within low-carbon heating grid projects in mixed-use neighbourhoods and when during the decision-making process do they occur. In order to determine this, an initial barriers framework was developed using literature on the barriers of the energy transition, barriers of district heating networks, and barriers of district heating networks in the Netherlands. By combing the literature and organising the barriers into the categories of informational, behavioural, organisational, economic & financial, technical, and legal, the barriers framework for this research was created (Table 8), which was then verified by interviews. The interviews validated the occurrence of all barriers in the framework, and also presented 11 new barriers not mentioned in literature. These discovered barriers include: lack of experience with energy cooperatives, willingness to connect, interorganisational resistance, individualism for collectivity, chicken & egg scenario, long project duration & changing actors, iterative process & time, high process costs, ensuring affordability for all, unreliable funding, and organisation of infrastructure.

Furthermore, the interview process found that informational, behavioural, and organisational barriers are the most predominant. More specifically, the top three barriers that occur in low-carbon heating grid projects include political-legislative uncertainty, lack of transparency & trust, and lack of participation & cooperation. In addition, the analysis found that the contracting phase experiences the most barriers, with the feasibility phase closely following. During the feasibility, behavioural and economic & financial barriers are most experienced, with the greatest barrier of this phase being lack of participation & cooperation. During the contracting phase, behavioural and organisational barriers are most experienced, with the greatest barrier of this phase also being lack of participation & cooperation, followed by lack of transparency & trust. Figure 38 shows the barriers mapped on the decision-making process.

When evaluating mixed-use neighbourhoods specifically, economic & financial, legal, and organisational barriers prevailed, with the top three barriers including regulatory uncertainty, high initial investment & risks, and tax system. Additionally, the interviews presented validation of both the typology and ownership of non-residential buildings being the source of complications when implementing a heat grid in a mixed-use neighbourhood reason. Therefore, priority is given to the recruitment of social housing with large apartment buildings as the kick-starters to a neighbourhood's transition to a natural gas free heating system.

7.4 SQ4: What is the role of the collective in low-carbon heating grid projects in mixed-use neighbourhoods?

In order to evaluate how collective decision-making should be adopted to overcome barriers in heat grid projects, the interviews and case study were used to evaluate what the current role of the collective is in such projects. This includes who is the collective and how they collaborate. It was found that the core collective typically comprises the municipality, housing association, and energy company who collaborate to make crucial decisions. Occasionally, other stakeholders are involved as needed, however they provide support and do not actively make determining decisions. Their collective role encompasses collaboration on all aspects necessary for project realisation.

During the initiation and feasibility phases, much decision-making occurs privately among the three parties. Typically, stakeholders convene in separate groups, each addressing specific project aspects. This ongoing collaboration demonstrates the multifaceted nature of decision-making, with subgroups working together toward the next steps, phases, and investment. Once decisions are reached, residents are informed about the transition from natural gas to a heat grid system, including home renovations. However, tenants express reluctance due to their lack of earlier involvement. Therefore, the municipality and housing association take responsibility for engaging residents and ensuring their support. Although the importance of the end-users' voice is in these projects is clear, they are not currently considered as the core collective due to their lack of involvement throughout the project. This should be pondered by the other stakeholders due to the impacts of their stance on the project.

7.5 MRQ: How can collective decision-making be orchestrated to overcome the barriers of low-carbon heating grid projects in mixed-use neighbourhoods?

This research strives to generate a better understanding of how collective decision-making can be used to overcome the barriers encountered in sustainable heating grid projects in mixed-use neighbourhoods to aid in the timely achievement of the energy transition. To evaluate, solutions must be elaborated for the barriers in which should be implemented by the collective during troublesome moments in the decision-making process. Additionally, it is necessary to identify the moments and decisions within the project that must be approached collectively, and whether the collective changes depending on the moment.

A hexagonal approach was presented in Section 6.3 for overcoming the most reoccurring and the newly found barriers of heat grid projects consisting of the following points: lessons learned approach, contracts & delivery models, boost initiation & planning, community engagement, increased research & development, and financing & legislation adaptation. The lessons learned approach consists of implementing a knowledge governance strategy, formal & informal knowledge sharing moments, encourage stakeholder feedback, and data-drive decision-making. It can be understood that these solutions must be employed from the first moment of project initiation and should be maintained throughout the entire process for optimal benefit acquisition. The contracts & delivery models aspect consists of adopting an alliance delivery model, contractual & relational governance, price district heating advantages, exhaustive & separated business case, simple contracts with long-term planning, and reorganisation of heat costs for end-users. These solutions demonstrate the need for standardisation of project procedures which can be resolved on an industry-wide scale and applied where necessary. Additionally, the costing propositions are institutional solutions that are needed in order to encourage heat grid project enthusiasm but must be done on a national scale by the relevant governmental bodies. The boosting initiation & planning facet involved appointing a project manager, investing in team alignment, developing a detailed & representative roadmap, scope frozen, resource procurement & allocation planning, risk assessment & contingency planning, and keeping the team motivated. The team-specific solutions should be applied from the start of the project and emphasized throughout the process, while the planning aspects should be conducted during the feasibility and contracting phases. Nonetheless, all of these solutions can and should be executed by the lead project manager.

The community engagement solutions propose investing in community building, building partnerships with community organisations, and involving end-users in the initiation phase through goal-setting while keeping them informed in the feasibility. The first two solutions should be conducted prior or in parallel to the project. Additionally, the increase research & development aspect includes collaborating with research institutions and increasing R&D for flexible systems in parallel to the project. Lastly, the financing & legislation adaptations include creating a political-legislative uncertainty impact assessment, increasing government interventions, improving heat price regulations, transitioning from a fixed price model, improving heat market policies, and providing policies to favour scaling up. All of these proposed solutions, excluding the first, are institutional solutions that must be considered by the relevant government bodies.

Furthermore, the decisions and moments of the process requiring particular attention in terms of collective decision-making were determined by analysing the barrier intensive and stakeholder intensive moments (Section 6.4, Table 16). The moments that are both barrier and stakeholder intensive are deemed as most pressing in terms of collective decision-making and arose in the feasibility and contracting phases. In the feasibility phase, the key moment is the end-user willingness research. During this time, it is expected for the individual residents to decide on connecting to the grid, however this should not be presented as an individual decision given that it is a collective system, therefore presenting the barrier of individualism for collectivity which poses many complications given that collective heating systems require everyone to agree to the proposed system for it to work effectively. Therefore, the municipality, housing association, and end-users should collaborate at this moment, with the housing association as the lead. During the contracting phase, several decisions and moments were highlighted. First, the decisions regarding the party to develop the system should be collectively made between the regional government, municipality, and housing association, with the municipality as the lead. Additionally, the works to be done in the homes must be decided between the housing association, energy company, and end-users, with the first leading, while the costs of this can be decided without the end-users. Furthermore, the letter of intent, investment plan, concrete business case, and cooperation agreement must be a collective effort between the municipality, housing association, energy company, and consultancy bureau, with the municipality leading. Lastly, the signed connection contracts consist of the housing association leading the collaboration between the municipality, housing association, energy company, and end-users.

Therefore, by considering the proposed solutions, the moments in which collective decision-making is particularly important, and who should be involved in such, collective decision-making can be orchestrated in low-carbon heating grid projects in mixed-use neighbourhoods to overcome the experienced barriers.

8.0 LIMITATIONS & RECOMMENDATIONS

1 The main limitation of the interview process upon which the generic analysis was generated relates to a lack of end-user, VvE, and commercial owner representation. Unfortunately, due to the inability to identify people that pertain to the end-user stakeholder category, they were not interviewed. Additionally, a lack of response by VvEs and commercial owners contacted resulted in their omission from the analysis. Therefore, further research should be conducted on their perspectives in term on this research's topics to fully understand all stakeholder views.

2 Another limitation of the interviews regards the questions posed. The topic at hand is one of high complexity, meaning that during the earlier interviews a more exploratory approach was to establish a comprehensible basis on the context of heat grid projects in the Netherlands, Therefore, time would lack to delve deeper into stimulating questions. As more knowledge was obtained by the interviewer, more specific and thought-provoking questions could be posed to the interviewees. However, this means that not all interviewees were posed questions at the same level of detail, resulting in different foundations among the interviews. A larger number of interviews or reinterviewing the earlier interviewees could prove useful to mitigate this limitation.

3 In regard to the studied case, the initiation of the project was somewhat unconventional given that the preexisting infrastructure in the area heavily influenced the process such that the typical tendering procedure was omitted. Additionally, the project was initiated by the municipality and housing association, therefore disregarding projects that are initiated by energy cooperatives. Further research should be undertaken into more cases to evaluate the differences in initiation process.

4 Furthermore, it was not possible to interview all stakeholders such that the energy company, consultancy bureau, and end-users were not interviewed. This limitation could be mitigated by adopting a more stringent case study approach in which a case is only chosen if all stakeholders can be considered. Therefore, further research must be conducted on the perspectives of these stakeholders on the project.

5 A general limitation of this research lays in the possibility of the results varying once the WCW law is enacted given that it aims to provide specific requirements on the initiation process, the ownership of the grid, and the roles of the project stakeholders. Although this was considered during the analysis and discussion of this research, it is a risk that must be noted.

6 Given that this topic is very relevant and complex, there are many areas which would benefit from further research. For example, the impact of internal governance within a party on the collaboration between different parties can be explored, as well as specific techniques to alleviate the financial barriers of these projects given that it was emphasized by interviewees as the most difficult barrier. Additionally, a comprehensive step-by-step guide to implementing the proposed solutions of this research can be the next.

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Appendix A – Data management plan

COLLECTIVITY FOR NEIGHBOURHOOD LEVEL HEATING GRIDS

0. Administrative questions

1. Name of data management support staff consulted during the preparation of this plan.

Diana Poppa

2. Date of consultation with support staff.

I. Data description and collection or re-use of existing data

3. Provide a general description of the type of data you will be working with, including any re-used data:

Type of data	File format(s)	How will data be collected (for re-used data: source and terms of use)?	Purpose of processing	Storage location	Who will have access to the data
Audio and video recordings	.mp4	Interviews and round table discussion	To document the interviews and round table discussion for transcription	Onedrive and local copy of Onedrive	Primary researcher and thesis supervisors
Signed consent forms	.pdf	Form given to the participants of the interviews and round table discussion	To control the participants' consent that agree to participate in the research and for their personal information and audio/video recordings to be recorded	Onedrive and local copy of Onedrive	Primary researcher and thesis supervisors
Contact information, employer, name, job	.cvs	Participant	To be able to contact the participants	Onedrive and local copy of Onedrive	Primary researcher and thesis supervisors

description and title					
Anonymised interviews and round table discussion transcripts	.pdf	Interviews and round table discussion		Onedrive and local copy of Onedrive	Primary researcher and thesis supervisors

4. How much data storage will you require during the project lifetime?

- < 250 GB

II. Documentation and data quality

5. What documentation will accompany data?

- Data will be deposited in a data repository at the end of the project (see section V) and data discoverability and re-usability will be ensured by adhering to the repository's metadata standards
- Methodology of data collection

III. Storage and backup during research process

6. Where will the data (and code, if applicable) be stored and backed-up during the project lifetime?

- Another storage system - please explain below, including provided security measures
- OneDrive

Encrypted local copy of the audio and video recordings, and signed consent forms from Onedrive.

IV. Legal and ethical requirements, codes of conduct

7. Does your research involve human subjects or 3rd party datasets collected from human participants?

- Yes

8A. Will you work with personal data? (information about an identified or identifiable natural person)
If you are not sure which option to select, first ask your* Faculty Data Steward *for advice. You can

also check with the privacy website ***. If you would like to contact the privacy team: privacy-tud@tudelft.nl, please bring your DMP.***

- Yes

8B. Will you work with any other types of confidential or classified data or code as listed below? (tick all that apply)

If you are not sure which option to select, ask your Faculty Data Steward ***for advice.***

- Yes, confidential data received from commercial, or other external partners

9. How will ownership of the data and intellectual property rights to the data be managed?

For projects involving commercially-sensitive research or research involving third parties, seek advice of your Faculty Contract Manager ***when answering this question. If this is not the case, you can use the example below.***

The research is conducted by a masters student from TU Delft. Hence, the university will remain the owner of the underlying datasets from the published paper. During the active phase of research, the primary researcher from TU Delft will manage the access rights to data and other outputs.

10. Which personal data will you process? Tick all that apply

- Data collected in Informed Consent form (names and email addresses)
- Other types of personal data - please explain below
- Email addresses and/or other addresses for digital communication
- Signed consent forms
- Photographs, video materials, performance appraisals or student results

Job description and role in the project

11. Please list the categories of data subjects

Managers, municipality representatives, tenants, housing association, energy producers, energy distributors

12. Will you be sharing personal data with individuals/organisations outside of the EEA (European Economic Area)?

- No

15. What is the legal ground for personal data processing?

- Informed consent

16. Please describe the informed consent procedure you will follow:

Each participant will be provided with a consent form in which they will need to provide their written consent for participation in this research and for their data to be processed prior to the interview and/or round table discussion. They will be introduced to the project and explained what their rights are.

17. Where will you store the signed consent forms?

- Same storage solutions as explained in question 6

18. Does the processing of the personal data result in a high risk to the data subjects?

If the processing of the personal data results in a high risk to the data subjects, it is required to perform a Data Protection Impact Assessment (DPIA). **In order to determine if there is a high risk for the data subjects, please check if any of the options below that are applicable to the processing of the personal data during your research (check all that apply).**

If two or more of the options listed below apply, you will have to complete the DPIA**. Please get in touch with the privacy team: privacy-tud@tudelft.nl to receive support with DPIA.**

If you have any additional comments, please add them in the box below.

- None of the above applies

22. What will happen with personal research data after the end of the research project?

- Anonymised or aggregated data will be shared with others

25. Will your study participants be asked for their consent for data sharing?

- Yes, in consent form - please explain below what you will do with data from participants who did not consent to data sharing

Personal data will be deleted after it is processed.

V. Data sharing and long-term preservation

27. Apart from personal data mentioned in question 22, will any other data be publicly shared?

- All other non-personal data (and code) produced in the project

29. How will you share research data (and code), including the one mentioned in question 22?

Question not answered.

30. How much of your data will be shared in a research data repository?

Question not answered.

31. When will the data (or code) be shared?

- At the end of the research project

32. Under what licence will be the data/code released?

Question not answered.

VI. Data management responsibilities and resources

33. Is TU Delft the lead institution for this project?

- Yes, leading the collaboration - please provide details of the type of collaboration and the involved parties below

Other research institutions may help with connecting the primary researcher to potential participants.

34. If you leave TU Delft (or are unavailable), who is going to be responsible for the data resulting from this project?

Question not answered.

35. What resources (for example financial and time) will be dedicated to data management and ensuring that data will be FAIR (Findable, Accessible, Interoperable, Re-usable)?

Question not answered.

Appendix B – Interview Protocol

Interview Protocol

Management in the Built Environment

Graduation Lab 2023/2024

Carlota Rubio Agullo

Interviewee name: [__________] Organisation:[________]

The interview begins with a formal introduction of the thesis study, the interview purpose, and an explanation of the consent. Moreover, permission for interview recording should be granted. Then the concept of informed consent needs to be explained. After that, questions about the basic background information of the participant and his/her work will be asked. The interview will be transcribed for further analysis and checking. At the same time, the audio recording will be kept during the processing period.

<u>Purpose of the interview:</u> Understanding the role, decision-making process, stakeholders of mixed-use neighbourhoods and their collaboration, and the barriers encountered in heat grid projects.

Introduction

I will record the conversation from now on. Hello [_______], nice to meet you and thank you for accepting the invitation for this interview. As you may know I am Carlota, a student of the Master of Management in the Built Environment at the Faculty of Architecture of TU Delft. This interview is part of my master's thesis research project about low-carbon heat grids in mixed-use neighbourhoods, specifically about how collective decision-making can be used to overcome barriers of these projects.

Before we begin, there are a few formalities that I need to settle. The first one is concerning the signed consent form, I will need it before starting the interview. Second, I would like to ask your permission to record this interview to facilitate the transcription process and serve for further analysis. The information here will remain confidential and we may stop this interview at any time if you feel uncomfortable. If required, you can always ask to not include and revise your responses, even after the interview.

I have planned this interview to last about one hour. During this time, I have several questions that I would like to cover, however given the semi-structured nature of this interview I may ask follow up questions depending on how the conversation goes. If time begins to run short, it may be necessary to interrupt you in order to push ahead and complete the line of questioning that has been planned.

Let's get to it!

Questions – Generic questions (to be adapted for each role)

A. **Background / Context (10min)**

a. Can you please introduce yourself.
b. What is your role and experience in heat grid project(s)?

B. Experience (10mins)

a. Can you please briefly describe the project that you are involved in?
b. Can you please describe the neighbourhood in which the project is located?
    i. What building functions are present in the neighbourhood/does the project reach?
c. From my literature study it was unclear whether neighbourhoods with differing building functions or different building ownership posed more difficulties in heat grid projects. What is your view on this?

C. Decision-Making Process (15mins)

I compiled a generic diagram from multiple sources from the literature that shows the key phases, decision-making moments, and involved stakeholders of heat grid projects. I will explain it to you and the idea is that you feel free to add, remove, correct, or give any remarks on how this process develops in practice. For this purpose, the following questions will be asked:

a. Do you recognize these moments and actors, and are there any differences in practice that you can point out?
b. What stages of the project(s) do you participate in? What is your role in the decision-making process?
    i. Would you have liked to participate in any other stage?
c. Who leads the decision-making process and what other stakeholders were involved?
d. From your perspective, what role did end users play in this process, and did you collaborate with them in any way?

D. Barriers (10mins)

I will now dive into the barriers encountered during the decision-making process.

a. From your experience, what stage of the decision-making process is most difficult and why?
b. From literature, I found that common barriers during the decision making process for heat grid projects include a lack of transparency and trust between parties, interorganisational resistance, a lack of cooperation, a lack of expertise and awareness, and financial limitations.
    i. Do you recognize any of these barriers? If so, which ones and when did they occur?
c. Are there other barriers or challenges that you have experienced?

E. Collective Decision-Making (15mins)

The hypothesis of my thesis is that an increase in collectivity with the involved stakeholders of heat grid projects will lead to a decrease in the severity of the encountered barriers and therefore allow for a smoother project process. I will now ask you some questions about collective decision making.

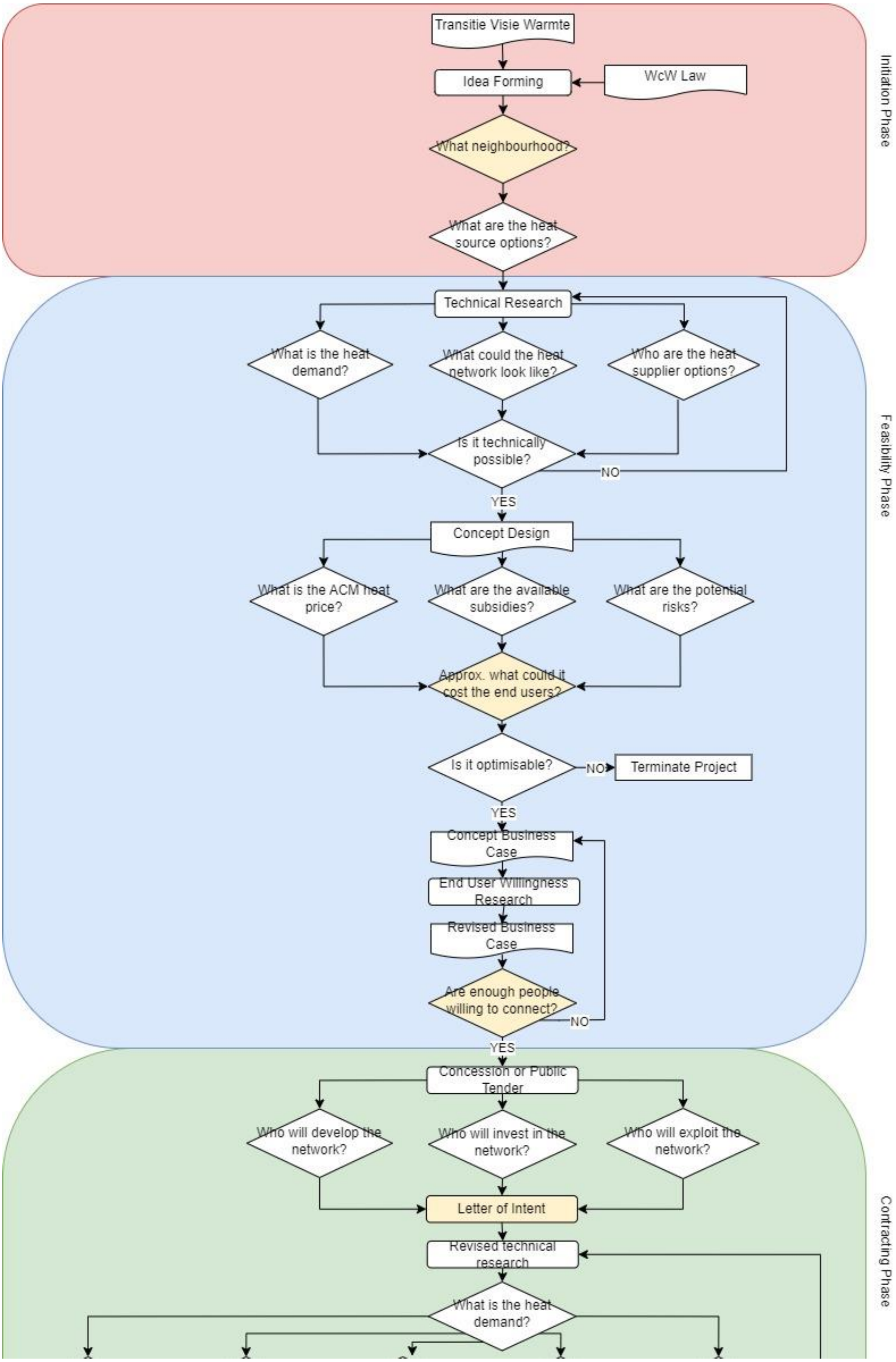
I have defined collective decision-making as "the participation of multiple stakeholders in the decision making process such that the decisions of the project are made as a team or collective to ensure maximal benefit for all project stakeholders."

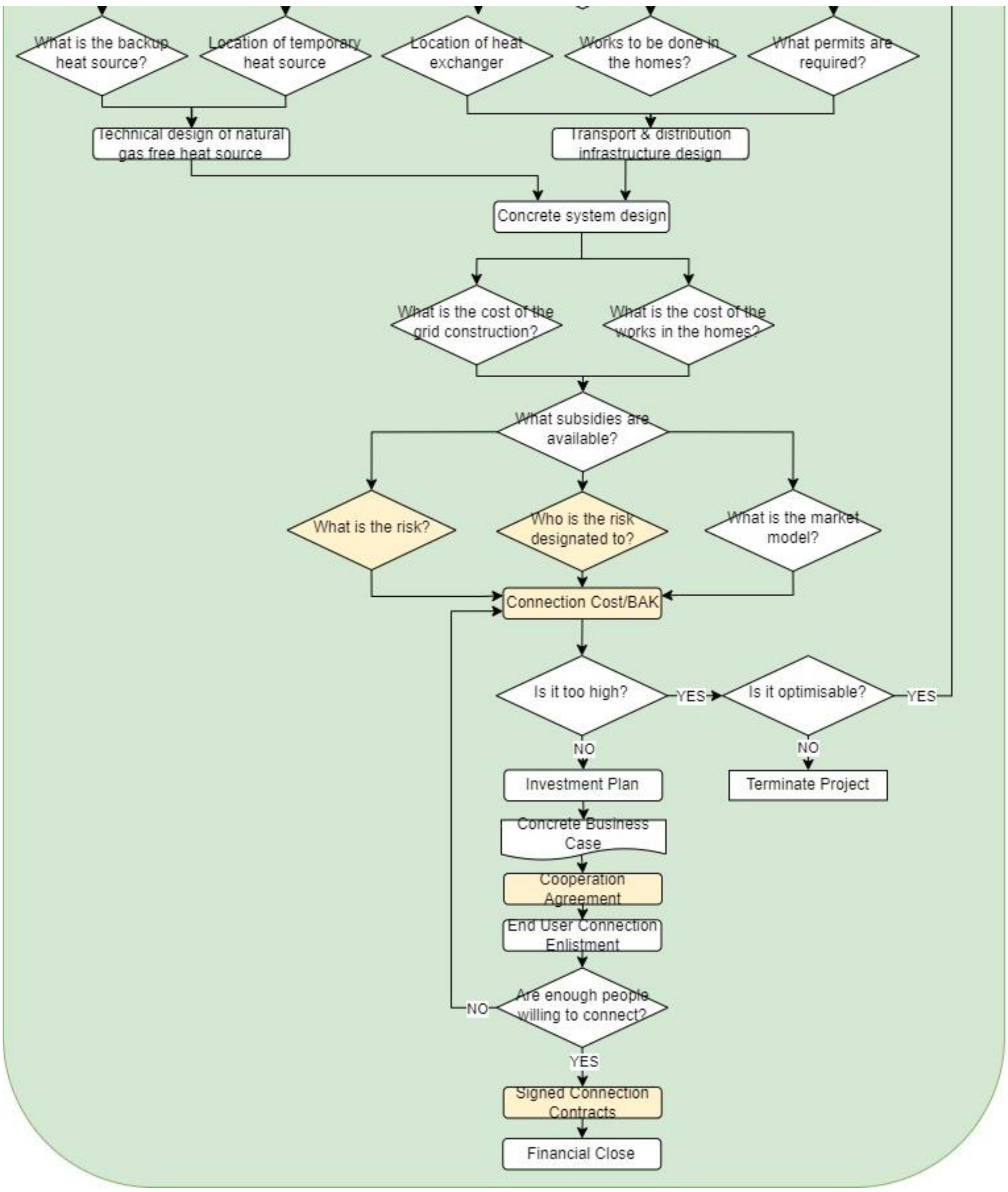
a. Have you experienced this?
    i. If so, can you please describe how you have experienced this and when?
    ii. If not, would you be willing to engage with other stakeholders to make decisions collectively?
b. How do you think that collective decision making could impact the decision making process?
c. In what way would you be interested in participating in collective decision making?

Closing

That was the last question. Once again, thank you very much for your time. This interview will help me a lot with my research on collective decision making in heat grid projects. If you would like, at the end of my research I would be happy to send you a short summary of the results. Should you have no more questions at this point, I will conclude this interview in this way. Should you change your mind later or have any questions, please feel free to email me. Thank you again for your participation and I will keep in touch.

Appendix C – Generic Decision-Making Process





What is the backup heat source?
Location of temporary heat source
Location of heat exchanger
Works to be done in the homes?
What permits are required?
Technical design of natural gas free heat source
Transport & distribution infrastructure design
Concrete system design
What is the cost of the grid construction?
What is the cost of the works in the homes?
What subsidies are available?
What is the risk?
Who is the risk designated to?
What is the market model?
Connection Cost/BAK
Is it too high?
YES
Is it optimisable?
YES
NO
NO
Investment Plan
Terminate Project
Concrete Business Case
Cooperation Agreement
End User Connection Enlistment
Are enough people willing to connect?
NO
YES
Signed Connection Contracts
Financial Close

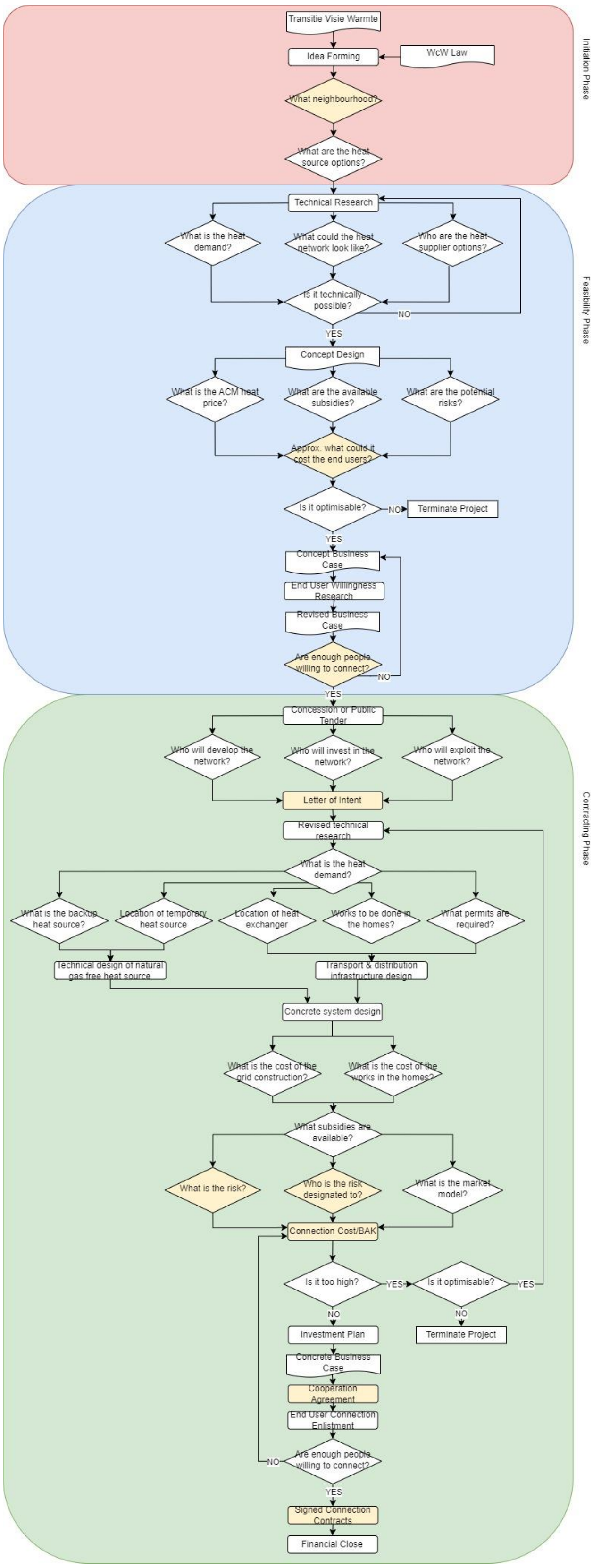
Appendix D – Case Groenoord Barriers Framework

Categorisation	Barrier	Degree	Total
Informational	Lack of information	12	34
	Lack of expertise	3	
	Lack of experience in DHN	-	
	Lack of transparency and trust	19	
	Lack of experience with energy cooperatives	-	
Behavioural	Lack of awareness	13	53
	Perceived value of energy	2	
	Inertia	-	
	Ignorance	2	
	Social acceptance	-	
	Resistance to change	5	
	Negative perceptions of the energy transition	-	
	Lack of participation and cooperation	16	
	Willingness to connect	6	
	Interorganisational resistance	4	
	Individualism for collectivity	5	
Organisational	Monopolistic position of DHN operator	4	31
	Fragmented value chain	3	
	Unfavourable business case	2	
	Resource scarcity	1	
	Mismanagement	1	
	Difficulty in decision-making	2	
	Stakeholder conflicts	7	
	Lack of well-defined direction	5	
	Chicken & Egg scenario	1	
	Long project time & changing actors	2	
	Iterative process & time	3	
Economic & Financial	Profitability	2	32
	Tax system	-	
	Market distortions	2	
	Market behaviour	-	
	Long payback times	2	
	Reduced long-term revenue for DHN operators	-	
	Low ROI	1	
	District heating prices uncertainty	4	
	High initial investment and risks	7	
	Connection fees	-	
	Cost efficiency vs flexible network design	1	
	Expensive transition costs	6	
	High capital costs	1	
	Sunk costs	1	
	High construction costs	-	

	Significant renovation costs for existing houses	1	
	High process costs	-	
	Ensuring affordability for all	4	
	Unreliable funding	-	
Technical	Perceived risks and uncertainties from immature technology	-	6
	Future demand uncertainty	4	
	Energy security	-	
	Complex construction in existing building stock	-	
	Complex energy systems	1	
	Organisation of infrastructure	1	
Legal	Regulatory risk and uncertainty	2	16
	Political-legislative uncertainty	14	

Appendix E – Original vs Validated Decision-Making Process

Generic



Validated