Developing Collaboration in District Heating Networks

A Process Perspective

Master Thesis

Elize Michelle van Dongen

TU Delft

Developing Collaboration in District Heating Networks

A Process Perspective

by

Elize Michelle van Dongen

to obtain the degree of Master of Science

at the Delft University of Technology,

to be defended publicly on Friday, April 11, 2025 at 15:30 PM.

Student number:	4956524	
Project duration:	Sept 1, 2024 – April 11, 2025	
Thesis committee:	Dr. ir. M.G.C. Bosch-Rekveldt,	TU Delft, chair
	Ir. M. van Os,	TU Delft, first supervisor
	Prof. dr. W.W. Veeneman,	TU Delft, second supervisor
Host organisation	Pricewaterhouse Coopers	
	M. ten Cate,	Supervisor
	P. van Asperen,	Supervisor

An electronic version of this thesis is available at http://repository.tudelft.nl/.

Cover image: OpenAI. (2025, April 2). "Flat illustration of a district heating system with a female engineer holding a map, buildings connected to a heat source through underground pipes, construction site with an excavator, clean and simple vector style, warm earth tones, blue sky with clouds." [AI-generated image]. ChatGPT-4o. http://openai.com/

TU Delft

pwc

Preface

The document before you marks the end of my time at Delft, University of Technology. I am very grateful for the educational as well as the personal journey Delft has given me. This research brings together two of my ambitions: sustainability and the built environment. The Dutch energy transition can be achieved through many pathways, and I firmly believe that District heating networks are a vital component of the mix to build a greener future.

Beyond the academic knowledge obtained during my master's degree, I have learned to trust in my own judgement. In that spirit, I would like to thank Marian, Magchiel and Wijnand for their encouragement and support. Special thanks go to my first supervisor, Magchiel. I remember you saying that liking your topic is essential, which made me pivot into this direction. After every meeting, I left feeling more enthusiastic than before. I am also thankful to Wijnand for discussing both the content and personal aspects of the process. Lastly, I want to thank my chair, Marian, who was already open to discuss the start of this thesis nearly year ago, during your course Dynamic Control of Projects.

I would also like to thank my supervisors from PwC, Max and Peter. Max, thank you for always pushing me to think one step further and for always being open to brainstorm. Peter, thank you for stepping in from another team and guiding me through the legal aspects of district heating. I also wish to thank the rest of the Capital Projects & Infrastructure team that made my time at the office very enjoyable.

To all interview participants: thank you for your enthusiasm and openness. The district heating sector is truly unique in that so many of its professionals are intrinsically motivated to contribute to a better world.

Finally, I want to thank my informal support system. To my parents, who acted as extra supervisors during the many flip-chart sessions. To my twin sister, my friends, my housemates and my boyfriend: thank you all for celebrating every small step forward with me.

To you, the reader, I hope this thesis offers a meaningful perspective, and perhaps help renew momentum in the Dutch energy transition.

Elize Michelle van Dongen
Rotterdam, April 2025

This page is intentionally left blank.

Executive summary

The Netherlands faces a major environmental challenge in phasing out natural gas, a task made more difficult by increasing grid congestion. District heating offers an alternative collective heat system for residential, commercial, and small industrial users. It can tap into unused sustainable heat sources, provide market flexibility to absorb shocks, and help stabilise the electricity grid through electricity storage. Given these advantages, the Dutch government set a target to expand district heating networks by half a million new connections by 2030, compared to 2019 levels. However, the sector is currently in decline due to regulatory changes, policy uncertainties and market uncertainties. District heating systems depend on voluntary participation, which makes collaboration, alongside financial viability, an important factor in their development and operation. Successful collaboration can even help overcome financial constraints. In one of the case studies in this research, the stakeholders continued the project despite an unexpected subsidy loss, because they collectively chose to share the financial risks due to their commitment to the shared goal. The main challenges in scaling district heating are not only technological, but also structural and organisational. By identifying the conditions that make collaboration successful within a single-system district heating network, this study aims to reduce uncertainty and support renewed momentum in the sector. The main research question reads:

"What conditions define successful collaboration during the construction, operation and exploitation of district heating?"

The study was grounded in collaborative governance and purpose-oriented network literature and applied a qualitative approach. The research methodology included a literature review, 4 expert interviews, 13 case study interviews, data analysis and the development of a practical tool. The research was structured into four parts: setting up the analytical framework for case analysis, the data gathering, the data analysis and the conclusions.

The analytical framework applied for case analysis

In the first part of the research, a framework was developed by combining the collaborative governance model of Ansell and Gash (2007) with the process view of purpose-oriented networks from Berthod and Segato (2019). The analysis captured both starting conditions of collaboration and the dynamic tensions that may arise during network development. Key stakeholder roles identified were the heat producer, distributor, municipality and end users (housing corporations and individual residents). Also, the (regional) governments proved to be important in the network development. The stakeholders had three types of incentives to join the network. They could join the collaboration because they were legally obliged (legal mandates), operationally dependent (resource dependencies) and/or intrinsically or extrinsically motivated. Two phases of network development were the formation phase (consisting of network initiation and formalisation) and the maturation phase (consisting of the construction, operation and exploitation). The decline phase was excluded. The success of collaboration was analysed through the realisation of key success factors, which were derived from the case study interviews.

To validate the foundation of the research, namely the specification of the stakeholder roles, collaborative phases, process tensions and the level of success in a collaboration, two expert interviews were conducted. The main contributions of the energy market expert and the legal expert were: describing example situations in which tensions can arise, adding the distinction between housing corporations and individual residents within the end users, validating that the starting condition 'history of conflict or cooperation' and 'incentives' are important and elaborating how the collaborative formalisation process works in the heat chain.

Data gathering and case study analysis

The second part of the research focused on analysing three case studies using the analytical framework. To gather data, 13 semi-structured interviews were conducted. The data was analysed in five ways: (1) identification of the key success factors, (2) an analysis of in which phase the tensions arose, (3) an analysis of which stakeholders were involved in tension management and (4) understanding how tension management affected the realisation of key success factors and (5) the expected effect of the proposed regulatory changes.

Key findings

In the third part, the data was discussed and rewritten into results and practical recommendations. The ten key findings of this study are presented below.

1. Successful collaboration in district heating networks is not a static state, **but a dynamic and context-specific process**. It begins at the initiation phase and extends into the maturation phase of the network and requires coordination and adaptive management across all stakeholder roles involved in the construction, operation and exploitation of the system.

2. This study refines the understanding of collaboration success in district heating networks by introducing the **meta-condition** that captures the overarching dynamics of 'success': ***"Individual goals serve as preconditions, while the shared goal acts as a catalyst for collaboration"***. This statement provides a conceptual definition of successful collaboration, which is realised through key success factors. This conceptualisation was confirmed across the three cases.

3. The **meta-condition explains the current sector-wide decline in district heating networks**, as collaboration fails to safeguard individual goals due to regulatory changes, policy uncertainties and market uncertainties, despite the presence of a shared goal.

4. Each case had case-specific key success factors. However, three **consistent key success factors** emerged across all three cases:

   (a) **Goal alignment** explains that individual goals require alignment;

   (b) **Trust** reflects how much trust there is in the shared goal, and the trust that others would safeguard their individual interests as well;

   (c) **Commitment** describes the degree to which the parties prioritise the shared goal, even when it requires setting aside individual objectives.

5. **Tension management** could be a governance mechanism to achieve and maintain key success factors for collaboration.

6. **Nine process tensions** were identified as levers to improve collaboration: (1) inclusivity versus efficiency, (2) integration versus fragmentation, (3) centralised versus distributed control over power resources, (4) network versus organisational resources, (5) interdependence versus autonomy, (6) transparency versus autonomy, (7) network versus organisational learning, (8) stability versus flexibility, (9) dialogue versus confrontation.

7. The **relevance and impact of each tension is context-specific**, depending on the project phase, the case-specific key success factors, the actor configuration, and the public or private nature of the network.

8. **Early awareness and management of process tensions** during initiation and formalisation phases could improve collaboration outcomes.

9. A **practical discussion tool** was developed to facilitate structured early-phase discussion on tensions. It consists of nine discussion cards and supports tension awareness and collaboration design. The **tool was conceptually validated** through an expert evaluation session. The experts were a district heating market expert and an expert on public-private collaboration structures.

10. The **success of collaboration is influenced by regulatory developments**. While collaboration can be designed to buffer against uncertainties, sector-level support may be needed to mitigate risks such as end user mistrust.

An overview of the concluding mechanisms for successful collaboration is shown in Figure 1.

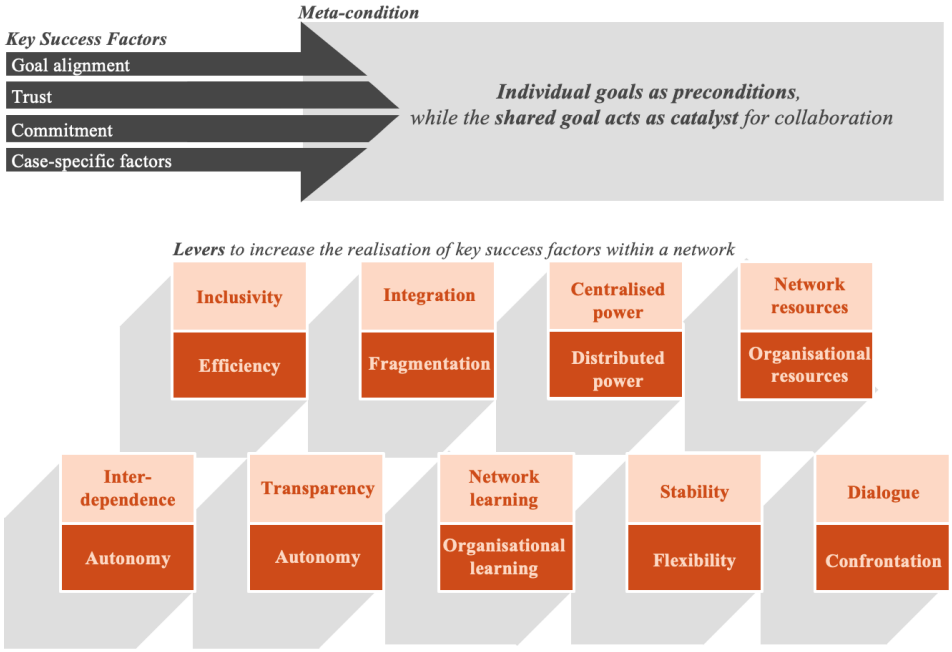


Figure 1: Overview of the relation between the meta-condition, key success factors and tensions

Sector and practical implications

The fourth part of the research included the discussion and conclusions. The discussion tool designed in this study enables stakeholders to shift from reactive to proactive design of the collaborative process. More successful projects can reduce sector-wide uncertainties. One of the main market uncertainties is the development risk associated with the voluntary connection of end users. This is one of the bottlenecks that can be addressed by tension management within a project. More positive stories about district heating from the end user perspective can, for example, help increase trust that individual goals are safeguarded, which can increase the willingness to connect. However, tension management is not limited to project level. National initiatives, such as clearer regulatory frameworks or public campaigns, could help address structural mistrust. Sector-wide, a better balance is needed between safeguarding public values and protecting private sector interests. While recent regulatory proposals aim to safeguard public goals, they have introduced uncertainties for private actors, particularly regarding long-term investment conditions.

Theoretical contribution

This study confirms that tensions are not just obstacles, but can be used as levers. Their impact is context-dependent and dynamic. Second, this study builds on purpose-oriented network literature by showing that individual and shared goals are not static. They evolve dynamically. A unified network can, for example, function even if the roles in the heat chain are fragmented over different parties, if the shared goal remains central. Third, the findings reinforce the idea in collaborative governance that collaboration is shaped by historical relations, distributed authority and incentives. Pre-existing roles and relationships had influenced the success of collaboration across the cases.

Applicability of findings

The findings apply primarily to district heating networks in the Netherlands involving public-private collaboration. They are most relevant to single-system networks with municipal involvement. Results may be less applicable to fully privatised systems or a liberalised market context. Limitations include that only operational cases were incorporated in the analysis. Not analysing failed projects introduced survival bias. Second, the public character of cases may have biased findings towards public value themes. Lastly, the findings have limited generalisability beyond Dutch institutional context.

Future research

This research is situated within the inductive phase of the scientific cycle. It provides a conceptual and empirical foundation for future research on collaboration in district heating networks. Several new research areas were identified. Future research could include failed projects to identify breakdown mechanisms and include the decline phase of the network. Also, a longitudinal study could be performed to analyse how tensions and the meta-condition evolve. The public-private dynamic under changing regulations could further be investigated. Cross-country comparisons could provide insights into institutional differences. Furthermore, the relation between tensions and collaborative outcomes can be modelled quantitatively by increasing the sample size and/or conducting a large-scale survey. Another avenue for research could be an analysis of which tensions can be best managed at the project versus at sector level. Finally, it is advised to shift the current academic debate around the heat chain configuration towards end user engagement, as this was identified as one of the most important bottlenecks.

This study demonstrates that successful collaboration in district heating networks is not a fixed outcome, but a dynamic process. By approaching collaboration as a process that can be intentionally designed and managed, stakeholders can better address complexities and uncertainties. Tension management is therefore not merely a theoretical concept, but a practical strategy to improve collaborative capacity in the Dutch energy transition.

Contents

List of Figures

List of Tables

List of Interviews

Interviews for validating analytical framework

Referring to the expert interviews

Role	Referred to as:	Date
Energy Expert	Energy Expert (int. EE, 2024)	13 November 2024
Legal Expert	Legal Expert (int. LE, 2024)	19 November 2024

Interviews for data gathering in case studies

Referring to the interviews for analytical framework

Role	Referred to as:	Date
Case study 1	INT1	11 December 2024
	INT2	12 December 2024
	INT3	16 December 2024
	INT4	17 January 2025
Case study 2	INT5	17 December 2024
	INT6	13 January 2025
	INT7	16 January 2025
	INT8	19 December 2025
Case study 3	INT9	14 January 2025
	INT10	14 January 2025
	INT11	10 January 2025
	INT12	17 January 2025
	INT13	7 January 2025

Respondents in the practical tool evaluation session

Referring to the respondents that participated in the evaluation session of the practical tool

Role	Referred to as:	Date
Hybrid (public-private) collaboration expert	Hybrid Expert (Evaluation session, 2025)	04 March 2025
Market expert	Market Expert (Evaluation session, 2025)	04 March 2025

Glossary

Abbreviation	Meaning
CAPEX	Capital Expenditures
CG	Collaborative Governance
CME	Construction Management and Engineering
DH	District Heating
DH Company	District Heating Company
DH System	District Heating System, meaning the physical system and infrastructure
DHN	District Heating Network. This refers to the stakeholder configuration of a district heating system
NGT	Nominal Group Technique. This is an interview technique used for the expert evaluation session
MSc	Master of Science
PON	Purpose-Oriented Network. This term refers to the network of stakeholders operating a district heating system.
RES	Regional Energy Strategy
SQ	Sub research Question
Wcw	The proposed Heat Act, Wetsvoorstel Collective Warmtevoorzieningen
Wgiw	Wet Gemeentelijke Instrumenten Warmtetransitie

1

Introduction

The heating and cooling sector accounts for approximately half of Europe's final energy consumption (Bertelsen et al., 2021; Lygnerud, 2018), a significant portion of which is currently met by fossil fuels such as gas-fired boilers (Nieuwenhout, 2022). The measures required to meet the European Union's climate goals and commitments of the Paris Agreements are increasing in urgency, as the deadlines approach and significant change is still needed. The European Union has the goal to increase the market share of district heating in the overall heat sector as a means to achieve its climate goals (European Commission et al., 2022), particularly within densely populated areas where individual heating systems are less efficient, space-efficient and harder to decarbonise. District heating (in short: DH) is a system that distributes heat generated in a centralised location for residential, commercial or (small) industrial needs. These systems offer the opportunity to decarbonise heat supply by integrating renewable energy sources (Di Lucia & Ericsson, 2014), waste heat recovery (Paardekooper et al., 2018) and industrial excess heat (Lygnerud, 2018).

The Netherlands has the ambition to move away from natural gas as a primary energy source. The Dutch heat transition refers to removing the use of natural gas from industry, the built environment and the agricultural sector (Henrich & Maas, 2020), and replacing it with sustainable heating alternatives. This is challenging, as decision-making in this transition is far from simple. The sustainable heat sector in the Netherlands still needs to grow significantly to achieve the Paris goals of reducing greenhouse gas emissions by 49% in 2030 and even 95% by 2050 compared to 1990 levels (Ministerie van Economische Zaken en Klimaat, 2022). District heating is a known, technically viable option to reduce the reliance on fossil fuels and decarbonise the heat system to achieve these goals. These systems typically consist of a central heat source, distribution network, and a series of heat exchangers that transfer the heat to end users (Bertelsen et al., 2021) and are operated by a district heating company (in short: DH company), which is responsible for the generation, distribution and/or supply of heat to end users. However, only 3% of the residential heat demand in the Netherlands is currently supplied by DH systems (European Commission et al., 2022), as can be seen in Figure 1.1. The Netherlands is significantly below the European level of average market share of district heating systems.

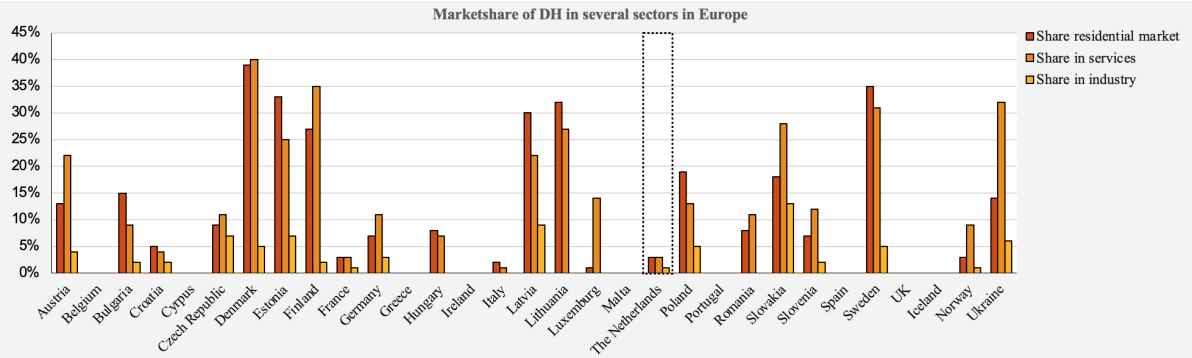


Figure 1.1: The Dutch market share of district heating is very low compared to other countries in the EU; made by author using data from European Commission et al. (2022)

1.1. Problem formulation

District heating systems offer a more sustainable collective alternative to natural gas (Van Heiningen, 2024). In 2023, large Dutch district heating systems (with more than 500 connections) achieved a 50,9% saving in CO2-emissions compared to the widely used high-efficiency gas boiler according to the research of Rijksdienst voor Ondernemend Nederland (2024). According to Bertelsen et al. (2021), district heating has significant potential to increase energy efficiency and integrate renewable energy sources in line with EU targets and Paris Agreements. They are categorised into five generations, with the latest focusing on energy efficiency and the use of renewable energy sources (Yao et al., 2024).

District heating systems facilitate the use of energy sources that would otherwise not yet be accessible for heating purposes, for example aquathermal energy, geothermal energy, waste heat, bioenergy (Valize, 2024; Werner, 2017). Secondly, these systems provide flexibility in the heat market to handle shocks, as multiple heat sources can supply the network. If one fails, other sources can be used as back-up which makes these systems more reliable for end users. Thirdly, these systems have the ability to store excess electricity, for example by storing it in water tanks, which can help stabilise grid congestion (Gonzalez-Castellanos et al., 2021). This is especially relevant as renewable energy and electrification are expanding rapidly, causing many electrical distributions to experience grid congestion (De Winkel et al., 2025).

These advantages led the Dutch government to set a target of realising 500.000 new DH connections in the current building stock by 2030 compared to 2019 (Diersen, 2022). In 2019, the number of connections was around 300,000 connections (Segers et al., 2019). Currently, midway through the target period, the number of total connections stands at approximately 515,000 (Rekenkamer, 2025). However, the growth rate has significantly declined, as each year fewer and fewer new connections are realised. For example, Vattenfall has reduced its own target from 10,000-15,000 new connections per year to 6,000-7,000 (De Ronde, 2024b). In 2023, Vattenfall only connected 3,575 new households and fourteen businesses. That was 10.3% less than the year before (De Ronde, 2024b). In 2023, the entire market only saw 22,000 new connections in the current building stock (Rijksdienst voor Ondernemend Nederland, 2024). The district heating market share in the Netherlands remains low (Chapter 1.1 and new plans are delayed (De Ronde, 2023). The decline in participation and investment can be attributed to regulatory changes, policy uncertainties (De Ronde, 2024a) and market uncertainties (Kokkonen & Vaagaasar, 2017). The Dutch government's proposed Heat Act, (in Dutch: the Wet Collectieve Warmtevoorzieningen), that is expected to go into effect in the beginning of 2026, introduces a new collaborative structure for managing district heating. It will require a shift from separate entities handling the heat production, distribution, and supply to one integrated district heating company. Some literature states that the optimal collaborative structure is separate entities handling the heat chain, while others perceive one company responsible for the entire heat chain as preferable (Martinez et al., 2023). This external change offers an opportunity to explore the existing collaboration among the different actors in the district heating systems and draw lessons for the future district heating systems.

1.2. Regulatory context

District heating networks operate within an institutionally regulated market at European, national and regional/local level. This section outlines regulations to provide the context in which the stakeholders operate.

European/international Much policy and governance work is already set at European Union-level to enable district heating. The Energy Efficiency Directive sets minimum requirements to gradually increase the use of renewables and waste heat in heating systems (Annex IX of directive 2023/1791 (The European Parliament, The Council of the European Union, 2023)). The Renewable Energy Directive includes the legal framework for the development of green energy across the EU economy and introduces new provisions to promote and deploy renewable energy sources in district heating and cooling sectors in articles 23 and 24 ("Renewable Energy Directive", 2023). Furthermore, the Governance of the Energy Union and Climate Action (The European Parliament, 2018) mandates member states to create National Energy and Climate Plans, which outline national decarbonisation strategies (Bertelsen et al., 2021).

National In the Netherlands, the Heat Act (in Dutch: "Warmtewet") governs the regulation of district heating systems ("Warmtewet", 2014). The goal of the law is to protect consumers, while on the other hand ensuring reliable, sustainable and efficient heat supply. It sets rules around access to networks, regulated prices (linked to gas prices), obligations to negotiate and metering standards. These provisions define the roles and responsibilities

of producers, suppliers and network operators.

Regional and local At a local level, municipalities play a role in implementing the heat transition. Through the Heat Transition Vision ("in Dutch: "Transitie Visie Warmte"), each municipality outlines how and when neighbourhoods will switch from natural gas to sustainable alternatives (Van der Molen et al., 2023). The Regional Energy Strategy coordinates energy sources across municipalities to avoid overlap and make efficient use of local resources (RES, n.d.). Implementation is further detailed in District Implementation Plans ("in Dutch: wijkuitvoeringsplan"), which are developed collaboratively with local residents and building owners (Rijksdienst voor Ondernemend Nederland, 2019). These plans consider technical feasibility, costs and social implications (Tweede Kamer der Staten-Generaal, 2024).

Regulatory developments There are currently two regulatory changes underway that directly affect the Dutch district heating sector (Netbeheer Nederland, 2024; Van Der Lugt, 2024). The first one is the proposed New Heat Act (in Dutch "Wetsvoorstel Collectieve Warmtevoorzieningen", in short: Wcw). This act aims to enhance public control over the heat transition (Consumer Protection, p.6 explanatory memorandum (Tweede Kamer der Staten-Generaal, 2024)). One of the key provisions is that only organisations with majority public ownership can be appointed to develop and operate district heating systems. This represents a shift from the current market, where private companies dominate the district heating market (Valize, 2024). Under the new law, a publicly owned company would become responsible for the entire heat chain, from production to supply (article 2.2). The second proposed change is the Act Municipal Instruments for the Heat Transition (in Dutch "Wetsvoorstel Gemeentelijke Instrumenten Warmtetransitie", in short: Wgiw), which gives municipalities additional legal instruments to guide the shift from natural gas to sustainable heating solutions in the built environment (“Wet gemeentelijke instrumenten warmtetransitie (36.387)”, 2024).

1.3. Societal relevance

The financial feasibility of district heating depends largely on the costs made and the number of households that connect to the network (Werner, 2017). According to Berenschot (2024), collective heating systems, such as district heating networks, can provide cost-effective and sustainable solutions at scale, especially in high density urban environments. However, their financial viability is dependent on the participation rate. Collective heat systems, such as district heating, compete with individual solutions such as the all-electric heat pump. Individual solutions such as the heat pump have the large disadvantage that they increase grid congestion (Berenschot, 2024), while district heating networks can help decrease grid congestion (Gonzalez-Castellanos et al., 2021). Both types of sustainable heat systems can be applied to facilitate the Dutch energy transition, but their competition has a negative effect on the feasibility of district heating networks (Berenschot, 2024). As more residents are opting for individual heat solutions such as the all-electric heat pump, district heating projects risk becoming less attractive for investors and municipalities, ultimately leading to a weaker business case. Given the urgency of the energy transition and the worsening grid congestion, the expansion of DH systems must be a priority now, while it still is a feasible option for decarbonisation.

1.4. Scientific relevance

District heating is increasingly more important in the shift away from natural gas (Martinez et al., 2022). However, unlike the gas and electricity sector, there is no strict division between parties in district heating networks, production or supply through the network (Nieuwenhout, 2022). In order to realise the benefits of district heating, the collaboration between these stakeholders should be optimised. Yet, the complex and dynamic dependencies in the heat chain (Dieperink & Teulings, 2021), as well as the potential effects of the new Heat Act, remain under-researched in existing literature. Researchers have been defining and studying cross-organisational collaboration from different perspectives. For example, as collaboration processes (Daniels & Walker, 2001; La Forme et al., 2007); collaborative planning (Bentrup, 2001; Innes & Booher, 1999); collaborative conflict resolution (Emerson et al., 2009) and collaborative management (Gerlak & Heikkila, 2006). In this study, **collaboration** is defined as the set of communicative practices in which representatives from multiple organisations engage, working interdependently to address issues that cannot be resolved by individuals or organisations acting in isolation (Keyton et al., 2008).

Thollander et al. (2010) performed a case study in Sweden on the collaboration between energy utilities and industry in district heating systems. It concluded that successful collaboration in the Swedish district heating

sector depends more on the individuals and organisations involved in the relationship between two parties than on the technology used in the collaboration. The 'human factor' affected the collaborations more than all other factors, particularly risk, credibility and trust, imperfect and asymmetric information, values and inertia. While the technology for district heating systems already exists (Paardekooper et al., 2018; Yao et al., 2024), there are challenges in organising collaboration between the stakeholders involved in the heat chain, such as public entities, energy utilities and private companies (Dzebo & Nykvist, 2017; Unruh, 2000). The resource exchanges between these parties cause interfaces that need to be managed. The complex interdependence and dynamic relations of infrastructure projects make them extra challenging to manage (Gondia et al., 2022). According to Eriksson et al. (2017), future infrastructure projects are expected to rely even more on collaboration as a way of tackling challenges (Vangen & Huxham, 2003) of the increased level of interdependence between infrastructure owners during the design, development, implementation and management of these projects.

Existing literature, such as studies by Martinez et al. (2023) and Kokkonen and Vaagaasar (2017), have concluded that there is a link between the collaboration between different parties in the heat chain, the performance of a district heating system, and efficiency of processes. Nezami et al. (2024) argued that the ability to design and evaluate collaboration is key to managing multi-disciplinary projects such as district heating, where actors share resources and expertise to develop resilient and sustainable infrastructure. Multi-disciplinary skills and knowledge are essential to develop district heating systems (Grafius et al., 2020). The collaboration directly affects the efficiency and resilience of infrastructure projects (Eriksson et al., 2017; Grafius et al., 2020). Kokkonen and Vaagaasar (2017) agreed that the success of complex infrastructure projects heavily depends on the quality of collaboration between the different organisations involved. "The better the collaboration, the better the outcome of a project", is what Emmitt and Ruikar (2013) stated. However, this can be very difficult to achieve. Lack of collaboration, insufficient participation from project team members and poor communication are often identified in the infrastructure sector. Successful organisational partnerships do not emerge spontaneously, even though it is known to have the capacity to leverage fragmented systems and produce increased innovation and efficiency (Grafius et al., 2020; Woodland & Hutton, 2012).

District heating systems are operated by multiple stakeholders. Over the past decades, stakeholder networks in the public domain have been conceptualised under various labels, such as policy networks, collaborative governance regimes and goal-directed networks (Ansell & Gash, 2007; Emerson et al., 2009; Provan & Kenis, 2008). Even though these terms often overlap in their focus on cross-organisational collaboration, they have also caused confusion in the academic field; sometimes similar network types are even referred to using different terminology or vice versa. During international workshops held in Barcelona (in 2016) and Arizona (in 2019), scholars identified the term goal-directed networks as potentially misleading, as they suggest that shared goals are already defined and agreed up front, while such goals are often dynamic, contested, and evolving (Nowell & Kenis, 2019). As a result, the concept of **purpose-oriented networks** (in short: PONs) was introduced. It aimed to better capture intentionally formed collaborations around public concerns without presuming goal consensus. PONs are defined as organised collaborations between three or more autonomous organisations that deliberately work together to address a shared purpose that cannot be solved by individual actors alone (Carboni et al., 2019; Herranz, 2009; Ring & Van De Ven, 1994; Saz-Carranza & Vernis, 2006; Sydow & Windeler, 1998). What distinguishes PON theory from traditional network models is its attention to the architecture of complexity. It pays attention to the interplay between purpose and operating context, the interplay between emergent and engineering structures and the interactions across individual, organisational and network levels of analysis (Nowell & Kenis, 2019). Seen through this lens, collaboration is not merely a structural arrangement, but a dynamic process shaped by continuous adaptation, negotiation and interdependence. This conceptual grounding provided a starting point for analysing district heating systems where boundaries, goals and roles of actors can be fluid and subject to change.

Building on this, Berthod and Segato (2019) emphasised that tensions are not just incidental but inherent features of collaboration within purpose-oriented networks. PONs often trigger paradoxical tensions such as inclusivity versus efficiency and autonomy versus inter-dependencies. These tensions stem from the dynamic and adaptive nature of collaboration where stakeholders with varying interests and capacities continuously negotiate their roles, responsibilities and contributions. Berthod and Segato (2019) advocated for a process perspective that sees district heating systems as manifestations of underlying and ongoing processes. This perspective is especially relevant to district heating, which, although appearing to be fixed physical infrastructure, is highly dependent on ongoing collaboration, external regulation and shifting technological conditions. The management of such systems requires careful navigation of inherent tensions (Berthod & Segato, 2019). As no single stakeholder holds complete authority over the entire network, managing a district heating system resembles managing a

purpose-oriented network: a complex, multi-actor and fluid. These characteristics have also been explored in **collaborative governance** literature, which focuses on how public, private and non-profit organisations (jointly) engage in and are accountable for the delivery of public value that could not be achieved alone (Voets et al., 2021).

While there is a substantial body of research on the technical aspect of district heating systems, there remains a limited understanding of the collaborative processes and governance mechanisms that sustain such networks (Emmitt & Ruikar, 2013; Gondia et al., 2022; Pamidimukkala et al., 2021). In particular, the process-based tensions that arise during network development remain under-explored (Berthod & Segato, 2019). It remains unclear what types of tensions arise during collaboration and to what extent their management can become a central object of network governance. Berthod and Segato (2019) underscored the need for a better conceptual and empirical understanding of such tensions, arguing that identifying and analysing them is essential for improving collaborative performance. Additionally, there is a growing body of literature on district heating being embedded in certain socio-technical regimes that complicate the collaborative process even more. The socio-technical regime includes technology, regulating markets and institutional frameworks (Unruh, 2000). These regimes shape the actions and interactions of stakeholders (Dzebo & Nykvist, 2017). The development of heat infrastructure requires large-scale resources, budget and various skills, which cannot be accomplished by working individually (Emmitt & Ruikar, 2013; Gondia et al., 2022; Pamidimukkala et al., 2021). Despite these factors being important, little is known about how to **use these dynamics** to manage district heating networks. As Thomson and Perry (2006) noted, collaboration in complex systems such as district heating often remains a "black box". Yet, understanding and unpacking this black box can contribute to network management (Thomson & Perry, 2006).

1.5. Relevance for MSc Construction Management & Engineering

The master programme Construction Management & Engineering prepares students to address the complexities of infrastructural projects (TU Delft, n.d.). This research contributes to that goal by analysing collaboration in district heating networks, which is a relevant system in the transition to sustainable energy. This study aligns with the core themes of the programme by integrating knowledge of engineering, management and legal aspects. Conducted within the context of a consultancy firm, the research reflects a professional environment in which strategic collaboration and regulatory awareness are important in delivering complex infrastructure projects. The study reflects academic research that is scientifically robust and practically valuable for decision-making in the Dutch district heating market.

1.6. Research design

! **Research objective**: The challenges that the district heating sector faces are not just technological, they are also structural and organisational. By understanding the factors that contribute to successful collaboration to develop the network, this research aims to identify ways to re-incentivise and scale-up the sector. The main research question reads as follows:

"What conditions define successful collaboration during the construction, operation and exploitation of district heating"?

Table 1.1: Scope: Definition of highlighted terms in main research question

District heating	A centralised system that distributes heat to residential, commercial and industrial buildings via a network of insulated pipes. It can combine multiple (renewable) heat sources that otherwise might not be usable (Bertelsen et al., 2021).
Collaboration	Set of (communicative) practices in which representatives from multiple organisations engage, working independently to address issues that cannot be resolved by individuals or organisations acting in isolation (Keyton et al., 2008).
Conditions	Circumstances and relational factors that shape the collaborative process, analysed through process tensions (Berthod & Segato, 2019).

The main question is split into five sub questions.

1. How is collaboration initiated and formalised in district heating networks?
2. What types of process tensions arise while developing district heating networks?

3. What are the key success factors for collaboration and how do process tensions affect them?
4. How should the collaborative process in district heating networks be designed?
5. How are external changes in regulations expected to affect the collaborative process in district heating networks?

The first three sub questions are descriptive. It starts with analysing what aspects are important in setting up the collaboration in the network (SQ1). After conceptualising how the collaboration is initiated and formalised, it is analysed what process tensions can arise during the network development (SQ2). Then, it is analysed how the design of the collaborative process influences the success of the collaboration (SQ3). This is followed by a prescriptive part, in which it aims to generalise how the collaborative process should be designed (SQ4). Lastly, it is analysed how external changes such as new regulations will change the way stakeholders are involved in the network. Some conditions might de-prioritise, while others might become more important, which is an explorative part of the research (SQ5).

Scope The scope can be seen in Table 1.1, where the highlighted terms of the main research questions are outlined. This study is situated within the framework of collaborative governance in infrastructure networks, with a specific focus on single-system, multi-actor settings. The research focuses on the Dutch district heating sector, because the sector is context specific and regulations differ between countries. Findings may be particularly relevant for comparable systems in other countries with similar governance structures, but generalisations should be done with caution as there might be differences in the local institutional, regulatory and technical contexts. It specifically addresses networks that supply heat to residential areas, small industries and service-oriented users such as foundations and associations (article 1 of the Heat Act, ("Warmtewet", 2014). Only **contiguous** heating systems with a single distribution party are included. As such, results are applicable to district heating networks where heat production, distribution and supply are managed by actors within one system. Transmission system operators connecting multiple district heating networks are excluded, as this would broaden the analysis beyond a single district heating system and introduce additional variables related to inter-system governance.

Summary 1: Introduction

! Each chapter ends with a **summary box** similar to this one. These boxes provide a quick overview of the main points addressed in the chapter. They are useful for revisiting key arguments, tracing the development of the analysis, or navigating through the document more efficiently. Readers can use the summary boxes as reference points to recall the chapter's focus without rereading the entire text.

This chapter explained the problem formulation, the regulatory context, the relevance and the research design. District heating provides a **promising alternative** to natural gas by enabling the use of sustainable heat sources, providing market flexibility and supporting grid stability. Despite its potential and the Dutch government's ambition to expand its use, the sector is currently facing **stagnation due to regulatory developments, uncertainties and market uncertainties**. Even though much attention has been given to the technical aspects of district heating, there is limited knowledge on the **collaborative processes** and **governance mechanisms** that make these systems function. It remains unclear how collaboration in the Dutch district heating sector can be conceptualised, managed and sustained over time.

This research aims to address these gaps by focusing on the structural and organisational aspects of collaboration. It seeks to understand what enables successful collaboration in district heating projects and how this can reduce uncertainties and re-incentivise the sector. This research focuses on the **collaboration formation** (how stakeholders initiate collaboration, define roles and formalise agreements), **collaboration maturation** (how collaborative patterns evolve, stabilise or shift over time), and **tension management** (how inherent tensions in the collaborative process influence the quality of collaboration and how this can be managed. The main research question is: **"What conditions define successful collaboration during the construction, operation and exploitation of district heating?"**.

The following chapter outlines the methodology employed in the research.

2

Methodology

A qualitative, interpretative approach was chosen, as there is little existing research on collaboration in district heating and due to the many complexities involved (De Bruijne, 2023). The research design consisted of literature review and case studies. The research was divided into four parts:

- The first part consisted of setting up the analytical framework used to conceptualise how the collaborative process works in district heating networks. This was the basis for the other research questions and is explained in Section 2.1;
- The second part consisted of empirical data gathering about how collaboration was developed in case studies, the key success factors and how the process affected the key success factors. This was explained in Section 2.2;
- Lastly, the gathered data was analysed. It was analysed how the collaborative process developed through (inherent) tension management. An analysis was made of how the collaborative process should be designed. This part included an analysis of how external regulatory changes such as the proposed Heat Act were expected to affect collaboration in these networks, which is explained in Section 2.3;
- Lastly, the results were synthesised in the discussion and conclusions in Section 2.4.

2.1. Setting up the analytical framework

The research started by developing a framework which provided the theoretical foundation for network analysis. Berthod and Segato (2019) developed a process view on the development of purpose-oriented networks (PONs). The authors proposed that PONs are not static entities but rather interconnected processes that evolve dynamically. They are shaped by the actions of stakeholders and by reflective management. In Chapter 3, the collaborative process and the network development are conceptualised. The conceptualisation started with a literature review.

2.1.1. Literature review

A structured literature review was conducted to support the development of the analytical framework. Databases searched included Google Scholar, JSTOR, TU Delft Repository, Scopus and WorldCat Discovery. The review focused on three key areas: (1) theories of collaborative governance relevant to district heating systems, (2) inter-organisational collaboration models applicable to district heating networks and (3) process tensions in multi-actor networks.

Search terms were derived and listed in Table 2.1. Selection criteria included conceptual clarity, relevance to networked infrastructure and empirical applicability. Six models were selected for further assessment based on their ability to conceptualise collaboration in networks. Each model is described and assessed using the analytical grid of Estampe et al. (2010), which facilitates comparison of collaborative frameworks. These models form the basis of the analytical framework discussed in Chapter 3.

Table 2.1: Literature searches

	Input in search engine
SEARCH 1	"Inter-organisational collaboration" OR Collaboration AND Evaluation OR Model OR Framework
SEARCH 2	"Inter-organisational collaboration" OR Collaboration AND Evaluation OR Assess* OR Framework AND Infrastructure OR services OR energy OR "District heating"
SEARCH 3	"Collaborative Governance"
SEARCH 4	"Collaborative Governance" AND Infrastructure OR services OR energy OR "District heating"
SEARCH 5	Tensions AND network

2.1.2. Measuring process tensions

Applying the process perspective of Berthod and Segato (2019) to district heating networks enabled an analysis focused on the role of tensions. Bakken and Hernes (2006) and Tsoukas and Chia (2002) argued that tension management could be a central object in network development. During the development of district heating networks, process tensions inevitably emerge, each with specific causes and effects. The analytical framework was designed to capture both initial collaboration conditions and emerging dynamic tensions. To systematically assess their impact on collaboration, this study applied a Likert-scale assessment, which is a common social sciences tool. It provided data intervals to capture an underlying continuous variable and as it could be applied to qualitative research (Tanujaya et al., 2022). A 5-point scale was chosen to balance data richness with respondent ease, as it reduces fatigue compared to longer scales while offering significantly more nuance than a 3-point scale (Altuna & Arslan, 2016). Research showed no statistically significant differences regarding the 5- and 7-point versions considering the normality, internal structure and differences in means (Altuna & Arslan, 2016). With a 5-point scale, it could be expressed whether the network was characterised by one side of the tension, leaned toward one side, or remained neutral. The scale was structured as:

- -2: Strongly favours one side of the tension;
- -1: Leans towards one side of the tension;
- 0: Neutral position;
- +1 Leans toward the other side;
- +2 Strongly favours the other side.

The Likert-scale aimed to reveal how tensions arise and are managed, allowing respondents to indicate their position during interviews. The selected tensions are further detailed in Chapter 3 Analytical Framework to maintain a clear distinction between methodology and theoretical development.

2.1.3. Evaluation through expert interviews

After constructing the initial version of the analytical framework, it was refined and validated through semi-structured expert interviews. This format was chosen over a structured and unstructured interview to allow exploration of expert perspectives while keeping the focus on the key elements of the framework (De La Croix et al., 2018). One-on-one interviews were conducted instead of a focus group, because each expert had their own specific knowledge and thus a different focus within the framework. The first interview conducted was with an **energy market expert** selected for their extensive knowledge of the Dutch energy transition and collaboration between industrial, infrastructural and energy actors. The second interview was held with a **legal expert**, whose expertise was in the Dutch regulatory framework and the design of contractual arrangements in district heating networks. This expert operated at the interface between public and private sectors, advising energy companies on how to collaborate with municipalities. Both contributed to the elaboration and refinement of the clarity and applicability of the framework. The interview protocols can be found in Appendix D. In Chapter 3, analytical framework, they are referred to as the 'Energy Expert (int. EE, 2024)' or the 'Legal Expert (int. LE, 2024)'.

2.2. Data gathering from case studies

Yin (2003) defined a case study design as creating a connection between the empirical data, the study's initial research questions, and to its conclusions. For the case study analysis, the process of building theories from case study analysis from Eisenhardt (1989) was applied. The case studies were used to identify causes and effects, to link conditions to key success factors for collaboration. How did the conditions occur, and how did managing them affect the key success factors? This was followed by backward reasoning in the prescriptive part of the study.

2.2.1. Case study methodology

Yin (2003) stated that there were four main case study designs: holistic design, single embedded design, multiple holistic design, and multiple embedded design. Holistic research designs require one unit of analysis within the case(s), whereas embedded researches require multiple units of analysis within the case(s). Also, research could use one single or multiple cases. A **multiple embedded design** was chosen as this fits the research objectives better than the other three designs. District heating networks are complex, comprising sub-units that operate in distinct contexts and require consideration as separate organisational role. The primary unit was one district heating network (DHN); and the embedded sub units were the key organisations within each DHN. The number of case studies was set at three due to time constraints of this study. The case study selection was stated in Chapter 4.

2.2.2. Entering the field: data collection procedures

The data collection consisted of three methods:

- Interviews with representatives from each stakeholder group within each case (case study sub-unit);
- Review of (grey) literature (policy documents, newspaper, previous studies);
- Literature synthesis to contextualise the empirical findings.

To enable triangulation of interview data and allow verification, the following minimum response rules were applied:

1. At least 3 interviews per case study to cover the majority of sub-units;
2. Each key stakeholder role had to be represented in at least two interviews across all cases.

For each case, a data review checklist was logged. This concluded with an assessment of the extent to which there was alignment or conflict in data from different sources. This triangulation of data was used for validation, as it assessed whether findings align with evidence from multiple sources and were fit-for-purpose. The data review checklist can be found in Appendix E. The data gathering can be read in more detail in Chapter 4.

2.3. Case analysis

Interview transcripts were coded in **Atlas.ti** to extract overarching themes related to collaboration. After that, within-case and cross-case analysis was performed to understand the mechanisms driving successful collaboration. The analysis followed a qualitative approach, applying thematic coding and analysing the causes and effects of tensions and their management. An inductive approach was chosen which involves generating knowledge from the ground up, as this is a new research area (Hecker & Kalpokas, 2025).

2.3.1. Co-occurrence analysis

The key success factors were derived from interview data, rather than literature, as respondents had first-hand experience with collaboration in their context, and existing scientific literature on success metrics in district heating collaboration is limited. To assess the relationship between the key success factors and the tensions that affect its realisation, a co-occurrence analysis was conducted. Although the underlying data was derived from qualitative sources, the analysis was feasible because the variables were converted into a numerical value by counting their occurrences in the interview transcripts using Atlas.ti. The coding scheme is presented in Appendix C.

The word count of the following variables was systematically counted:

- The number of respondents mentioning each key success factor;
- The number of times a tension is mentioned associated with a certain phase;

- The number of times a tension is mentioned associated with one or more stakeholder(s);
- The number of key success factors that are mentioned to be affected by the tensions.

The case analysis followed three steps:

- Step 1: It was analysed which key success factors were named;
- Step 2: The co-occurrence of concepts was analysed:
  - First, co-occurrence analysis of the tensions with the collaborative phases was performed to identify which phases were most tension prone;
  - Second, a co-occurrence analysis between tensions and stakeholder roles was performed. The goal was to identify which stakeholders are involved in its management;
  - Third, co-occurrence analysis was performed between which tensions affected the realisation of which key success factors.
- Step 3: It was compared how the respondents believed the tension should have been managed.

By analysing when the tensions arose, who was involved in managing them and what effect they had on the key success factors for collaboration, SQ3 was answered. Based on this inductive analysis, it was determined what lessons could be learned on how the collaborative process should be designed to address SQ4. These lessons learned about setting-up and maintaining successful collaboration were presented in a **practical, tangible tool** that stakeholders can use during the network development. This tool presents the scientific results in a way that supports the design of collaborative structures in district heating networks.

2.3.2. Scenario-analysis

The last part of the data analysis was an explorative analysis on the regulatory changes. A scenario analysis was performed on the effect of two currently proposed regulatory changes that apply to district heating markets to answer SQ5.

2.3.3. Expert evaluation session

The results and the practical tool were **evaluated with an expert session**. The aim of the session was to assess (1) the applicability of the concept, (2) the clarity in use, and (3) the expected impact on the district heating sector. Two experts participated: one with in-depth knowledge of hybrid (public/private) collaboration structures, and one with extensive experience in the district heating sector (having worked in the sector from within the municipality, as well as in heat production and distribution). A **focus group** was chosen over individual interviews to enable participants to respond to each other's ideas and stimulate discussion. According to De La Croix et al. (2018), focus groups can reveal dynamics that individual interviews might overlook particularly when participants build upon or challenge each other's viewpoint. However, this method also introduced risks, such as having a dominant voice that overshadows the other, or that some ideas remain unspoken due to group dynamics. These risks were mitigated by selecting participants with equal status and familiarity with open discussion and by structuring the session using the **nominal group technique**. This technique combined individual reflection with collective prioritisation to ensure independent input and group discussion. It consisted of four steps:

1. Each expert wrote down their opinion on the three topics individually, using post-its;
2. All ideas on the post-its were read aloud;
3. A group discussion took place;
4. The most important feedback was reflected upon.

This method ensured that each participant had an equal opportunity to contribute and contained the synthesis of key validation points.

2.4. Conclusions

2.4.1. Congruence analysis

The study ended with a congruence analysis to compare the empirical findings with theoretical expectations. It was applied to assess how well the applied theories explained the mechanisms or outcomes to challenge the

analytical framework. It was analysed whether tension management could be a central object of managing district heating networks, and the fit-for-purpose of using purpose-oriented network literature. Based on the data analysis, results and the practical tool, conclusions were drawn.

Summary 2: Methodology

The research methodology included a literature review, expert interviews, case study interviews and qualitative data analysis. Figure 2.1 summarises the methodology and links with the chapter.

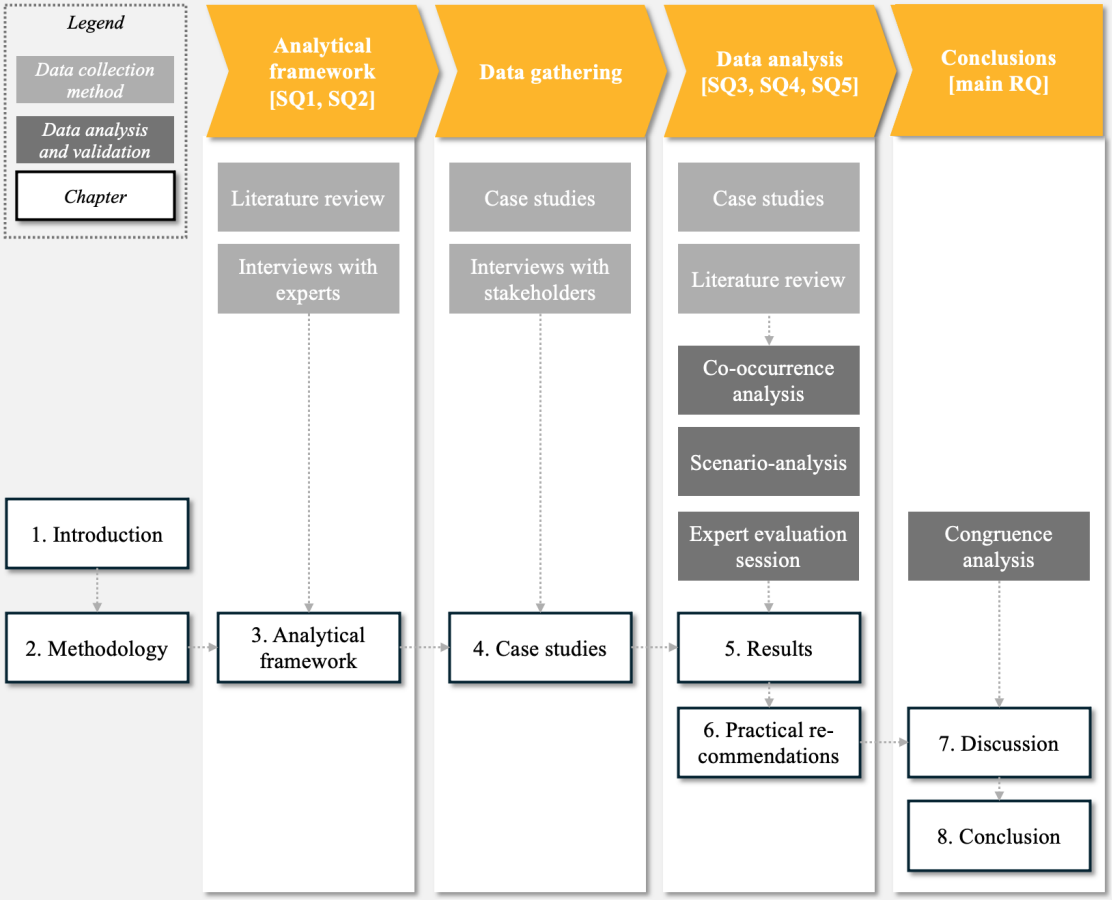


Figure 2.1: Summary of Chapter 2: Methodology, and report lay-out

Through the **literature review** and **expert interviews**, this study conceptualised how collaboration is initiated and formalised in district heating networks, addressing sub question 1. The literature review also identified process tensions that may arise during network development, answering sub question 2. Both aspects are elaborated in Chapter 3 Analytical framework. The analytical framework was then applied to collected data from **case studies**, with data collection methods detailed in Chapter 4 Case studies. In Chapter 5 Results, the findings related to the next three sub questions are presented. First, the study applied a **co-occurrence analysis** to map when the tensions arose, who was involved in managing them and their impact on the key success factors for collaboration which informed the answer to sub question 3. Lessons were then derived on how the collaborative process should be designed, which led to answering sub question 4. A **scenario-analysis** was conducted to examine the potential impact of two proposed regulatory changes in the district heating sector, used to explore sub question 5. Chapter 6 introduces a practical tool based on these findings, which was evaluated through an **expert evaluation session**. Finally, a **congruence analysis** was conducted in Chapter 7 Discussion, after which Chapter 8 Conclusions was written.

The next chapter presents the analytical framework for case study analysis.

3

Analytical framework for case study analysis

This chapter presents the analytical framework used for data gathering. All key concepts are explained, starting with a description of existing models in Section 3.1. Based on that, the four items below are conceptualised in Section 3.2:

1. The main stakeholders involved in the network;
2. The phases in the network development;
3. The tensions that can arise during the network development;
4. Measuring the 'success' of the collaboration.

3.1. Existing models for operationalising the collaboration process

This section presents six existing models that can be applied to district heating networks, with the potential to conceptualise previously undefined factors. These models were identified using the search terms outlined in Table 2.1. Each model is described and assessed using the analytical grid of Estampe et al. (2010), which facilitates comparison of collaborative frameworks.

The **collaborative governance model** by Ansell and Gash (2007) is a theoretical framework that shows how different stakeholders work together to address complex public issues. It is relevant in situations when there is no single actor that can solve a problem alone and cooperation across multiple sectors is necessary. It is an iterative model that identifies that there are starting conditions before the parties start cooperating. Also, it incorporates institutional design and leadership with the collaborative process. The framework by La Forme et al. (2007) integrates two models: the **Collaboration Characterisation Model** and the **Collaboration-Oriented Performance Model**. These are based on five existing supply chain models (Gilmour, Cooper, SCOR, ASLOG, and EVALOG) and together assess both the nature and outcomes of collaboration. **Cooper's Model** (Cooper et al., 1997) focuses on aligning supply chain structures with internal processes and introduces internal benchmarking as a means to improve collaboration. The **Collaborative Assessment Tool** evaluates collaboration across seven critical categories. The framework can be seen as 'wheels to a vehicle', where improving one can make the entire vehicle go faster, and where one bad wheel can cause the entire vehicle to slow down (Marek et al., 2014). The **Inter-Organisational Collaboration Tool** focuses on horizontal collaboration between infrastructure owners and evaluates collaborative capacity at individual, relational, and organisational levels (Nezami et al., 2024). Finally, the **Collaboration Evaluation and Improvement Framework** (Woodland & Hutton, 2012) identifies five entry points to assess and enhance collaboration. It supports evaluators in describing collaborations, measuring changes over time, and improving actor capacity for joint work.

A comparison of the six models follows on the next pages, in which their strengths, limitations, and relevance to district heating networks are shown.

Table 3.1: Literature review on models for assessing collaboration part 1

Characteristics	**1. Collaborative Governance model of Ansell and Gash**	**2. Collaboration characterisation model and Collaboration-oriented performance model**	**3. Cooper's model**
References	Ansell and Gash (2007)	La Forme et al. (2007)	Cooper et al. (1997)
Origin of model	Widely cited, especially in public policy and administration contexts, focusing on collaboration between government, private sector and civil society	2007, provides two models: a collaboration characterisation model and a collaboration-oriented performance model. Validated on a textile company	Created by the Ohio State University in 1994, based on models used in automobile sector
Type of analysis used	Relies on qualitative analysis, emphasises processes in collaborative governance, such as trust-building, commitment to the process and shared understanding	Qualitative and quantitative analysis based on triangular data	Describes three levels: strategic, tactical, and operational. Emphasises the link between supply chain process and structure
Conditions and constraints	Emphasise on iterative, adaptive processes rather than fixed stages. Multi-actor perspective	Creates a collaborative profile of the company by filling in the framework, which is process-oriented	Very broad, adapted to all kinds of companies
Degree of conceptualisation	5D-model with key variables: starting conditions, institutional design, facilitative leadership, collaborative processes and outcomes	CC = 3D, which incorporates processes, dimensions and level of dependencies between stakeholders; CoP combines this with performance indicators	Focuses on 7 processes, incl. customer relationship mgmt, customer service mgmt, demand mgmt, order fulfilment manufacturing, supplier relationship mgmt, product development and commercialisation.
Established indicators	Focuses on intermediate outcomes with feedback loops, that influence greater societal outcomes	Models processes and uses performance indicators: flexibility, reactivity, reliability and cost assessment	Enables internal benchmarking
Strengths for the research	Applicable in multi-actor public-private partnerships. Well suited for long-term collaboration and understanding the roles of trust in a cooperation	Process oriented and focuses on assessing the maturity and performance of collaboration between partners using structured key performance indicators (reliability, flexibility and costs)	Good for assessing alignment of strategic, tactical and operational processes and can be used on high-level governance and operational performance
Limitations for the research	The focus on trust-building might be a bit one-sided. There is no analysis for stakeholders and their dependencies included	Suited for operational efficiencies of current DHN, but does not incorporate the broader institutional environment. It also lacks the 'soft side'	Does not focus on public policy and institutions. Not optimised to public-private collaborations

Table 3.2: Literature review on models for assessing collaboration part 2

Characteristics	**4. Collaboration Assessment Tool**	**5. Inter-Organisational Assessment Tool**	**6. Collaboration Evaluation and Improvement Framework**
References	Marek et al. (2014)	Nezami et al. (2024)	Woodland and Hutton (2012)
Origin of model	Created in 2014	Created in 2024 by Faculty of Civil Engineering in Delft	2012, on behalf of the American Evaluation Association
Type of analysis used	Evaluative model; a seven-factor model of effective collaboration, with accompanying evaluation tool	Assessment model; revolves around questionnaire that assesses individual, relational and inter-organisational collaboration	Assessment model; both qualitative as quantitative analysis to evaluate the processes, dynamics and outcomes of collaboration across multiple organisations
Conditions and constraints	For evaluators, practitioners and for studying the complexity of collaborative processes	Developed for multi-owner infrastructure sectors, where there is horizontal inter-organisational collaboration. A more holistic, qualitative approach	Requires longitudinal analysis of all stakeholders involved
Degree of conceptualisation	Factors: context, membership, process and organisation, communication, function, resources and leadership. Factors are validated with a confirmatory factor analysis and showed strong internal consistency	The three types of collaborations explained in 12 criteria, and 36 sub criteria, validated by interviews	Five entry steps for analysis: 1: operationalise collaboration, 2: Identify and map communities of practice, 3: Monitor stages of development, 4: assess levels of integration, 5: assess cycles of inquiry
Established indicators	It describes the factors as interlocking gears that move the wheels of collaboration; the more gears spin in the appropriate directing, the better the collaboration goes	Enables benchmarking of collaboration between organisations in an infrastructural network	Includes levels of integration, stages of development and quality of collaborative processes
Strengths for the research	Useful for triangulating stakeholders' observations and can be applied in sectors with public and private actors	Integrates institutional arrangements, legal frameworks and the socio-political context.	Comprehensive method that incorporates collaboration in all life-cycle stages
Limitations for the research	Emphasise on internal processes, not so much on inter-organisational collaboration	Is made for horizontal integration, not vertical integration of organisations in a network. It only sketches an image of the capacities that enable collaboration	The longitudinal analysis is too time-consuming for this study

Justification for selecting the Collaborative Governance model of Ansell and Gash (2007) The collaborative governance model (CG-model) by Ansell and Gash (2007) was selected because it aligns with the research objective of analysing collaboration within district heating networks. Unlike prescriptive models, such as the collaborative assessment tool (model 4), the inter-organisational collaboration tool (model 5) and the collaboration evaluation and improvement framework (model 6), the CG-model offers a descriptive approach. It acknowledges the iterative and adaptive nature of collaborative processes, which fits the dynamic and often uncertain development of district heating networks. An important strength is that the CG-model acknowledges starting conditions. Collaboration does not happen in a void, but is shaped by a history of conflict or cooperation, by incentives to join the collaboration, and by regulations. This is very relevant in district heating networks. For example, the Energy Expert (int. EE, 2024) explained how past tensions between a housing corporation and a municipality in other projects negatively influenced their ability to work together on a new district heating initiative, even though the project itself was unrelated. The model also incorporates external influences, such as shifts in the regulatory environment. This is particularly important in the Dutch context, where two major policy changes, the "Wet collectieve Warmtevoorzieningen" and the "Wet Gemeentelijke Instrumenten Warmtetransitie" are expected to affect how collaboration is structured. Other reviewed models were less suitable for this objective. The framework by La Forme et al. (2007), is applicable for assessing supply chain performance, but lacks attention to institutional and multi-actor aspects of collaboration. Coopers' model (Cooper et al., 1997), although broad, is primarily designed for internal benchmarking and less applicable in a networked governance setting where no single actor is in control. The last three models are prescriptive, whereas a descriptive model is needed. In conclusion, the CG-model provides the most suitable basis for understanding and analysing collaboration in complex, multi-actor settings such as district heating networks. Combined with purpose-oriented network themes, it enables this study to define the stakeholders, the phases of network development, the tensions that arise and assess how external factors influence the collaborative process.

3.2. Conceptualising key elements in collaboration

3.2.1. Stakeholder roles in district heating networks

A district heating network consists of a number of stakeholders. The generic market roles of stakeholders in a district heating system have been described by Heukmès and Hofer (2020) as follows: the (1) producer of heat and cold, (2) the distributor of energy, (3) the energy supplier and (4) end users. Another important stakeholder as stated by the Energy Expert (int. EE, 2024) is the municipality. These roles are described below.

Figure 3.1: Generic stakeholders in a district heating network

First of all, there are the **heat producers**. These are the companies that generate heat (waste) and sell it to parties in district heating systems (Ma et al., 2020). This can be heat incineration companies, electricity generators, solar power generators, aquathermal heat generators, geothermal heat generators, biomass, coal and oil companies. Then, there are the **energy distributors**. These are the parties involved in operating a district heating network, laying down the pipes, and constructing the physical system. Considerations to operate such networks may include ensuring secure and stable energy supply, to minimise running costs, to prevent monopolies and/or to maximise ownership benefits. A technical solution should balance these interests and align with social and political acceptance (Yao et al., 2024). Then, there are the **energy suppliers**, which are companies that have contact with the end users to sell the procured heat. There are several possibilities of how these three roles of the heat chain are allocated between the stakeholders, ranging from fully integrated into one district heating company to all roles fragmented in different companies.

The **end users** can be residential use, (small) industrial use or commercial use. This is a standard energy purchase contract. There is one specific group of end users that is named explicitly, which is the housing corporation. The Energy Expert (int. EE, 2024) explained that housing corporations represent a larger group of end users and have the power to connect their residential assets to the district heating sector. Even though the end user's main role is 'buying energy', the Energy Expert (int. EE, 2024) explained that their role in the system often activates

earlier. For example, involving a housing corporation early in the project can significantly reduce the occupancy risk. However, this involvement can also slow down the decision-making process. **Municipalities** are involved in developing the Heat Transition Vision and District Implementation Plans, which may include DHN plans as explained in Section 1.2, and play a role in creating a support base for the project.

Adding more stakeholders to manage complexities An important note given by the Energy Expert (int. EE, 2024), is that network complexities can sometimes be managed by adding more (external) stakeholders to the pool. For example, in one project, the stakeholders agreed on introducing an external stakeholder role, called 'district heat coordinator'. This role separated the interests of the end users from the housing corporations, as they might prioritise their own interests. The coordinator attended the steering committees and working groups. Another example that the Energy Expert (int. EE, 2024) gave is the appointment of the role of 'external communications manager'. This stakeholder also attended the steering committees and groups to ensure neutral communication among the stakeholders and to mediate conflicts effectively. This role, in the example case financed collectively by the stakeholders, helped in resolving issues such as miscommunication about subsidies.

Prehistory of cooperation or conflict According to the model of Ansell and Gash (2007), the prehistory of collaboration or conflict between parties affects the collaborative performance in a project. If parties have worked together prior to joining the network, it can have a positive or negative effect on the collaboration. The Energy Expert (int. EE, 2024) elaborated that past collaborations between stakeholders can influence the dynamics of the current project. Positive histories can foster goodwill, while negative histories can complicate the collaboration. For example, housing corporations are often included in the initiating phase of DHN, as it has many connections to offer which decreases the occupancy risk. However, a housing corporation often communicates with the municipality on many other items, which could benefit or harm the status of the relationship. If the relation is negatively affected and both parties join the DHN, collaboration can be more challenging than when parties have no or positive prehistory of collaboration.

Incentives Collaborative governance literature by Ansell and Gash (2007) and Ansell et al. (2020) defined multiple incentives as part of the starting point of collaboration. From those models, the three most relevant incentives are chosen that (a) reflect the changing institutional environment, (b) addresses that the investments for these operations are large and (c) addresses that the parties strive for their own business goals while being in a dependent system. The incentives to collaborate were categorised into three divisions, and the reasons can be found using the following statement:

"Do you collaborate because you (1) ***have to***, (2) ***need to***, and/or (3) ***want to***?"

with "have to" = legal mandates;
and "need to" = resource dependencies;
and "want to" = because of intrinsic and extrinsic motivations.

Legal mandates consist of what the law depicts in terms of organisational collaboration, but also as 'social contract' and norms and values. During the interview with the Legal Expert (int. LE, 2024), the expert explained that this incentive also includes the Heat Act as formal contract, as it describes roles and responsibilities for the production and supply of heat for end users. Provisions from the Heat Act ("Warmtewet", 2014) that can act as legal incentives are exemplified in Table 3.3. Resource dependencies can also be a cause of collaboration. Resource dependency theory suggests that organisations with greater resource scarcity might be more inclined to collaborate intensely; organisations with greater resource sufficiency, might be less inclined to collaborate (Guo & Acar, 2005). Three sub incentives that can be defined are real assets, financial assets and intangible assets (Chen, 2024). And at last, intrinsic and extrinsic motivations can also cause parties to collaborate. In psychology, motivation can be interpreted as being intrinsic or extrinsic (Rose & Manley, 2010). The first refers to the motivation to collaborate for its own sake, without an apparent reward rather for the activity itself. In the district heating sector, this can be safeguarding public values or purposefully supporting the heat transition. Extrinsic motivations typically involve a reward, which can be monetary incentives (Henrich & Maas, 2020), but also strategic alignment (Chi et al., 2020). The incentives, sub incentives and examples are shown in Table 3.3.

Table 3.3: Incentives, sub incentives and examples of why parties can join the consortium

Legal mandates	
What legal incentives mandate parties to collaborate in a district heating network?	
Sub incentive	Examples
Heat Act ("Warmtewet", 2014)	Supplier ensures a reliable supply of heat at reasonable conditions and with due observance of high service quality (Article 2, §2.1)
	A contract for the supply of heat can be terminated by a consumer by means of notice (Article 3c)
	A building owner who owns an internal piping system used for heat supply must maintain the piping and individual connections to ensure reliable heat delivery unless otherwise agreed with the supplier (Article 3d)
	The Dutch Authority for Consumers and Markets determines the maximum price that a supplier will charge for the supply of heat (Article 5)
Resource dependencies	
What resources do parties have that create a need to collaborate to enable a district heating network?	
Sub incentive	Examples
Real assets (Chen, 2024)	Heat source (Werner, 2017)
	Distribution network (Werner, 2017)
	Heat exchangers (Werner, 2017)
Financial assets (Chen, 2024)	Investment accounts (Chen, 2024)
	Bank deposits (Chen, 2024)
Intangible assets (Kenton, 2024)	Knowledge (Diefenbach, 2005)
	Positive brand identity (Chen, 2024)
Intrinsic and extrinsic motivations	
What intrinsic motivations can parties for wanting to collaborate in a district heating network?	
Sub incentive	Examples
Intrinsic motivations (Rose & Manley, 2010)	Environmental considerations such as contributing to climate protection or energy efficiency (Michelsen & Madlener, 2013)
	Safeguarding public values, such as maintaining equitable access to energy, protecting end users or ensuring affordability (Martinez et al., 2023)
Extrinsic motivations (Rose & Manley, 2010)	Financial rewards (Henrich & Maas, 2020)
	Strategic considerations, such as competitive advantage for parties in the heat supply chain (Chi et al., 2020)

3.2.2. Phases of network development

Berthod and Segato (2019) stated that network development can be seen as a purposeful, engineering process, that consists of three main processes: the formation, the maturation and the decline of the network. The formation phase is very important, as this is where the foundation of the collaboration is laid. In the maturation phase the collaborative patterns become increasingly stabilised during the construction, operation and exploitation of the network (Berthod & Segato, 2019). After the initiation and maturation phases, there is the **decline phase**, which includes all activities that contribute to halting the development of networks and ultimately the termination. This is a more dormant state of the network (Berthod & Segato, 2019). Due to the scope of this research (developing collaboration to construct, operate and exploit the network), this phase is not included in this analysis.

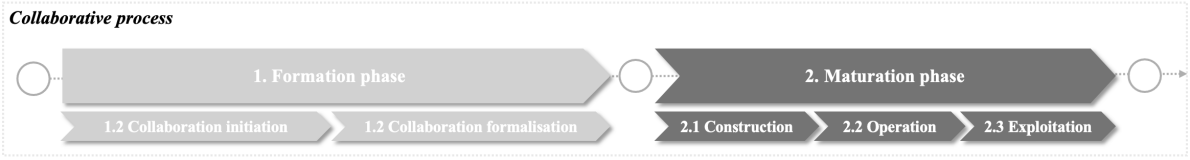


Figure 3.2: Generic phases in the collaborative process of a district heating network

Phase 1.1: Initiation The required roles to realise the DHN are first identified. There are one or more initiator(s) that initiate the network. Standard roles that must be fulfilled for heat to be transmitted from the source to an end user are heat supplier, distributor, supplier, end user and municipalities. The two other starting conditions for collaboration are prehistory of collaboration and collaborative incentives (Ansell & Gash, 2007). The output of this phase is that there are stakeholders that are going to collaborate to realise a DHN, each with their own incentives and prehistory of cooperation. The next step is to formalise this in a consortium.

Phase 1.2: Formalisation After the stakeholders decide to join the collaboration consortium, the collaboration is formalised in collaboration agreements and contractual agreements. It is decided which heat chain roles are in-housed in the district heating company, and which are outsourced. According to the Legal Expert (int. LE, 2024), the formalisation process involves creating a collaboration agreement, where roles, responsibilities and governance structures are defined. Such agreements are typically signed by all parties involved in the heat chain. The Legal Expert (int. LE, 2024) stated that the goal of the agreement is to ensure that the stakeholders do not end up in an impasse. It should be defined beforehand who decides if conflicts arise. Key elements of a collaboration agreement are:

1. The governance structure;
    (a) Determining decision-making authority and voting rights;
    (b) Assignment of roles within steering groups and working groups;
    (c) Appointment of contact persons for effective communication).
2. Conflict resolution mechanisms.
    (a) Including clauses to address dispute resolution and to avoid deadlocks;
    (b) Setting out decision-making processes, such as determining who has final authority in specific scenarios;
    (c) Defining exit strategies to prevent lock-in situations.

Besides the collaboration agreements, there are regular contracts. These are more transactional in nature than collaboration agreements and regulate specific aspects of the relationship between parties. They are less about long-term strategic alliances and more about delivery of a service or a good. The Legal Expert (int. LE, 2024) explained that a district heating company is typically set up between one, two or three parties responsible for the heat production, distribution and/or supply, but they may also contract other parties for this. This is shown in Figure 3.3. Examples of contracts used can be supply contracts (between the heat producers and distributor to provide a specified quantity of heat), or a contract between the heat distributor and the supplier. The number of roles internalised in the DH company results in the level of vertical integration or bundling. The end users also have a contractual agreement with the party responsible for the supply. The Legal Expert (int. LE, 2024) explained

that well-defined contractual agreements are relevant for collaboration in the maturation phase. The division of investment responsibilities, risk allocation, exit strategies must be made clear before actually constructing, operating and exploiting the DHN.

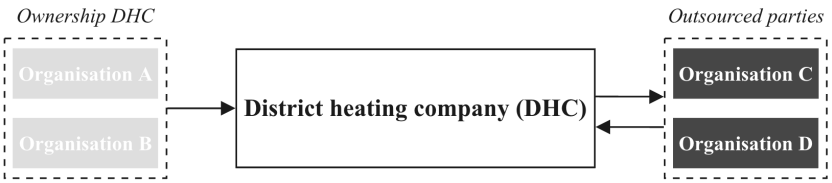


Figure 3.3: Contractual agreements of a district heating company

Phase 2.1: Construction In the construction phase, the construction of the physical system is done. This involves laying pipes, installing heat production assets and other infrastructure needed for the district heating system to be able to ultimately deliver heat towards the end user. A significant part of the investment costs are made in this phase, also known as the capital investment costs (the CAPEX). The construction will take time to complete, in which delays may occur.

Phase 2.2: Operation Then, the technical system is maintained. This phase consists of all day-to-day activities that are needed to keep the system in operation. It includes routine maintenance of for example the pipes and heat production units, repairs during downtime but also life-cycle management to extend the system's lifetime. In the longer term, renovations can occur and expansion to accommodate more users or for example new heat sources. Operational costs come from the upkeep of the technical system.

Phase 2.3: Exploitation Lastly, there is the exploitation phase. This consists of all activities around the economic operation of the system: the function of buying and selling heat. Here, the stakeholder(s) that have the roles of heat producers, distributor and supplier are very dependent on each other. Contracts between them are managed and heat tariffs are set for end users. In this phase, cost-effectiveness is very important. Operational expenses from the previous phase are balanced with revenue streams here. Exploitation costs are very dependent on market dynamics, energy prices, consumer demand, efficiency but also number of connections of the DHN.

It is important to know that the collaborative process is not static, but dynamic. During the maturation phase, initiated collaboration can change, and formation can also change. If for example one party chooses to leave the consortium, a new party could be added to the consortium. Also, the changes in the legal environment (the external influences) affect the dynamics of the collaboration.

3.2.3. Process tensions incorporated in the analysis

After it was conceptualised which stakeholder roles and phases there are in the network development, it is conceptualised which tensions can arise. Many different tensions can be applied, as Berthod and Segato (2019) have already demonstrated in their literature review. They present a selection of eleven network tensions that can arise at different points in the collaborative process of purpose-oriented networks. From this selection, nine tensions are included in this research, as shown in Figure 5. Two tensions—'internal versus external legitimacy' and 'diversity versus unity'— were omitted due to practical and contextual considerations. First, given time constraints and the need to avoid analytical overload, reducing the number of examined tensions helps ensure analytical depth over breadth. Second, these two tensions appeared less directly applicable to DHN, because the others already capture stakeholder alignment, interdependencies of the heat chain. This is why the tensions external/internal legitimacy and unity/diversity are assumed less critical to consider. Tensions are abbreviated as 'TX', where 'T' stands for 'Tension' and 'X' corresponds to the order in which the tensions are listed in Figure 3.4. This order is random. T1: **Inclusivity** versus **efficiency**: DHN often have many stakeholders as they are interdependent but also specialised. Having many voices can slow down decision-making and reduce efficiency (Provan & Kenis, 2008). For example, including a housing corporation in construction plans can decrease the occupancy risk for the DH company, but slows down the decision-making process (Energy Expert (int. EE, 2024)). T2: **Integration** versus **fragmentation**: stakeholders form into collaborative structures in this phase, but fragmentation occurs when different parts of the heat chain operate under separate contracts (Huerta et al., 2006). For example, heat producers may operate independently of the distributor, creating inefficiencies in aligning

production with demand. T3: **Centralised** versus **distributed control over power resources**: power imbalances are important to manage. The power can be divided in the network, which can cause problems (Agranoff, 2007; Huerta et al., 2006; Provan & Huang, 2012; Provan & Milward, 1995). For example, a municipality might want equal decision-making power with a private supplier, even though the municipality might bring in less financial assets (Energy Expert (int. EE, 2024)). T4: **Network resources** versus **organisational resources**: DHN can require significant resource pooling (linked to the collaborative incentive: resource dependencies) (Huerta et al., 2006). For example, when there are no shared finances and a municipality prioritises funding public housing over a district heating system, it creates strain on network resources. T5: **Interdependence** versus **autonomy**: balancing the interdependence of collective interests and goals and the partners' need for autonomy (Thomson & Perry, 2006). For example, a heat producer's decision to invest in infrastructure upgrades might depend on if a distributor is willing to share costs, creating tension over personal vs common goals (Energy Expert (int. EE, 2024)). T6: **Transparency** versus **autonomy**: networks consists of a specific level of transparency or accountability between parties, but at the same time this clashes with the original appeal of autonomy of parties (Berthod et al., 2017). For example, a municipality might demand detailed reporting from the DH company, which can lead to friction over operational autonomy. T7: **Network learning** versus **organisational learning**: as processes are very dynamic, collective learning to adapt the system is important, but there can be tensions between learning within the organisation or inter-organisational (Huerta et al., 2006). For example, with the proposed new Heat Act, the municipality might organise in-house workshops to learn how to deal with it, while it could have more benefits to organise the workshop for the entire network. T8: **Stability** versus **flexibility**: long-term stability in contracts and governance is important for planning and investments, but flexibility is required to adapting to regulatory changes (Provan & Kenis, 2008). For example, fixed-price supply contracts between heat producer and DH company might provide stability of DH company, but could hinder flexibility when energy prices fluctuate (Legal Expert (int. LE, 2024)). T9: **Dialogue** versus **confrontation**: collaboration requires balancing dialogue between partners, but also confrontation (Ospina & Saz-Carranza, 2010) (Energy Expert (int. EE, 2024)). For example, a municipality might have a history of conflict with the housing corporation that is involved in the DHN, which might require mediated dialogue to resolve.

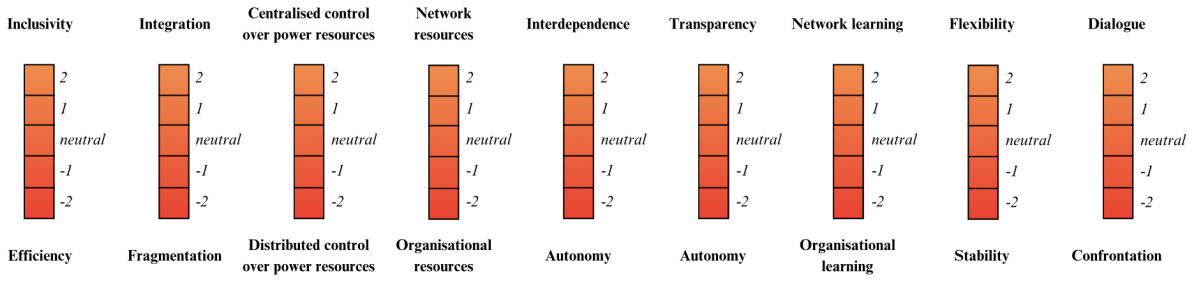


Figure 3.4: Tensions operationalised

3.2.4. Key success factors for collaboration

In this study, successful collaboration is defined as setting up and maintaining long-term collaboration of high-quality. The long-term perspective is important as district heating networks require high investments, consists of many phases with many interdependencies. It is important that the parties do not only collaborate successfully in the initiation phase, but also 20 or 25 years later to ensure that the project is still operating in a way that meets stakeholder's needs. The concept of 'success' in collaboration, however, is context-dependent. While both the collaborative governance model of Ansell and Gash (2007) and the process view of developing purpose-oriented networks of Berthod and Segato (2019) provide concepts to analyse how collaboration evolves, they do not offer a systemic approach to evaluate whether collaboration is successful. Therefore, this study adopts a contextualised approach by identifying key success factors as perceived by stakeholders themselves. These factors reflect both case-specific insights and patterns that may be relevant for the wider Dutch district heating sector.

Summary 3: Analytical framework

The analytical framework provides a structured approach to understanding collaboration in district heating networks. It combines elements of **purpose-oriented network literature** and **collaborative governance theory**. An overview can be seen in Figure 3.5.

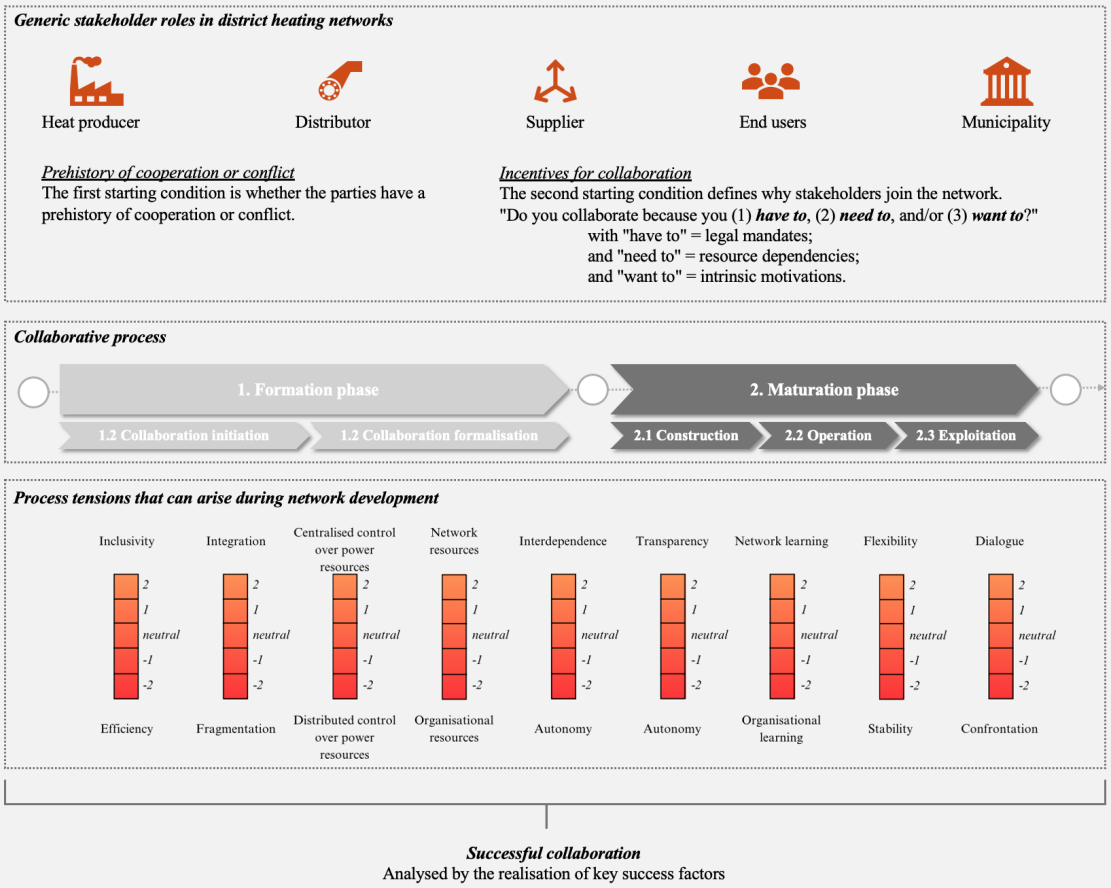


Figure 3.5: Summary of Chapter 3: Analytical framework

The main stakeholder roles in the network include **heat producer, distributor, supplier, end users and municipalities**. Each stakeholder enters the collaboration under specific **starting conditions**. The first is whether the parties have a prehistory of cooperation or conflict, and the second is what incentives they have for joining the network. Incentives can be legal mandates, resource dependencies and/or intrinsic motivations. **Network development is conceptualised in two main phases**: the formation phase (consisting of the initiation and formalisation phase) and the maturation phase (consisting of the construction, operation and exploitation phase). Throughout these phases, the stakeholders can face the nine **process tensions**, representing trade-offs that influence the success of collaboration. Finally, the success of the collaboration is assessed based on stakeholder perceptions of **key success factors**.

The next chapter describes the selection of case studies and data collection methods for the case study analysis.

4

Case studies

The conditions for successful collaboration were analysed using empirical data from the three case studies. This chapter outlines the methods used for data collection and analysis for the case studies specifically.

4.1. Case selection

As explained in Chapter 2, a multiple embedded case study design was chosen (Yin, 2003). The number of case studies was set at three due to time constraints of this study. These three were chosen using theoretical sampling, based on four selection rules:

1. The networks have different role distributions in the district heating companies;
2. All involved parties differed completely from those in the other case studies to ensure independence between cases;
3. The networks were already constructed;
4. The networks were delivering heat to end users, to indicate that they were in the operating and exploiting phases of the maturation.

The first selection criterion was based on the impact of the proposed Heat Act, which is expected to affect the distribution of roles within district heating networks. Since the district heating market is relatively small compared to the gas and electricity sectors, and some stakeholders are active in multiple networks, it was important to ensure case independence. Therefore, the second selection rule was to select cases without overlapping stakeholders. The third criterion was that the distribution network had already been constructed. This increases the likelihood that all relevant stakeholders have already collaborated in practice. Lastly, only networks that had entered the maturation phase (i.e. operation and exploitation) were selected, so that collaborative patterns had time to stabilise (Berthod & Segato, 2019). An overview of the differences in role distribution between the selected cases is provided in Figure 4.1.

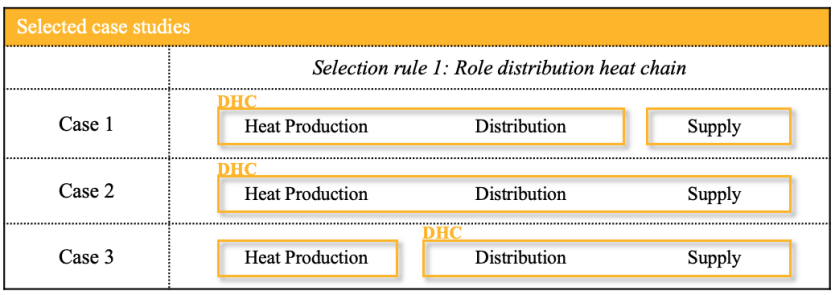


Figure 4.1: Three cases with different role distributions (rule 1). All cases had different parties in the network (rule 2), had been constructed (rule 3) and were in the operating and exploiting phases (rule 4)

4.2. Case data collection instruments

According to Yin (2003), six tools can be used for data collection in case study research: documentation, archival records, interviews, direct observations, participant observation and physical artefacts. In this study, three of these methods were used: interviews, documentation, archival records. **Case study interviews** formed the first and most important source of data. **Documentation** included both academic literature and grey literature (e.g. newsletters and Energeia articles) that had previously reported on the selected cases. Finally, **archival records** consisted of municipal documents and audit reports, such as those from the Rekenkamer. To support transparency and consistency across the case studies, three reporting tools were developed:

1. Document review checklist. This checklist was used to track which data collection methods were applied to each case study. A short version is provided below; the full version can be found in Appendix E;

   ✓ Interviews conducted?
   ✓ Literature research performed?
   ✓ Grey literature reviewed?
   ✓ Other observations noted?
   ✓ Triangulation of data sources possible?

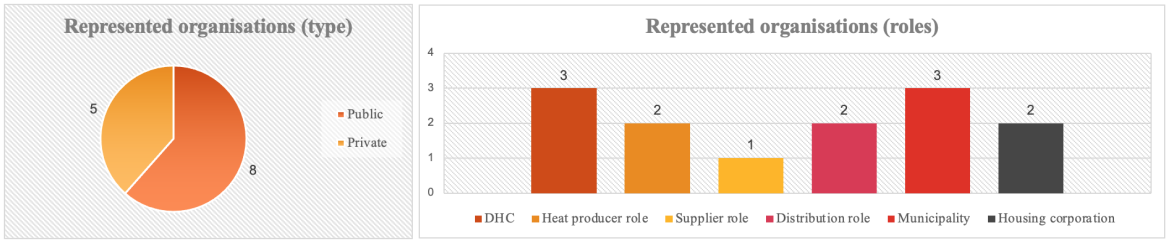
2. An interview protocol, with semi-structured interview questions, available in Appendix D;

3. An informed consent form used to obtain consent from interview respondents, included in Appendix F.

Data management This research dealt with sensitive data, which is why a data management plan was developed. It describes what data was gathered, stored, and protected. The most important aspect is the fact that all data is handled anonymously and that a consent form was used for the interview respondents. The consent form describes the general objectives of the interview, the possible data risks, the fact that the data was used anonymously and that the anonymised results would be published. Respondents were asked for permission to record a video and/or audio recordings. The interviews were transcribed and made anonymous. The video and/or audio transcript was deleted after the transcription was made. The consent forms were stored on a protected network drive in line with storage obligations. The data management plan was approved by the TU Delft Data Management Support Staff and can be found in Appendix F.

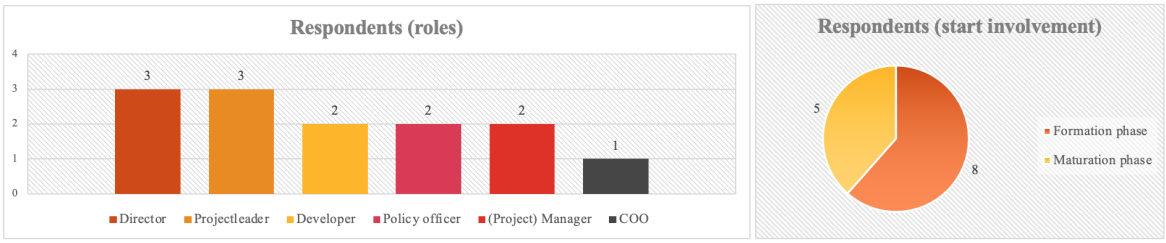
4.2.1. Interviews

Interview type There are three main types of interviews: structured, semi-structured and unstructured (De La Croix et al., 2018). Structured interviews follow a fixed set of questions, while unstructured interviews are open and adaptive. Semi-structured combine elements of both, using questions to address main themes while allowing flexibility based on the respondents' input. This format was chosen to ensure consistency across the interviews while leaving room for personal associations and interpretation from the respondent (De La Croix et al., 2018). Respondents were selected using strategic sampling based on two parameters: the organisation they represent (producer, distributor, supplier, end user, municipality - each with at least two respondents), and a balance between public and private parties. Respondents were approached via email or LinkedIn. Snowball sampling was used to expand the sample, asking respondents to suggest colleagues if unavailable (De La Croix et al., 2018). Figure 4.2 shows the represented organisations. In only one case, the supply role was fragmented, so a specific supplier was contacted. In the other cases, the DH company respondent covered this role, which met the verification criterion. Figure 4.3 provides details of the respondents: their role and the start of involvement in the project.



(a) Types of represented organisations (b) Roles of represented organisations

Figure 4.2: Demographics of represented companies



(a) Roles of respondents

(b) Starting phase of involvement of the respondent

Figure 4.3: Demographics of respondents

Referring to the interviews Respondents participate anonymously in this research. Therefore, there are pseudonyms used for referring to the interviews. For case 1, the four respondents are referred to as INT1, INT2, INT3 and INT4. Case 2 consisted of four respondents, referred to as INT5, INT6, INT7, and INT8. Case 3 consisted of five respondents, referred to as INT9, INT10, INT11, INT12 and INT13.

Interview guide The nine process tensions were discussed with each respondent to reflect on the collaboration as a whole. To gather more in-depth perspective, a second part was added to the interview guide focusing on the effect of tensions in concrete situations. Respondents were asked to describe crucial moments in the project when collaboration went exceptionally well, and another when it was particularly challenging. This allowed for a critical reflection on how the tensions were applied and how they evolved dynamically. Next, respondents were asked to identify what they considered key success factors for collaboration in district heating networks. The interview concluded with a discussion on the anticipated regulatory changes and their expected effects on the collaboration. To ensure efficient use of the interview time, respondents received an email two days in advance with preparatory information, including (a) the aim of the study, (b) the explanation of the concepts of tensions and (c) information about the informed consent form. This gave respondents the opportunity to familiarise themselves with the concepts and ask clarifying questions. The version of the interview guide sent to respondents is shown in Figure 4.4, and the full interview protocol is included in Appendix D.

Interview Guide

Below are 9 typical tensions that can arise in the collaboration process within a district heating network. You are asked to **mark** the position that, in your opinion, best characterises the collaboration in your district heating network. There is no right or wrong choice; the decision lies somewhere between the two extremes.

Inclusivity	Integration	Centralised control over power resources	Network resources	Interdependence	Transparency	Network learning	Flexibility	Dialogue
2	2	2	2	2	2	2	2	2
1	1	1	1	1	1	1	1	1
neutral	neutral	neutral	neutral	neutral	neutral	neutral	neutral	neutral
-1	-1	-1	-1	-1	-1	-1	-1	-1
-2	-2	-2	-2	-2	-2	-2	-2	-2
Efficiency	Fragmentation	Distributed control over power resources	Organisational resources	Autonomy	Autonomy	Organisational learning	Stability	Confrontation

Process tensions

1. Where does this tension arise, how is it 'filled in' and what is its effect?
2. What was a crucial moment during the construction or operation of the district heating network where collaboration went very poorly?
3. What was a crucial moment during the construction or operation of the district heating network where collaboration on the project went very well?

Optimisation

1. In your opinion, what are the key success factors for collaboration in a district heating network?
2. If you could redesign the collaboration consortium, what would you do differently?
3. What are the most significant regulatory changes do you expect? Do you think these changes will reduce or worsen certain problems in the collaboration?

Figure 4.4: Short version of the interview guide (translated to English); this is the version that is sent to respondents for preparation

4.2.2. Literature review

For each case, a literature review was performed using the following search term: (Warmtenet OR Warmtenetwerk OR District Heating) AND (case name OR case location). The search results were reviewed, and relevant findings that could support data triangulation were summarised in Appendix E. [Note: the filled-in versions are included in the Committee Version only].

4.2.3. Grey literature review and other observations

In addition to academic sources, grey literature such as archival documents and news articles was reviewed. Other observations included all additional data collection methods, such as a site visit and guided tour of one of the district heating systems.

4.3. Case introductions

Case 1 Case 1 describes a system that operates a district production pump with collective air heat pumps as the heat source. A district heating company was set up for the heat production and distribution, and had contracted another company for heat supply to end users, as seen in Figure 4.5. In this case, the district heating company was a public entity, meaning that both production and distribution were publicly governed, while the supplier was a private party. The end users were renters from a housing corporation. The municipality and the DH company were planning to expand the end users group to individual homeowners. During the development network, there were crucial moments in which collaboration went well and when it was challenging. During the formation phase, the network had a huge setback. An important subsidy did not get through (INT3). At that moment the project was in jeopardy: it was possible that the housing corporation would switch to individual solutions instead of going through with the collective heating. The organisations then came together and engaged in a discussion about their shared belief. "It would be crazy that we would cancel the project just because of a financial setback?" said INT3. The end of this crucial moment was the milestone of signing all contracts, the end of the formalisation phase. A moment where collaboration was challenging was connecting individual homeowners (INT3; INT4). Collaboration was difficult because the individual homeowners felt that they had been excluded from the decision-making process in the beginning of the project (INT2). This strained the project relationship, even though the individual relationships remained positive (INT2).

Figure 4.5: Role distribution of the heat chain in case 1

Case 2 The system in case 2 was operated by one public district heating company that in-houses the heat production, distribution, and supply as seen in Figure 4.6. Thus, all the roles in the heat chain were publicly governed. However, the system did make use of some private energy sources, such as solar energy parks, which were connected to the network through external contracts. The end users were mostly housing corporations, some individual homeowners, industry and services. This network also endured a huge setback during its development. The network wanted to connect a geothermal energy source, but the plan was cancelled due to complexities in the soil situation (INT7). This decision had a large impact which shook the confidence in the project (INT5). In such situations, when a solution is not immediately clear, there is the risk that stakeholders start pointing fingers at each other (INT5). Yet, the commitment between the parties here caused the project to continue (INT6). A decision was made to use another temporal heat source despite the original sustainability alternative. The parties trusted each other that another sustainable heat source would be found while construction continued. This was only possible because the parties continuously discussed and aligned individual goals with each other (INT5). One party stepped out of the consortium because that party had prioritised the use of the geothermal energy source as an individual goal. This situation resonated with what happened in case 1, in which there was a financial set-back that was overcome by having a certain quality of collaboration.

Figure 4.6: Role distribution of the heat chain in case 2

Case 3 The system in case 3 was operated by a district heating company that in-housed the distribution and supply role, but outsourced the heat production to another company as seen in Figure 4.7. The district heating company was a joint-venture between the municipality and a private party, making it a hybrid governance model. The production role was carried out by an external public party.

In this case, an interesting metaphor emerged: **"the district heating network can be seen as a marriage"** (INT13). Parties joined in a long-term commitment, with shared responsibilities and inevitably unknown challenges that arise during the network development. Similar to committing to a marriage, stakeholders committed without knowing the future what the future would hold, including unexpected changes such as policy shifts, financial problems, or technical setbacks.

Figure 4.7: Role distribution of the heat chain in case 3

4.4. Reporting and documentation

The following items were reported. First an in-depth within-case analysis was conducted, which can be seen in Appendix B. It elaborated how the tension arose, what the effect on collaboration was and how the respondents perceived it differently or similarly. Then, the cross case analysis was performed. This combined the cases by analysing (a) the causes per tension and when they arose, (b) how it affected the cases similarly or differently and (c) how the respondents believed it should be managed. This can be read in Chapter 5. In discussion, synthesis with data from interviews and (grey) literature was conducted. The findings were compared to aligning and conflicting literature within-case to build internal validity. It also discusses how respondents perceived tension management across cases and whether they considered it to have a positive, neutral or negative effect on key success factor realisation. It was there discussed which tensions were handled effectively across cases and in which management approaches differed significantly.

Summary 4: Case studies

Three cases were selected to apply the analytical framework. These cases differed in role distribution and involved stakeholders, but all had a constructed system that was already supplying heat to end users.

- **Case 1** was operated by a public district heating company, which in-houses heat production and distribution. A private supplier was contracted to manage customer relations. The end users are part of the housing corporations;
- **Case 2** was also operated by a public district heating company, but this was responsible for heat production, distribution and supply. the network used multiple heat sources, and the end users include housing corporations, small commercial and small industrial users;
- **Case 3** is managed by a public-private joint venture that in-houses the distribution and supply roles, while heat production is outsourced to an external public party.

Data was collected through **13 semi-structured interviews (4-5 per case)**, ensuring that each key stakeholder role (producer, distributor, supplier, end user and municipality) was represented at least twice across the sample. Eight respondents were involved from the start of the project (formation phase), while five joined during construction, operation or exploitation phases (maturation). After the data was gathered from these interviews and (grey) literature review, the data was analysed. The **data analysis approach** for the interviews and (grey) literature was outlined in Section 2.3 case study analysis.

The next chapter presents the results of the within- and cross-case analysis.

5

Results

5.1. Key success factors for collaboration in district heating networks

Due to limited research on collaboration in district heating networks as stated in Section 1.4, this analysis starts by defining what the KSFs are for long-term collaboration in district heating networks. Figure 5.1 shows an overview.

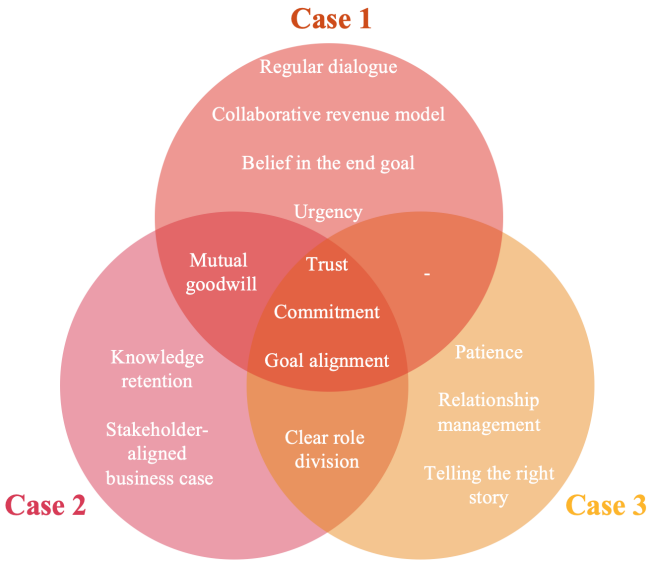


Figure 5.1: Key success factors across the cases

Three KSFs were mentioned in all case studies: Trust (INT3, INT4, INT6, INT7, INT9, INT10), commitment (INT2, INT3, INT4, INT5, INT11), and goal alignment (INT2, INT5, INT6, INT11, INT13). Then, there are KSFs mentioned in two out of three cases. Mutual goodwill was mentioned by respondents in case 1 and case 2 (INT1, INT2, INT7). Clarity of role division was mentioned by respondents in case 2 and case 3 (INT5, INT12, INT13). Lastly, there are a few KSFs that are only mentioned by respondents in one case. In case 1, the respondents stated that regular dialogue (INT2), a collaborative revenue model (INT1), belief in the end goal (INT3) and urgency (INT2, INT3) are critical for successful collaboration. In case 2, the respondents stated that knowledge retention (INT6) and a stakeholder aligned business case, meaning that parties incorporate other parties' interests' in their business case (INT8), is key for success. The critical success factors for collaboration mentioned in case 3 are equality (INT11), patience (INT11), relationship management (INT11), telling the right story (INT11, INT12). **While some factors were case-specific, goal alignment, trust, and commitment consistently emerged as key factors for successful collaboration.**

5.2. Meta-condition for successful collaboration

One respondent described an overarching meta-condition of **why** the key success factors contribute to successful collaboration. This meta-condition captures the fundamental dynamic of collaboration within the network: "**Individual goals serve as preconditions, while the shared goal acts as a catalyst for collaboration"** - as stated by INT2. Using this meta-condition, it can be explained why the three consistent key success factors contribute to successful collaboration.

- **Goal alignment** explains that individual goals and shared goals require alignment. Goals are dynamic, and should be aligned for the collaboration to be successful;
- **Trust** reflects how much trust there is in the shared goal, and the trust that others will safeguard their individual interests as well, especially in the relation with end user engagement. If parties do not trust each other, then an unsuccessful collaboration is developed.
- **Commitment** describes the degree to which the parties prioritise the shared goal, even when it requires setting aside individual objectives. When parties prioritise their individual goals over the shared goal, the collaboration can be seen as unsuccessful.

The meta-condition is not a one-time achievement, but it requires continuous evaluation, as both the shared and individual goals of networks parties evolve over time (Nowell & Kenis, 2019).

5.3. Results co-occurrence of concepts overview

If the key success factors (in short: KSF) determine the success of collaboration by its meta-condition, the next question is: how can these be improved? The respondents indicated that tension management played a significant role in increasing KSF-realisation. The tensions can be seen as levers that enhance KSF realisation, if managed properly. Its management is based on when the tension arises, who is involved and which KSFs is leveraged, which is explained in the following sections. This section summarises the co-occurrence of the concepts in the interview transcripts in three figures. Section 5.4 elaborates the results per tension.

When do tensions arise? Across the case studies, tensions occurred most frequently during the initiation and formalisation phases. Their co-occurrence declined in later phases (construction, operation, exploitation) as seen in Figure 5.2. One exception is T4: network resources versus organisational resources. This tension appeared more prominently in the maturation phase than during the formation. This can be explained by the fact that the system is constructed during the maturation phase, which leads to high resource dependencies.

		Co-occurence analysis of collaborative phases and tensions				
		Initiation	Formalisation	Construction	Operation	Exploitation
Tensions	**T1** Inclusivity vs. Efficiency	9	8	2	4	2
	T2 Integration vs. Fragmentation	7	6	1	1	1
	T3 Central vs. Distributed control over power resources	5	5	4	5	4
	T4 Network resources vs. Organisational resources	1	1	7	7	7
	T5 Interdependence vs. Autonomy	5	4	5	4	4
	T6 Transparency vs. Autonomy	2	3	3	2	2
	T7 Network learning vs. Organisational learning	4	1		2	
	T8 Stability vs. Flexibility	4	5	4	4	4
	T9 Dialogue vs. Confrontation	5	4	3	3	3
	Total metions per phase	*42*	*37*	*29*	*32*	*27*

Figure 5.2: "When?" In which phases the tensions occurred in the case studies

Who experiences tensions? The stakeholder roles experience the tensions differently as seen in Figure 5.3. The roles in the heat chain (producer, distributor, supplier) and municipalities frequently encountered the process tensions. End users were mentioned less frequently in tension management ([Heat chain roles: 76 mentions], [Municipality: 65], [End users: 48]). It is interesting that on the one hand end users are less mentioned to be involved in tension management, while on the other hand end user engagement has been stated to be the biggest challenge in network collaboration (INT1, INT5). Public stakeholders focused more on T1, T6 and T9, while private parties were more concerned about T2 and T4.

Tensions	Co-occurence analysis of stakeholders and tensions		
	Heat chain roles	End-users	Municipality
T1 Inclusivity vs. Efficiency	9	8	9
T2 Integration vs. Fragmentation	10	4	6
T3 Central vs. Distributed control over power resources	9	6	10
T4 Network resources vs. Organisational resources	10	4	6
T5 Interdependence vs. Autonomy	8	8	9
T6 Transparency vs. Autonomy	5	3	5
T7 Network learning vs. Organisational learning	9	7	8
T8 Stability vs. Flexibility	8	2	6
T9 Dialogue vs. Confrontation	8	6	6
Total mentions per stakeholder role	*76*	*48*	*65*

Figure 5.3: "Who?" Which stakeholders were involved in tension management in the case studies

Which key success factors are affected by the tensions? Three key success factors were consistent across all cases, which were goal alignment, trust, and commitment, as seen in Figure 5.1. Figure 5.4 shows that these three have also been mentioned as being affected by the most tensions. Goal alignment received 21 mentions over all interviews and was linked to 7 tensions. Trust received 20 mentions and was linked to 6 tensions. Commitment received 16 mentions and was linked to 6 tensions.

Tensions	Co-occurence analysis of which KSFs are affected by the tensions														
	Belief in the end goal	Clear role division	Collaborative revenue model	Commitment	Equality between stakeholders	Goal alignment	Knowledge retention	Mutual goodwill	Patience	Regular dialogue	Relationship management	Stakeholder-aligned business case	Telling the right story	Trust	Urgency
T1 Inclusivity vs. Efficiency		1		2		5		1			1				
T2 Integration vs. Fragmentation		1	1	1		3					1	2		1	
T3 Central vs. Distributed control over power resources					1										
T4 Network resources vs. Organisational resources		1			1					1				3	
T5 Interdependence vs. Autonomy				2		6								2	
T6 Transparency vs. Autonomy		1				2							1	7	
T7 Network learning vs. Organisational learning	1	1		2		1	2				1			3	
T8 Stability vs. Flexibility				6		1	2	1			1				
T9 Dialogue vs. Confrontation				3		3		2		3			1	4	
Per KSF: how many times they they are affected by	*1*	*5*	*1*	*16*	*2*	*21*	*4*	*4*	*0*	*4*	*4*	*2*	*2*	*20*	*0*

Figure 5.4: "What?" Which key success factors were affected by the tensions in the case studies

5.4. Cause and effect of the process tensions

T1: Inclusivity versus efficiency In all cases, the tension was most apparent in the initiation and formalisation phases. There was a need for inclusivity as participation was voluntary. Inclusivity had a positive effect on stakeholder commitment, but at the same time it slowed decision-making. Efficiency risked excluding key stakeholders and causing difficulties in relationships later on. In case 1, the municipality, DH company and the housing corporation sat together to write a set of conditions based on each party's interests to safeguard individual goals (INT2, INT3). However, the supply role had been outsourced and was only involved later on, and individual homeowners also did not sit at this table (INT1, INT4). This caused a strained relationship and difficulties in goal alignment between the supplier and the other parties and end users and the other parties. In case 2, the same problem with end users occurred. Housing corporations were involved early in the initiation phase, which led to good collaboration. However, individual homeowners were not, causing difficulties in connecting them (INT5, INT6, INT7). One respondent even stated that this was not a tension, but that "inclusivity is needed to be efficient" (INT5), as participation is on a voluntary basis. Case 3 depicted a larger network, in which the respondents stated that inclusivity could also come from ensuring each perspective is considered, rather than involving every single end user directly (INT9, INT10). The respondents in this case agreed that high inclusivity is needed within the 'triangle' of DH company, municipality, and housing corporations, but that effective inclusion is needed for

contact with end users, since it is not feasible to involve all end users directly (INT12).

! Respondents' perspectives on managing the tension: More early inclusivity was expected to lead to better goal alignment and mutual goodwill according to the respondents in case 1. For case 2, it helped using a behaviour psychologist to help understand end user motivations to nudge participation in the maturation phase, when trying to connect more end users (INT5). From case 3 it can be deducted that efficient decision-making was good for the relationship between HP-DH company, but that inclusivity needed to happen to connect end users to prevent resistance. Thus, a hybrid approach of both inclusivity in early end user engagement and efficiency in technical decisions were seen as helpful for the quality of collaboration in these cases.

T2: Integration versus fragmentation The tension between integration and fragmentation arose because there were many stakeholder roles in the network that needed to be fulfilled in a certain way. The fact that there was no centralised control made this challenge more difficult. The level of integration or fragmentation of the heat chain was chosen in the initiation phase and formalised in the formalisation phase. The main trade-offs were which parties were able and willing to connect to the network, what heat source was available and what (types of) end users were expected to connect. This tension manifested differently for the heat chain and for end users. In case 1, the supply role had been fragmented from the DH company that did the production and distribution roles. This led to difficulties in aligning the business model and required extensive contractual structure (INT1, INT2). A problem that arose was for example that the supplier chose a Belgian service company due to economic reasons, which caused end users to feel distanced from the network, who then complained to the municipality. Even though the end users and municipality preferred a service company that they felt a connection with, they could not change the decision of the supplier. It was also chosen to focus on housing corporations to make the initial financial risk acceptable, which means that the end users were integrated. However, this caused individual homeowners (fragmented segment of the end users) to feel excluded. This led to difficulties in connecting individual residents (INT3, INT4). Case 2 did have an integrated heat chain, which increased the financial viability by enabling subsidies to be reallocated (INT6), which would have been more difficult if the roles were fragmented and had their own yield requirements (INT12). Respondents in case 2 were generally satisfied with the full integration of the heat chain (INT6, INT7). Respondents in case 3 suggested that including dedicated end user representatives (beyond housing corporations) could provide a more structured approach to safeguarding their interests (INT10). In case 3, the heat production was fragmented from the other roles in the network. INT9 and INT10 stated that an advantage of integrating the distribution and supply role was the increase in trust, transparency and efficient operations of those two roles (INT9, INT10). However, within the integrated roles, there was still some economic fragmentation that required internal settlements (INT12). A respondent in this case perceived that integration is not necessarily needed for successful collaboration, but that it is important that the network works as a unified whole (INT11). The respondent warned against monopolistic behaviour and not having incentives to collaborate when the heat chain is fully integrated (INT11).

! Respondents' perspectives on managing the tension: In case 1, the respondents agreed that integrating the supply role in the DH company would have had a positive effect on the quality of collaboration by enhancing goal alignment and trust. According to the respondents of case 3, full integration is not necessary and could even cause monopolistic behaviour. Parties should strive to function as a unified whole with a certain level of integration (but not full), in which goals are constantly aligned. If chosen for a fragmented approach, standardised contracts could help manage the complexity of the contractual structure that respondents in case 1 perceived (INT2). Lastly, respondents in case 2 stated that creating an integrated role to safeguard individual residents' interests can contribute to their engagement. The Energy Expert (int. EE, 2024) gave the example of hiring an external district manager purely to express and represent end users' individual interests to build trust and align goals.

T3: Central versus distributed control over power resources This tension occurred due to the allocation of capital investments between parties, public-private positioning, and risk division, which were decided upon in the initiation and the formation phase and impacted all phases in the maturation phase. In case 3, power dynamics were also influenced by land ownership (INT12) and whether the heat chain was integrated or fragmented (INT9). Respondents in case 1 and 2 both stated that theoretical power was in the hands of the largest shareholder of the DH company, but that practically the power was distributed over each stakeholder as mentioned in the analytical framework in Section 3.2. In case 1, a shift in power resources was detected during the collaborative process. In the formation phase, end users had the leverage of deciding whether to connect or not, which was a crucial

aspect for the DH Company in determining whether the financial risk was acceptable (INT2, INT4). During the operation phase, it could be seen that power was more centralised within the DH company, based on expertise authority (INT2, INT3). To protect end users, the municipality did retain veto power over connection rates (INT3). One major problem perceived which was caused by misalignment of responsibilities. Specifically, the supplier lacked infrastructure ownership, but was still responsible for supply security (INT1). In case 2 the respondents were mostly in line with the statements made in case 1. Respondents agreed that some level of central control is necessary for financial feasibility and coordination (INT5, INT6), especially in an integrated heat chain (INT9, INT10). In case 3, the municipality had land ownership. This influenced the power distribution as leasehold agreements gave the municipality diffuse control (INT12). Besides how the power was distributed, it was also important that within each organisation there was strong leadership that helped get everyone in the organisations on the same page (INT12). Strong leadership caused the people to be more aligned, which helped the collaboration with other parties in the network (INT12). In this case the tension was most prominent until the construction phase, after which power differences became less relevant (INT11). After that, authority became tied to expertise, which caused technical knowledge to hold more decision-making power over their knowledge area (INT13).

! Respondents' perspectives on managing the tension: The respondents of case 1 stated that the misalignment between financial investments and responsibilities could be improved by better role division (INT1) or by integrating the supply role in the DH company (INT2). In case 2 and 3, the perceived tension management should focus on acknowledging the power resources of end users. If the theoretically powerful DH company were to start construction without realising how much power the end users hold, it could have a negative effect on collaboration.

T4: Organisational resources versus network resources This tension arose in the case studies due to differences in finances, role division, and organisational priorities. The resources mentioned were financial resources, time and personnel. Across all cases, it could be seen that time was often seen as a shared resource, while finance resources generally remained the property of individual organisations. Shared personnel were mentioned only infrequently. In case 1, time was the primary shared resource as the DH company, municipality, supplier and housing corporation had been collectively investing effort in engaging end users (INT1). This improved the trust and commitment between end users and other parties in the network. However, this relationship was not deterministic (INT2): investing more time did not necessarily lead to a successful collaboration; and investing less did not directly have a negative effect on collaboration. In case 2, budget responsibilities remained individual as financial resources were not pooled (INT5, INT6, INT7). However, there was a collective traineeship that served as a form of shared personnel. This had a positive effect on knowledge retention in the case. In case 3, some respondents perceived financial resources to be purely individual with no common funds (INT9, INT10). They did not see it as a problem, as the most important factor was whether the (individual) resources were allocated to the shared goals or not (INT10). Other respondents did see positive sides of shared resources. It was mentioned to help build equality between parties (INT11, INT12). For example, the heat producer initially contributed two full-time equivalents to the DH company which was seen as insufficient to establish equality. The respondents in this case collectively hired an external project leader, which had a positive effect on the collaboration (INT13). This was similarly done in case 1, where it had a positive effect (INT3).

! Respondents' perspectives on managing the tension: "Skin in the game" mattered, but it did not have to be financial; contributions in time or personnel could also enhance collaboration (INT12). The key take-away from case 2 and 3 was that resource allocation should focus on achieving shared goals rather than individual objectives (INT6, INT7). Whether the resources were network or individual was less important; as long as they were coordinated at the network level and optimised to the shared goal.

T5: Interdependence versus autonomy This tension arose in the maturation phase but could have been handled in the formation phase in all three cases. Delivering heat satisfactorily to end users, required high coordination among the heat producer, distributor, supplier, municipality and end users (INT2, INT3, INT13). The stakeholders were interdependent in ensuring a reliable heat network, but each party also had its own expertise and responsibilities where working autonomously was better (INT11). The extent to which parties worked interdependently or autonomously depended on priorities, the structure of the heat chain and the relationships (INT2, INT11, INT13). The respondents perceived the level of end user satisfaction as quite good in case 1 (INT3, INT4). What contributed to this end user satisfaction was setting up the set of conditions in the initiation phase where the individual interests of parties were discussed and acknowledged (INT2). Secondly, the DH

company, supplier, municipality and housing corporation together designed a communication strategy for end users, based on the end users' drivers (INT3). However, the fragmented supply role led one respondent to see the focus of the supplier as more on autonomous goals. For example, as stated before, the outsourcing of the user services for economic reasons (INT3). In case 2, it was necessary to work interdependently for achieving the shared sustainability goals (INT6). A major setback was the cancellation of the geothermal heat source. This even caused one party to step out of the consortium, as it prioritised its individual goal (related to the motivation of using geothermal energy) rather than the shared goal (INT6). The project was in jeopardy. However, the other parties trusted that another sustainable heat source would be found while the construction went on (INT6). This commitment was only possible because the parties continuously aligned individual goals (INT5). The tension was also present in relation to end users. "Connecting individual homeowners depends entirely on the trust that you will handle their interests properly" (INT5). In case 2 it helped to visualise how individual interests within and outside of the network scope would be safeguarded (INT6). An 'example apartment' was built. This visualised the change for end users if they were to connect to the network (INT6, INT8). They could actually walk through the apartment, see the internal installation, but also actually try out the induction hob and how to adjust the heating. In case 3, high interdependence was necessary again due to the interconnected nature of the network (INT13). However, autonomy was needed for stakeholders to work within their expertise, especially in the operation phase. In this case, the housing corporation had a high commitment to the shared goal of sustainable heating, which made net expansion easier (INT12). However, the case did have problems between the heat producer and DH company, which, at one point, collaborated on a supplier-client basis, but that proved to be too autonomous. It was later on adjusted to a more interdependent form of collaboration, which improved the relationship (INT11).

! Respondents' perspectives on managing the tension: This tension affected goal alignment according to the respondents in these three cases. Respondents in case 3 stated that the shared goals in the district heating sector are often set relatively well, as parties often have intrinsic motivation for joining the network (INT12). So, the challenge was safeguarding individual interests. Respondents indicate two areas with recommendations for how to handle this tension:

1. Within the heat chain: parties could work interdependently in the formation phase to sketch a framework of individual interests and the shared goals. This would enable working autonomously later on in maturation phase and provides room for autonomy based on authority. This led to goal alignment, commitment and trust in case 1 (INT2, INT3). If parties work autonomously in the early phases, or overly interdependent in later phases, it might decrease the quality of collaboration.
2. In the relation with the end users: safeguard their individual interests, both inside and outside of the scope of the network (such as combining the installation of the DHN with greening the street or improving parking spots). This caused an increase in trust, commitment and goal alignment between end users and other parties in the network.

T6: Transparency versus autonomy The level of transparency in these cases varied depending on multiple factors. For example, it depended on whether a party was public or private, since public entities have greater accountability obligations than private parties (INT2, INT9). Organisational structures also influenced the level of transparency of financial and planning documents (INT11, INT12). The respondents in case 1 perceived transparency as very important due to the voluntary nature of network participation. As mentioned before, parties were transparent about their individual goals in the initiation phase, which ensured that all parties approved the project and led to more trust and goal alignment (INT6, INT7). In case 2, transparency about planning was very important during the construction phase, as it made it possible to couple projects such as street renovations and greenery improvements (INT5, INT6, INT7). The municipality in case 2 had a "glass house" approach. This helped build trust with end users (INT6). However, INT7 stated that quality of information is as important as being transparent. In this case, the respondents indicated that they did not want more or less transparency between the parties, the main area of improvement point was the quality, which was not always perceived as high enough. In case 3, the perceived level of transparency varied between the respondents. The municipality and distributor, as co-shareholders, had full transparency, but the heat producer, a private entity, lacked access to information about the DH company (INT11). This led to scepticism regarding financial matters in case study 3 (INT12).

! Respondents' perspectives on managing the tension: Respondents agreed that the management of this tension should focus on sharing relevant information, particularly about clarifying goals, expectations, and financial issues (INT13). Being transparent about goals in the formation phase created the possibility of goal reflection in the maturation phase (INT3). This had a positive effect on developing collaboration

patterns (INT2). The take-away from case 3 is that the quality of information is important. One example of how information quality was ensured was by appointing a role within the municipality that simplified technical/difficult reports. By rewriting them into accessible texts and presentations, it helped to tell the right story and increased knowledge retention (INT12).

T7: Network learning versus organisational learning This tension arose from balancing internal expertise development with knowledge-sharing across stakeholders in the network. Where the focus lay depended on what expertise was missing and how involved parties could best learn about those topics. It also depended on whether parties took the initiative to organise network learning activities. Across the cases, it was observed that the focus shifted during the collaborative process. Network learning was important during the formation phase and the connection of end users, while organisational learning was important in the maturation phase where collaborative patterns stabilise. The focus shifted again to network learning when the systems were expanded geographically or when new policy changes arose (INT1, INT3, INT13). Network learning played a large role in case 2. Especially in relation to end users. Network learning was used to counteract the negative image of district heating, for example by building the example apartment, by "social proof" through success stories, and by organising user-focused training sessions such as an induction cooking class. These actions helped build trust (INT6, INT8). The respondents of case 3 explained that they implemented the same principles for end user engagement by giving out free cooking sets and cooking classes (INT12). Most respondents of case 3 were satisfied with how they organised network learning. Besides trust-building, network learning had also been used to understand end user motivations, which made it easier to align individual incentives with shared goals (INT7). In case 2, a behavioural psychologist was hired that identified four drivers for end users to connect to the network: (1) lower costs; (2) desire to contribute to a better world; (3) a sense of belonging; and (4) a better future for their grandchildren (INT7). These intrinsic motivations (from Section 3.2) were then used to design a communication and promotional strategy. Even though these efforts were enthusiastically mentioned by multiple respondents, the connection rate among individual homeowners was still low. The same concept had been implemented by the organisations in case 1 (INT2, INT3). Besides the psychologist, the respondents of case 1 mentioned that there were few network initiatives. They reacted enthusiastically when talking about its opportunities. Two respondents in case 3 found two topics most important to learn about on a network-level, which were (1) reducing installation costs and (2) maximising connection rate (INT9, INT13).

! Respondents' perspectives on managing the tension: Organisational learning should be the basis in every phase. In the formation phase, during network expansions and external changes, network learning was very important. However, when work becomes stable, the focus could shift back to organisational learning. Recommendations for managing network learning can be divided into three themes: Learning within the heat chain to reduce installation costs. Learning within the entire network to maximise connections by learning more about end user engagement. And lastly, learning as a network from another network to help improve the market (INT9).

T8: Stability versus flexibility This tension presented a challenge due to the need for long-term commitment amid many uncertainties. Respondents agreed that both ends of the tension were important but should be implemented at different phases in the project. In case 1, there was a very stable stakeholder core of the DH company, municipality and housing corporation. This enabled commitment and goal alignment (INT2), as relationships were built. Another helpful element was the use of a flexible shell outside the stakeholder core (INT2). This allowed for the hiring of external persons when needed, for example the psychologist to analyse end user motives (INT3). In case 2, respondents stated that persons involved in the core organisations should also be 'stable' (long-term involved), as this contributed to knowledge retention (INT6). However, when a geothermal heat source failed, flexibility in operations was needed to look for a new source while still trying to sustain the project (INT5). This caused one party to step out. Changes in personnel, such as a newly appointed municipal official in case 3, also disrupted relationships and required time for rebuilding trust (INT11). In case 3, the respondents interpreted stability in different ways, but considered both stability and flexibility important. INT12 mentioned stability in energy security, but with flexibility in which heat sources were connected. This created competition on the heat production market. INT9 mentioned stakeholder commitment as an important stable factor, while INT12 stated that flexibility in execution and daily operations was important.

! Respondents' perspectives on managing the tension: A stable stakeholder core and secured heat supply could support long-term commitment and trust, as seen in case 1 and 3. Flexibility could be implemented

in a "flexible stakeholder shell" for special expertise. Flexibility in project execution could also help in dealing with uncertainties, as seen in case 2.

T9: Dialogue versus confrontation This tension arose as district heating was a relatively new market, where extensive dialogue is needed for coordination (INT13). Respondents across all cases agreed that dialogue was important in every phase of the collaborative process. However, respondents differed in whether they viewed confrontation as a destructive or a constructive way of collaboration. Some found it necessary to overcome deadlocks, others perceived it as a last resort that should be avoided through the contractual agreements (INT6, INT12). In case 1, the respondents perceived regular dialogue to have great impact on collaboration in the formation and construction phases. The municipality, DH company, and housing corporation met up weekly to discuss the challenges each party faced, next steps and risks they foresaw (INT2). This improved trust and goal alignment. After that, in the operating and exploiting phases, dialogue had been perceived as less impactful on the quality of collaboration as roles and responsibilities were already established (INT1). In case 2 the same applied. Intense dialogue in the formation and construction phases enabled alignment on tariffs, technical issues, and investment planning (INT5, INT8). Dialogue had increased the commitment of parties, as seen in case 3 (INT13). The respondents in case 2 and case 3 explained that confrontation should not be avoided, but that it had helped to get through impasses and unresolved problems (INT6, INT11). The level of dialogue did differ for the end user side of the network. End user engagement needed a different approach (INT6, INT8). Part of the end users preferred participation activities, while others were more comfortable reading information on a website, and some preferred not to be contacted at all (INT6).

! Respondents' perspectives on managing the tension: Parties agreed that for each role, except end users, dialogue should be maximised and confrontation should be accepted, as this helped overcome deadlocks in the case studies. The "exposure-effect" from psychology suggested that increased exposure to individuals, even without direct interaction, leads to a more positive perception. This principle could be used in district heating networks to help build familiarity and trust over time. For the end user engagement, a tailored approach is required. An important observation regarding this tension is that the effect of dialogue seems asymmetrical (Thomann, 2023). More dialogue seemed to generally improve collaboration as it gave opportunities to align goals and build a relationship, but a lack of dialogue did necessarily prevent the realisation of key success factors.

5.5. Explorative analysis: the effect of external regulatory changes

The two proposed acts expected to influence the collaborative process are the proposed Heat Act (in Dutch "Wetsvoorstel Collectieve Warmtevoorzieningen", in short: Wcw) and the Act Municipal Instruments for the Heat Transition (in Dutch "Wetsvoorstel Gemeentelijke Instrumenten Warmtetransitie", in short: Wgiw) Wgiw, as explained in Section 1.2. This section presents a scenario analysis exploring the potential effects of these regulatory changes on collaboration within district heating networks.

5.5.1. Scenario analysis of the newly proposed Heat Act

Although respondents identified anticipated effects of the newly proposed Heat Act, as shown in Table 5.1, its true implications remain uncertain. Multiple scenarios may emerge based on how the Heat Act is implemented, each with different potential outcomes.

One of the key regulatory changes introduced by the Heat Act is that one company will be responsible for the entire heat chain, with the option of outsourcing. Two scenarios that could unfold are: **Scenario 1: Centralised model with efficient outsourcing**. If the designated DH company effectively integrates the heat chain, this may reduce contractual complexity (T2). Also, it might stabilise financial structures as a centralised responsibility could enable long-term investment strategies (T4). **Scenario 2: Integration leads to monopolistic behaviour**. Alternatively, if the DH company gains excessive control, this may reduce incentives for competition and innovation as market dominance may suppress incentives for efficiency. Trust in the system might decline, particularly among end users, as prices may be dictated by a single entity. Increased public oversight might become necessary, potentially increasing the administrative burden on regulators. The same approach can be applied to the other proposed Heat Act regulations, as outlined in Table 5.1. This table outlines the proposed regulatory changes and their anticipated effects, as derived from the interviews. While these findings provide insights into potential outcomes, given the the explorative nature of this analysis, it is likely that many more scenarios could emerge. As INT2 states, "time will tell the scale of the impact." These scenarios demonstrate that regulatory changes alone do not determine

a single outcome; rather, their effects are shaped by market conditions, stakeholder dynamics, and governance structures.

Table 5.1: The explored effect of the proposed Heat Act on the collaborative process

Change caused by the proposed Heat Act	**Anticipated effect on collaboration**	**Source**
One district heating company will become fully responsible for the entire chain, with the option of outsourcing	It could encourage integration over fragmentation, reducing the relevance of managing T2 for the heat chain roles.	INT1, INT2
	It could simplify operations by reducing the number of contracts between stakeholders, saving time and lowering complexity.	INT3
	It could allow financial surpluses in one part of the chain (e.g. heat production) to be reallocated to other parts (e.g. for developing the infrastructure). This could have a positive effect on sharing network resources (T4).	INT6
Public ownership of district heating companies	The law could enhance the transparency obligations between parties (T6), which could enhance collaboration. However, it remains essential that parties share relevant, high-quality information rather than 'more' information.	INT2, INT6
	Unlike market parties, public entities can expand into low-yield districts by offsetting costs with high-yield ones. This change could influence T4 by allowing public parties to prioritise public values over profit. It could also affect T1 by enabling the inclusion of less-profitable areas.	INT6
	However, it could cause difficulties for the distributor role. They often find a 50/50 division acceptable, but will avoid minority shareholding. The decisive say at 51% will create a skewed situation: the heat chain parties invest almost half, but have little influence.	INT9, INT10
	In the current situation, municipalities were not expected to have sufficient human resources and expertise to establish their own DH companies. If each municipality were to set up its own DH company, it could negatively impact T4, as it could require around 8,000 professionals, whereas only 2,000 are currently active in the DH sector.	INT9, INT10
Economies of scale potential	It could improve the cost structure and financial sustainability, which could positively affect collaboration by resource-sharing (T4).	INT2
Heating communities	It could increase involvement of local parties, which may influence T1: inclusiveness versus efficiency.	INT3

5.5.2. Scenario analysis of the Act Municipal Instruments for the Heat transition

Beyond the proposed Heat Act, the proposed Act Municipal Instruments for the Heat Transition (in short: Wgiw) introduces additional regulatory changes that may lead to multiple scenarios.

One of the most significant regulatory changes is the municipal power to designate areas for disconnection from natural gas within a specified time frame. This shift in authority could result in two scenarios: **Scenario 1: End users opt for an alternative collective heat system such as district heating**. If natural gas is no longer an option, end users may be more motivated to join sustainable collective heat systems such as district heating. This might decrease the development risks for parties involved in the construction of the system. **Scenario 2: Many end users in one district install individual heat sources**. However, an alternative is that a significant number of end users in one district might choose individual heating solutions (e.g. heat pumps). This could increase the development risk of district heating, as fewer users would be available to connect.

Although both scenarios contribute to the energy transition (INT11), the widespread adoption of individual heating solutions weakens the business case for district heating networks in the same area. This can be problematic given that heat pumps increase grid congestion, whereas district heating systems can reduce it by storing electricity in storages (Berenschot, 2024). Other proposed changes in the Wgiw, along with possible scenarios derived from the interviews, are summarised in Table 5.2.

Table 5.2: The explored effect of the proposed Act Municipal Instruments for the Heat transition on the collaborative process (Wgiw)

Change caused by the Wgiw	Anticipated effect on collaboration	Source
Municipal authority to designate areas for disconnection from natural gas within a set time frame	It could allow municipalities to take on greater development risks. The current inability to formally designate district heating zones makes managing competition between markets challenging. This could help address this challenge.	INT12
	It could shift power dynamics (T3) by increasing municipal control over the choice of sustainable alternatives.	INT5, INT9
	Phasing out natural gas as a heating option could reduce available alternatives for building heating, which may support more focused dialogue management (T9)	INT12

The key insight from the explorative analysis is that there is no singular outcome. The effects of regulatory changes will depend on how their details unfold and how stakeholders respond. Certain tensions (for example, T1: Inclusivity vs. efficiency, T2: Integration vs. fragmentation) were expected to play a large role in shaping collaborative dynamics. Respondents indicated that tension management should not focus on one fixed result, but rather on a range of possibilities requiring resilience in collaborative structures.

Summary 5: Results

This chapter presents the **when, who, what and how of tension management** in the three case studies. An original conceptual model is developed for analysing the collaborative dynamics in district heating networks, based on empirical insights from three case studies An overview can be seen in Figure 5.5.

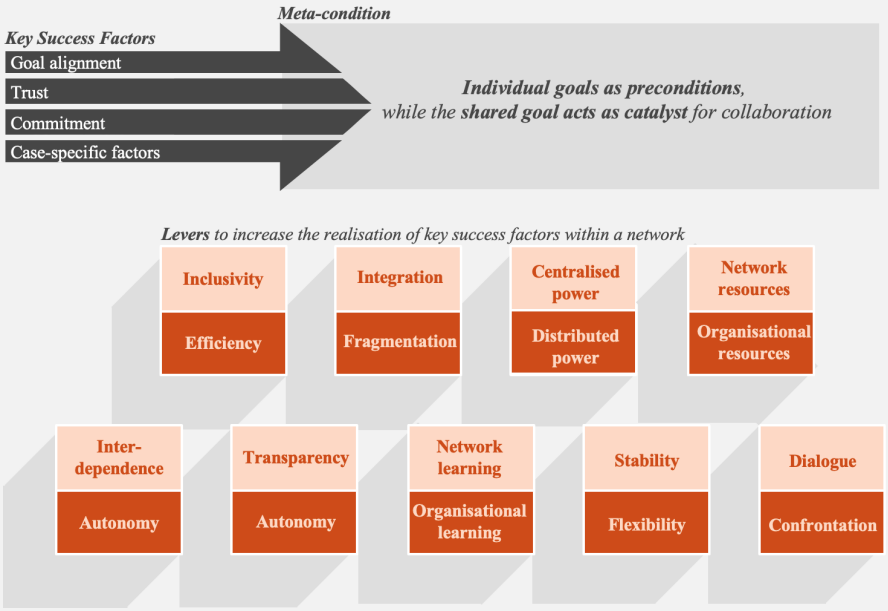


Figure 5.5: Summary of chapter 5: Results, the conditions defining successful collaboration in the case studies

The **meta-condition** for successful collaboration was defined, being: "individual goals serve as preconditions, while the shared goal acts as a catalyst". There were three universal key success factors for collaboration in district heating networks that influenced to what extent the meta-condition was met, which were **goal alignment, trust, and commitment**. However, as the networks were very context specific, each network also had case-specific key success factors. In each of the cases, tension management was perceived as a governance mechanism to conceptualise and improve the collaborative process. **Tensions arose primarily in the formation phase and its management varied per stakeholder**. Managing them could serve as levers to enhance the realisation of key success factors. Lastly, an **explorative scenario analysis** of two proposed regulatory changes showed that there was no singular effect on the collaborative process, but rather a range of possibilities that required a resilient collaboration structure.

The next chapter discusses how these results can contribute to the Dutch district heating sector.

6

Practical recommendations

This research contributes to collaboration in district heating networks by integrating purpose-oriented-network literature with collaborative governance theory. Case studies showed that tensions arise early and require proactive management. Respondents indicated that early tension management supports informed decision-making and reflection (INT2, INT3, INT8). To address this challenge, this study introduces a **discussion tool** for use in the initiation phase of district heating projects. This tool reflects the core mechanisms identified in Chapter 5 results, which are:

1. The meta-condition for collaboration, that captures the overarching dynamic in the collaborative process;
2. The key success factors that determine to what extent the meta-condition is met;
3. The process tensions that might enhance or hinder collaboration, depending on how they are managed.

This tool operationalises the results and presents a structured way to translate abstract tensions into actionable collaborative design choices.

In which settings are the findings applicable? These findings are particularly relevant for Dutch district heating systems with similar governance structures. While they may apply to other countries, generalisation requires caution due to institutional, regulatory, and technical differences. Each project operates within unique conditions, influencing which key success factors are most critical Ansell and Gash (2007). To ensure the tool's practical relevance for the district heating market, it is chosen to focus on the three consistent key success factors across all case studies: goal alignment, trust and commitment.

6.1. A tool to facilitate interactive discussion

By opening the discussion at the front-end of the project, during the initiation phase, tension management can be used most efficiently. A tool has been developed to facilitate structured discussion during an interactive session. Rather than prescribing fixed solutions, the tool aims to help stakeholders understand key mechanisms that contribute to a successful collaborative process. The tool is structured around tensions, which reflect trade-offs in collaboration. Case studies showed that these are not just obstacles but structured dilemmas without a one-size-fits-all solution. By framing them as tensions, the tool encourages proactive engagement and supports stakeholders in navigating trade-offs as design considerations in governance and decision-making.

The interactive session The session enables stakeholders to proactively define design principles prior to contractual agreements, making it most effective during the initiation phase. To ensure a productive session, three preparatory steps are required: (1) define a first shared objective of the project; (2) identify relevant stakeholders; and (3) analyse the (potential) individual interests. The timing ensures early meta-condition evaluation. Second, the management of multiple tensions is most effective when initiated in the initiation or formalisation phases, as this is the most tension-prone part of the process. Third, the tool is designed to kickstart collaboration, which requires at least two parties to join the session. The participants should thus reflect at least

two different organisations that (a) are already committed to the project and (b) represent two different stakeholder roles, which are heat producers, distributors, heat suppliers, municipalities, or housing corporations.

Session outcome: from awareness to design principles The goal of the session is to create awareness of how tension management can be used to improve the collaborative process. Each tension is presented on a separate discussion card. Each card structures the discussion in three steps: (1) understanding the tension, (2) starting the discussion based on a provocative question and after that (3) the participants write down the design principles on how they want to address the tensions. The discussion can help shape the design principles that serve as a foundation for decision-making, which can increase the shared understanding of how certain challenges can be overcome. The design principles can serve as a foundation for contractual agreements and for the collaboration throughout the construction, operation and exploitation phases.

6.1.1. Design choices of the tool

- Title and framing: The tool is titled: "Samenwerking in een warmtenet: Hoe pak je het aan?", with the subtitle: "Een hulpmiddel voor interactieve sessies bij de start van een warmtenet", which translates to: "Collaboration in a district heating network, how do you approach it? A tool for interactive sessions at the start of a DHN." The title is framed as a question to reflect a common challenge, encouraging participants to use the tool for structured discussion rather than a prescriptive guide.
- Structure of the content: The tool consists of an introduction card, nine discussion cards, and a disclaimer card, each with a front and back. The introduction card includes a user manual explaining the tool's purpose, usage, and next steps.

  The nine discussion cards focus on the nine process tensions.

  The disclaimer card states that even though the tool facilitates structured discussions based on which design principles can be written, it does not dictate fixed solutions. Setting up a successful collaboration in district heating is multi-causal and context-dependent. This tool serves as a foundation for dialogue rather than a prescriptive framework. It also includes contact information of the researcher for more scientific explanation of the information.
- Consistent layout of discussion cards for readability: It was decided to give each discussion card the same layout for clarity and readability. The front side of each card displays the name of the tension. The back side has the following information:
  - Affected key success factors (goal alignment, trust, and/or commitment);
  - Relevant phases (initiation, contract phase, construction, operation, and/or exploitation);
  - Stakeholder relevance (parties in the heat chain, municipality, and/or end users).
  - "What to talk about?" This section outlines the considerations in the tension management. As setting up collaboration in district heating is context specific, it is chosen to outline considerations in this part instead of recommendations. It consists of the considerations from the three cases of the research, and ends with a question to kickstart the discussion.
- Chosen discussion topics: The tensions are chosen as discussion topics as they can function as levers to enhance or hinder collaboration, depending on how they are managed. There are eight process tensions that have influenced the goal alignment, trust and/or commitment in the three case studies as seen in Figure 5.4, which are: inclusivity versus efficiency, integration versus fragmentation, network resources versus organisational resources, interdependence versus autonomy, transparency versus autonomy, network learning versus organisational learning stability versus flexibility, and dialogue versus confrontation. The only tension that was not mentioned to affect the consistent key success factors was T3: centralised versus distributed control over power resources. This tension is still added as a discussion card in the tool, because it did influence case-specific key success factors such as equality between stakeholders.
- Visual indicators for relevance: The tool has colour-coded indicators that show whether the tension is relevant in a certain phase with a coloured block (is relevant) and a grey-block (is not relevant). This system is also applied to the key success factors and stakeholders section. It is chosen to do so to help users quickly identify relevant aspects without losing the overview of the information. An example can be seen in Figure 6.1.

- Physical format: The A5-size cards are bound with an openable ring, allowing easy flipping, separation, and distribution during discussions.
- Publication channel: The tool is available through the TU Delft repository.

(a) The front of card 1: Title page, cover image from Cole (n.d.)

(b) The front of card 2: First tension as discussion card

(c) The back of card 2: What, When, Who and How of tension management

Figure 6.1: A selection of three pages from the practical tool. The entire tool can be found in Appendix A

Example of usage A municipality and a distributor initiate a district heating project. They mapped the expected individual interests of each stakeholder role, which increases their understanding of each other. However, it is uncertain whether the DH company will integrate the supply and heat production roles in-house or externally, and how end users will be engaged. To address these uncertainties, the municipality, distributor, and heat producer **(Stakeholders participating)** hold an interactive session using the discussion tool **(Phase: initiation)**. The parties discuss the themes card by card, starting with the question printed at the bottom of each card. After discussing each card, they write down the **design principles** they find important for each tension. They end their interactive session by creating a shared plan for the next few months, with the first milestone being the draft version of the contractual agreements.

6.1.2. Content for the discussion cards

- **T1: Inclusivity versus efficiency** It affected goal alignment and commitment and was most prone in the initiation and formalisation phases. The tension had affected each stakeholder role. Efficiency and inclusivity can sometimes be at odds in collaboration processes. Technical decisions can be made more quickly within a small group, whereas involving residents early on can improve the support base and goal alignment. In practice, when residents are involved too late in the process, it can lead to distrust and resistance to connecting to the network. On the other hand, an overly extensive participation process can slow down or frustrate decision-making. A balanced approach requires strategically determining at the outset who to involve and when. (Regional) governments can also play a role in the initiation phase, for example, by considering financing options or defining a range for connection costs. This can contribute to greater clarity for end users. Question to start the discussion: "In which phases do you see the importance of working efficiently, and in which phases rather than that of inclusivity?"
- **T2: Integration versus fragmentation** It affected goal alignment, trust and commitment. It was most prominent in the initiation and formalisation phases and relevant for all stakeholders. In a district heating network, parties can choose to establish a district heating company that combines production, distribution, and supply. This can streamline processes and simplify internal coordination. In practice, this approach has been shown to help with, for example, the flexible reallocation of financial resources or swift action in response to unexpected events. At the same time, full integration of roles is not always necessary or desirable. Having different parties responsible in the heat chain can create opportunities for innovation

or more competitive pricing. However, this requires careful alignment of interests. If there is poor coordination between the DH company and the fragmented role, it can cause misunderstandings, delays, or frustration among end users. This can happen for instance when decisions made by one party do not take into account the (individual) objectives of another. A large challenge in this tension is representing the interests of the (fragmented) end users. Appointing an independent representative as a point of contact can help ensure that end users' interests are explicitly considered in the decision-making process. Question to start the discussion: "Which roles would you want to integrate within the heating company?"

- **T3: Centralised versus distributed control over power resources** It had affected case-specific key success factors, but not trust, goal alignment or commitment. It was evenly relevant in each case and for each stakeholder role. When setting up a district heating network, governance must be defined during the contracting phase: who decides what, when, and based on what criteria? The distribution of power (whether financial, legal, or technical) can be concentrated in a centralised party (such as the district heating company or the municipality), or spread across multiple stakeholders. Both approaches have advantages and disadvantages: centralised control can enable decisive action but may lead to distrust or dependency, while distributed power enhances legitimacy but can slow down decision-making. In practice, formal authority (such as ownership) does not always align with actual influence. It is just as important how the expertise is distributed across the stakeholders and the level of commitment among end users. Problems could arise when responsibilities and decision-making power are not properly aligned. For example, if a separate supplier is responsible for preventing disruptions, it is beneficial for them to also have influence over the network's maintenance. Question to start the discussion: "How do you want to ensure governance in the network?"

- **T4: Network versus organisational resources** It affected trust, especially in the construction, operation and exploitation phases. It was relevant for all parties, but most relevant for the roles in the heat chain. Within collaborations, tension can arise between utilising individual resources and making joint investments at the network level. Organisations typically have their own priorities, schedules, and financial frameworks, which can complicate collaboration if there are no (clear) agreements on who contributes which resources. In practice, 'time' is often perceived as a shared network resource: parties jointly invest in meetings, communication with residents, or project coordination. Financial resources, on the other hand, usually remain tied to individual organizations. Not every party needs to contribute in the same way. Contributions can be financial, but also take the form of effort and expertise. The key is to align how each party deploys its own resources toward the shared goal, without necessarily requiring the creation of pooled network resources. Question to start the discussion: "Which forms of shared resources do you think contribute to realising your shared goals?"

- **T5: Interdependence versus autonomy** It affected goal alignment, trust and commitment. This tension was the only tension that was equally prominent in each phase and evenly important for each stakeholder (Figure 5.3). All parties are highly dependent on each other for the system to function as a whole. At the same time, it is important that each party remains a certain level of autonomy within their own area of expertise. This tension runs throughout the entire collaboration but requires a different approach at each phase. During the initiation and contracting phases, it can be valuable to discuss individual interests with each other. Making these interests explicit creates space for independent action later on, without losing sight of the shared goal. In the implementation phase, parties can then rely on each other's expertise, as long as the common direction remains clear. This tension is particularly relevant when engaging end users. Ultimately, end users decide for themselves whether they wish to connect, but their decision is often influenced by more than just technical aspects or price. Considering their broader interests in the project (such as contributing to greening initiatives or improving parking facilities alongside the installation of the heating network) can help to create a support base and increase their engagement.Question to start the discussion: "What are the individual interests of the end users and how can these be safeguarded in your project?"

- **T6: Transparency versus autonomy** It affected trust and commitment. "Connecting individual homeowners depends entirely on the trust that you will handle their interests properly" (INT5), and "Everything hinges on transparency" (INT1) give a good image of the importance of this tension. It was evenly prone in the entire collaborative process, from initiation to exploitation, but it differed for the stakeholders. Transparency can help build trust and commitment, but it also requires careful consideration: how much information do you share, with whom, and when? Too much transparency can limit autonomy, while too little may create distrust or lead to misunderstandings. The challenge lies in finding the right balance

between openness and professional flexibility. In practice, the challenge is not just whether information is shared, but also how it is communicated. Relevant information, such as financial analyses or schedules, must be accurate and easy to understand. Appointing a person or team to translate complex information into accessible language can help increase trust both internally and externally. It is also important to consider which financial expectations should be communicated transparently and to whom. Finally, this tension is particularly relevant when engaging with end users. Not every end user requires the same level of transparency (some may find a website sufficient, while others prefer meetings or personal communication). Question to start the discussion: "Where do you see the importance of (financial) transparency?"

- **T7: Network learning versus organisational learning** It affected goal alignment, trust and commitment. Networks that prioritised learning adapt better to uncertainties of the market. It was relevant in the formation and operation phases, as these are the areas where most expertise was missing. It was most relevant for the heat chain and the municipality and less for end users that have a smaller (technical) role in the network development. Learning can take place at two levels within one project: within the entire network or within individual organisations. Both are important but serve different purposes. Organisations often focus on internal efficiency, whereas learning initiatives at the network level can contribute to goal alignment, trust, and commitment. Tension arises when learning objectives at different levels are not aligned. On a network level, the focus of learning can be on optimising the connection rate and increasing support among end users. This can be improved, for example, by introducing residents to district heating through demonstration projects, such as a model apartment where they can experience how the system works. On an organisational level, learning may be aimed at internal process optimisation, such as reducing installation costs. Additionally, for municipalities, it can be valuable to incorporate lessons from other district heating networks during the initiation phase. This can help gather more information about organisational structures and political decision-making processes. Question to start the discussion: "What kind of network learning initiatives do you find valuable?"
- **T8: Stability versus flexibility** affected both goal alignment and commitment to the project. It was prone in each phase of the collaborative process, but was perceived as less relevant for end users. A district heating network requires long-term collaboration, where stability and flexibility must be carefully balanced. Stability (through for example fixed partnerships, clear contracts, or long-term stakeholder involvement) can contribute to building trust, knowledge retention, and consistent decision-making. At the same time, flexibility is important to adapt to unexpected developments (such as changes in legislation, project setbacks, or team restructuring). In practice, stable structures could work well as long as the context remains predictable. However, when unforeseen changes occur, having built-in flexibility to adjust both attitudes and contracts can be beneficial. Commitment to the shared goal is very important to prevent the collaboration from going stagnant. Energy security also requires this balance: legal certainty can be ensured through contracts, while operational flexibility can be achieved by opening the network to multiple heat sources. Question to start the discussion: "In which aspects do you find stability important, and where is flexibility needed?"
- **T9: Dialogue versus confrontation** It affected goal alignment, trust and commitment. It was most important in initiation and formalisation phases, which is understandable as this was where the foundation was built and where problems relating to history of conflict were mitigated (which has been named to create challenges in collaboration). It is evenly important for end users and municipalities, but has a slightly higher co-occurrence for parties in the heat chain. This can be explained by the fact that a high level of both dialogue and confrontation are needed to discuss and decide to join the project and start the construction. Dialogue and confrontation are both important for a good collaboration, but they require the right timing and a foundation of trust. Regular discussions can increase goal alignment, while confrontation can help clarify each party's incentives and break deadlocks. However, communication styles often differ between parties. Creating a culture that encourages both dialogue and constructive criticism can contribute to successful collaboration. For end users, repetition and visibility can be beneficial. The more frequently they encounter (positive associations with) the district heating network and its stakeholders, the more familiar and positive their perception may become. "Social success stories" (where municipalities show end users' positive experiences with the network) can positively contribute to this. End users may have varying communication needs, meaning that a single standard strategy may not be effective for everyone. The project support base can be increased by adapting the communication strategies to different types of end users. Question to start the discussion: How do you set up the communication strategy for involving end users?

6.1.3. Evaluation of the tool

An expert session was held to assess three aspects of the tool: (1) applicability of the concept, (2) clarity in use, and (3) expected impact. The participants included an expert on hybrid (public/private) collaboration structures and a market expert with extensive experience in district heating networks from multiple roles (municipality, heat production, and distribution). The evaluation confirmed that framing collaboration around tensions helps clarify individual and shared interests early in projects. Experts noted that challenges often stem from competing priorities, not isolated inefficiencies. The tool ensures proactive discussion of tensions, preventing misalignment and delays in later phases. Both experts agreed that the discussion tool is valuable for initiating dialogue and supporting the establishment of successful collaboration. The Market Expert (Evaluation session, 2025) confirmed that the tool facilitates open discussion, which helps build trust and mutual understanding. The expert also stated that the sector often lacks experience with the systems as there are often new stakeholders involved in the networks. The tool helps leverage existing yet fragmented sector knowledge. The Hybrid Expert (Evaluation session, 2025) further evaluated that the tool can align public and private perspectives by starting discussions with 'a common language' instead of diverging into siloed decision-making. Misalignment between public and private stakeholders is a common challenge and the tool can help to align the perspectives and prevent siloed decision-making. The expert also confirmed that structuring the tool around tensions rather than a fixed procedural framework makes it more adaptable to different project contexts. Thus, this tool contributes to the integration of tension management in the project at an early stage, which reduces the risk of stakeholder misalignment in later phases. The experts identified three vulnerable areas, which have been addressed in the tool. First, the selection of participants was revised. Initially, the tool required municipalities and the initiating party of the heat chain to be involved. However, the Market Expert (Evaluation session, 2025) noted that in some cases it could be strategic to involve municipalities at a later stage, for example when fast decision-making is required. To address this, the tool now requires at least two participants that (1) are already committed to the project; and (2) represent different key stakeholder roles, which are the heat producers, distributors, heat suppliers, municipalities or housing corporations. Secondly, the timing of the session was refined. The Hybrid Expert (Evaluation session, 2025) explained that the session is more efficiently used if it is organised after a smaller group of stakeholders has already laid some groundwork. To address this, the tool currently specifies three preparatory steps that must be completed before organising the session. Lastly, a lack of follow-up action was identified. The experts stated that the use is clearer when it is known what steps should be done after the session. To address this, the tool includes the next steps in the user manual and it is included that tension management is dynamic as goals are dynamic.

Summary 6: Practical Recommendations

This chapter introduced a **discussion tool** designed to enhance early-phase tension awareness and provide structure to the collaborative process. Since each district heating network operates within a unique context, the tool does not prescribe a fixed approach but instead facilitates a structured discussion on how to design collaboration. It consists of **nine discussion cards**, each focusing on one process tension that had influenced goal alignment, trust and/or commitment in the case studies. The cards outline the main considerations of tension management derived from the case studies. **It enables stakeholders to actively handle challenges** in collaboration rather than reactively. The entire tool can be found in Appendix A. It consists of 11 cards with a front and back printing. Figure 6.2 illustrates the interactive sessions that can be organised with the tool.

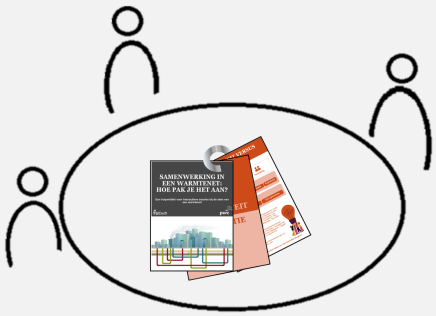


Figure 6.2: Summary of chapter 6: Practical recommendations, example use of the tool

7

Discussion

This chapter synthesises the findings from the three case studies and situates them within the broader debate on collaboration in district heating networks. It reflects on the implications of the theoretical framework, the key success factors, the process tensions and external regulatory changes. It is structured as follows:

- Section 7.1 Interpretation of key findings;
- Section 7.2 Practical and theoretical implications;
- Section 7.3 Methodological reflection;
- Section 7.4 Limitations.

7.1. Interpretation of key findings

7.1.1. The meta-condition for successful collaboration

A significant result from this study is the identification of a meta-condition: ***Individual goals serve as preconditions, while the shared goal acts as a catalyst (INT2)***. This dynamic had shaped collaborative outcomes over all three cases. Case 1 illustrated that trust in the shared goal and commitment to it helped overcome financial setbacks when a subsidy was lost. Despite financial uncertainty, stakeholders remained committed because the shared goal was strong. Case 2 showed that collaboration was strained when one organisation prioritised its individual goal (relating to geothermal energy development) over the shared goal (creating a sustainable, collective heat network) In all cases, end user engagement was difficult. The meta-condition can also explain this challenge as there is a lot of mistrust of not safeguarding their individual goals. These explanations aligned with what respondent INT12 pointed out: the core issue in this meta-condition in the sector is not the absence of a shared goal, but rather the difficulty of safeguarding individual goals of the main stakeholder roles. Successful collaboration can only occur when the meta-condition is met. This also related back to the collaborative starting conditions as explained in Section 3.2. Many parties in case 3 joined the network due to (at least) intrinsic motivations (INT12) thus the shared goal was relatively well safeguarded. The sector-wide trend of decreasing district heating investments (see Section 1.1) also aligns with the meta-conditions.

- **Regulatory changes**: The introduction of the public character of DH company in the proposed Heat Act affects financial returns by capping potential profits, even though profits are an important individual interests of private parties. Given the high costs of developing district heating networks, it can be expected for private parties to withdraw as their individual goals cannot function as preconditions for the network any more;
- **Regulatory uncertainties**: Since district heating systems require high capital expenditures, long-term financial predictability is important. However, ongoing uncertainties about the asset valuation methods in the proposed Heat Act results in investment hesitation. As long as these uncertainties persist, collaboration again breaks down because the individual goals are not met, even if a shared goal exists;
- **Market uncertainties**: The uncertainty around end user commitment creates high development risks for developing parties. As noted in Section 1.3 societal relevance, district heating competes with individual

heating solutions. Although end users may share the goal of transitioning to sustainable heating, they often hesitate to commit if their individual needs such as costs are not guaranteed.

7.1.2. Robustness and applicability of key success factors

The realisation of key success factors defines to what extent the meta-condition is met. Each district heating project is unique and operates within specific starting conditions for collaboration, as described by Ansell and Gash (2007). While some key success factors were consistently important in the case studies, others varied in importance depending on the specific context. Three key success factors were found to be consistently important in all three cases: goal alignment, trust and commitment. Their significance varied across stakeholder roles and project phases:

1. **Goal alignment** was universally important, but the ease of achieving it depended on, for example, experience. Parties that were already familiar with district heating had internal learning curves that allowed individual goals (e.g. network expansion) to align more with shared objectives (as stated by INT7);

2. **Trust** was especially important in relation to end users. Respondents noted that trust challenges often originated from outside the project, linked to the broader public discourse around district heating networks. Some end users entered projects already sceptical, even when they had not previously interacted with the district heating network. Respondents identified three types of end users: the ones that are eager to join, the ones that can be persuaded and the critics. The latter group often consumed the most energy but had limited relevance for actual project dynamics;

3. **Commitment** was necessary across all roles due to the voluntary nature of participation. However, its fragility varied. In fragmented systems, specific actors (for example the producers in case 2 and the supplier in case 1) are more easily replaced compared to other roles (e.g. the municipality). This means that some commitments are more important for network success than others.

The relevance of key success factors also shifts by project phase:

- In the early project phases, the initiation and formalisation, trust and goal alignment among heat chain parties are essential for setting up the network;

- Later on, in the construction, operation and exploitation it can be seen that trust between end users and other parties became more important, and that commitment became important.

Other key success factors mentioned were belief in the end goal, clear role division, collaborative revenue model, equality between stakeholders, knowledge retention, mutual goodwill, patience, regular dialogue, relationship management, stakeholder-aligned business case, telling the right story, and urgency. This indicates that successful collaboration depends on the context of the project. Lastly, a statistical co-occurrence analysis confirmed that respondents from **public parties mentioned trust and goal alignment more frequently than private parties**, who tended to prioritise the revenue model and risk mitigation. Thus, the nature of the organisation also impacts which success factors were seen as most critical.

Thus, besides the three consistent key success factors, there are factors that differ per project. The relevance of the factors depends on which actors are dominant, what the nature of the organisation is and which phase the project is in. This underlines the dynamic nature of managing collaboration.

7.1.3. Evaluation of tension management as a way of improving collaboration

The following paragraphs discuss how the tension management differed per case. Figure 7.1 provides an overview of whether the respondents perceived the tensions as being managed in a way that has a positive effect on the realisation of key success factors, a neutral/both or a negative effect on collaboration. All respondents were quite positive about their tension management. Respondents in case 3 were generally more positive about their tension management than those in case 1 and case 2. This is likely due to case 3 being a more mature system that has already undergone shocks but is now stable, while case 1 has just started the operation and exploitation phases where stakeholders are still finding out what works best and case 2 is somewhere in between.

		Handeld in a way that had a ….. effect on KSF realisation for successful collaboration		
		Negative	Neutral	Positive
Tensions	**T1** Inclusivity vs. Efficiency		Case 1, Case 2, Case 3	
	T2 Integration vs. Fragmentation	Case 1		Case 2, Case 3
	T3 Central vs. Distributed control over power resources		Case 1	Case 2, Case 3
	T4 Network resources vs. Organisational resources		Case 2	Case 1, Case 3
	T5 Interdependence vs. Autonomy			Case 1, Case 2, Case 3
	T6 Transparency vs. Autonomy		Case 2	Case 1, Case 3
	T7 Network learning vs. Organisational learning		Case 1, Case 2, Case 3	
	T8 Stability vs. Flexibility			Case 1, Case 2, Case 3
	T9 Dialogue vs. Confrontation			Case 1, Case 2, Case 3

Figure 7.1: Overview: whether respondents in the cases perceived the tensions as handled in a way that had a negative, neutral or positive effect on the KSF-realisation for successful collaboration (based on within-case analysis in Appendix B)

Overlap in tension management Certain tensions were seen as effectively managed across all cases, which are T5 (interdependence versus autonomy), T8 (stability versus flexibility), and T9 (dialogue versus confrontation). In all cases, aligning goals early in the process was key, for example by documenting them as boundary conditions. In all cases a certain level of stability in the stakeholder core and flexibility in work and mindset has been mentioned as important and was perceived as implemented in a good way. Regular dialogue, especially with end users, was important in all cases. T1 (inclusivity versus efficiency) and T7 (network learning versus organisational learning) are both perceived to not be handled optimally across all cases. These are two tensions where in all cases there were possibilities for better management, but which had not been done. In particular, individual end users felt left out of decision-making, which later led to issues when trying to engage them in the network. For network learning, all respondents stated that it can have a positive effect on developing long-term collaboration but that few initiatives were organised.

Outliers in tension management There was one interesting outlier that shows an example of ineffective tension management, which is T2 integration versus fragmentation in case 1. The supplier role was fragmented from the DH company, which had a negative effect on the level of goal alignment and caused the revenue model of the DH company to not align with the revenue model of the supplier. The respondents indicated that if they were to restructure the collaborative consortium, they preferred having the roles of the heat producer, distributor and supplier integrated into one DH company. It is interesting to compare this with case 3, where the heat producer role was fragmented. This did cause some difficulties, but these were managed satisfactorily causing the benefits to outweigh the drawbacks.

Tensions with strong influence on collaboration Three tensions most closely linked to key success factors were T2 (integration versus fragmentation), T7 (network versus organisational learning) and T9 (dialogue versus confrontation). Each affected the realisation of at least six key success factors and appeared over all three cases Figure 5.4). ***These tensions were most influential when proactively managed across two domains: within the heat chain operations, and externally with end user engagement***. Table 7.1 describes these three in more detail.

Tensions which management had been associated with the least effect on KSF realisation First of all, T3 Central vs. Distributed Control Over Power: While T3 was more than averagely mentioned by respondents in relation to a specific phase it occurred in and which stakeholders it affected, it was only once mentioned in relation to a key success factor. This suggests that T3 is crucial for the system design, but does not directly determine the success of collaboration through key success factors. It is also the only tension that did not directly affect one of the three consistent key success factors of goal alignment, trust, or commitment.

Table 7.1: Tensions with a strong influence on the success of collaboration

T2: Integration versus fragmentation	
Affected KSFs:	Goal alignment, stakeholder aligned-business case, clarity of role division, realising a collaborative revenue model, commitment, relationship management, and trust
Causes & effects:	The tension arose as there were many stakeholder roles in the network that needed to be fulfilled in a certain way. The fact that there is no centralised control made this challenge worse. The level of integration or fragmentation of the heat chain was chosen in the initiation phase and formalised in the formalisation phase. The main trade-offs were which parties were able and willing to connect to the network, what the heat source was available and what (types of) end users the parties expected to connect. This tension occurred differently for the heat chain and for end users. Fragmentation of the supply role in case 1 led to misaligned business models and end user dissatisfaction; the integration of the heat chain in case 2 enabled internal subsidies coordination; fragmentation of the heat producer role in case 3 demonstrated that full integration is not always necessary as long as actors work in unity. The integration or fragmentation of end users also differed per case. In case 1, there were only integrated end users in a housing corporation. This case, as well as case 2, faced difficulties engaging fragmented end users (individual residents). Case 3 better managed their end user engagement. Hiring an external district manager to express and represent end users individual interests to build trust and align goals (int. EE, 2024). Respondents in case 2 agreed that creating an integrated role to better represent individual residents' interest can help with the collaboration.
T7: Network versus organisational learning	
Affected KSFs:	Trust, commitment, knowledge retention, belief in the end goal, clarity of role division, goal alignment, relationship management.
Causes & effects:	This tension arose from balancing internal expertise development with knowledge-sharing across stakeholders in the network. Where the focus was, was based on what expertise was missing and how involved parties could best learn about those topics. But also, it depended on whether parties took the initiative to organise network learning activities. Across the cases it was seen that the focus shifted during the collaborative process. Network learning was important during the formation phase and the connection of end users, while organisational learning was important in the maturation phase where collaborative patterns stabilise. The focus had shifted again to network learning when the systems were expanded geographically or when new policy changes arose (INT1, INT3, INT13). Recommendations about network learning were divided into three parts based on these three cases: Learning within the heat chain to reduce installation costs. Learning within the entire network to maximise connections by learning more about end user engagement. And lastly, learning as network from another network to help improve the market. Respondents reacted enthusiastic on initiating more network learning events.
T9: Dialogue versus confrontation	
Affected KSFs:	Trust , commitment, goal alignment, regular dialogue, mutual goodwill, and telling the right story
Causes & effects:	This tension arose as district heating was a relatively new market, where extensive dialogue is needed for coordination (INT13). Respondents across all cases agreed that dialogue was important in every phase of the collaborative process. However, some respondents found confrontation necessary to overcome deadlocks, other perceived it as a last resort that should be avoided through the contractual agreements (INT6, INT12). The respondents agreed that for each role, except for end users engagement, dialogue should be maximised, and confrontation accepted, as this helped to get through deadlocks in the case studies. For end user engagement a more delicate approach was needed, as this is a large group of individuals that cannot all be personally engagement with. Some end users preferred participation activities, some were okay with reading information on a website and some did not want to be contacted at all (INT6). These trade-offs were important to know at the front-end, so that an effective communication strategy could be set-up. Important to note at this tension is that the effect of dialogue seems asymmetrical (Thomann, 2023). More dialogue seemed to generally improve collaboration as it gave opportunities to align goals and build a relationship, but a lack of dialogue did not mean that such key success factors were not realised.

7.1.4. Relation between regulatory changes and successful collaboration

The most mentioned anticipated effect of the **proposed Heat Act** is that an integrated heat chain will be obliged, which has an effect on T2 integration versus fragmentation. However, as stated before, whether the network is integrated or fragmented does not necessarily have an effect on successful collaboration, as it is mitigated by working as a unity. However, the proposed law does affect the incentives of parties to join the collaboration, such as (negative) financial incentives for private due to the public ownership proposition. Lastly, the proposed law effects the level of transparency, especially about financial expectations within heat chain and municipalities. However, again, it is mitigated by relevance and quality to actually built trust. The proposed Heat Act does have a clear effect on the market. As explained in the introduction, the investments rate are decreasing and new plans are delayed (De Ronde, 2023). The largest effect of the proposed Heat Act thus cannot be found in tension management, but in the overarching meta-condition, as currently, the individual goals of private parties are not safeguarded in the (proposition of the) regulation. Even though the proposed Heat Act is largely disputed in (grey) literature, one respondent had the opinion of the proposed Act Municipal Instruments for the Heat Transition (in short: **Wgiw**) being a larger disruptor than the proposed Heat Act. This is because the Wgiw is expected to affect one of the fundamental power dynamics of the district heat sector. It gives municipalities the power to designate areas to be disconnected from natural gas per a certain time period. With that, it will increase the need for alternatives, as the main used heat source in the Netherlands (Nieuwenhout, 2022) can be obliged to stop in that area. One respondent stated that the most inefficient dialogue that had occurred in their case was the competing with alternatives before starting the project (INT12). With this law, there will be a need for other heating options than natural gas, which can improve the business case for DHN. Also, the act allows municipalities to take on greater development risks, which affects the tension T3. The goal of the regulatory changes analysis is to explore how regulations affect long-term collaboration. ***It can be concluded that there is a dependency of the collaboration on the regulations, but the exact extent to which they depend is only explored. This is because both laws are not currently instituted yet. When the laws are instituted and collaborative patterns stabilise over a certain period of time, it would be interesting to perform a new analysis on its effect on collaboration.***

7.2. Practical and theoretical implications

This section describes what the practical and theoretical implications the findings have. For the practical implications, it is examined at what level tension management should occur, the use of the discussion tool and the dynamics in safeguarding public/private interest. For the theoretical implications, it is examined what the implications are of using tensions as an analytical lens, the contributions to purpose-oriented network literature, the contributions to collaborative governance literature and the overall implications for future research.

7.2.1. Practical implications

The discussion tool for an interactive sessions The study proposed a discussion tool to enhance early-phase tension awareness and provide structure to the collaborative process. This tool is focused on addressing tension management on a project level. Since each district heating network operates within a unique context, the tool did not prescribe a fixed approach but instead facilitated a structured discussion on how to design collaboration. It consists of nine discussion cards, each focusing on one process tension. The cards outline the main considerations of tension management derived from the case studies. It enables stakeholders to actively handle challenges in collaboration rather than reactively.

At what level should tension management occur? One bottleneck in district heating sector of the Netherlands is the systemic issue of public mistrust. Public mistrust was not just a project-level challenge, but was influenced by national (political) discourse. Even though this mistrust can be (partially) dealt with on project-level, the question remains if this is the most efficient level for tension management. This suggests that sector-wide strategies could be important to improve collaboration success per project.

Safeguarding interest of the public and private parties A final practical implication of the research concerns the dynamics between public and private parties that operate in the district heating sector. This is primarily an implication on sector-level. Current regulatory developments, such as the proposed Heat Act (Tweede Kamer der Staten-Generaal, 2023), shows the political effort to restore trust in the market and increase goal alignment of public values. It aims to safeguard long-term public interests, such as affordability, transparency and reliability of supply. However, this study finds that while public steering aims to safeguard public values, it fails to safeguard private interests. It currently reduces investment security for private actors, while these parties are essential

for network development. The resulting uncertainty has led to decline in private sector engagement (De Ronde, 2024b; Rijksdienst voor Ondernemend Nederland, 2024). A balance is yet to be found that enforces public values, but that also maintains the condition under which the interests of private parties are also safeguarded. Failing to address private interests undermines the goal alignment that the regulatory reform aims to achieve.

7.2.2. Theoretical implications

This study contributes to a growing body of research on the governance and collaborative dynamics in district heating networks. While the technical aspects of district heating have been studied, the processes that enable cross-organisational collaboration remained under-researched (Emmitt & Ruikar, 2013; Gondia et al., 2022; Pamidimukkala et al., 2021). This research addresses that gap by adopting a process-oriented perspective and applying a framework of process tensions to understand dynamics of collaboration in district heating networks.

Tensions as analytical lens First, this research demonstrates that process tensions offer a valid perspective to analyse collaboration in complex, multi-actor systems, aligning with the statement from Berthod and Segato (2019) to position tension management as a central object of inquiry within network governance. Recurring tensions, such as integration versus fragmentation, network learning versus organisational learning and dialogue versus confrontation, were identified as structural elements in network development. However, their manifestation was found to be context-dependent. As such, tensions cannot be understood in an isolated way, but must be analysed in relation to exogenous pressures, institutional changes and (political) framing (Berthod & Segato, 2019; Emerson et al., 2009). Contrary to assumptions in literature, this study finds that not all tensions are equally important. A subset of tensions (e.g. T2, T7, T9) had influenced collaborative success more than others (T3, T4) when looked at the three case studies. This finding suggests the need for a selective and context-sensitive application of the tensions framework in district heating research. Furthermore, while tensions can show where frictions in the process arise, the study also identifies an overarching meta-condition that mediates the effect of tensions on collaboration outcomes. As such, tension management alone does not sufficiently explain network success: rather, its effectiveness depends on whether the individual goals can be safeguarded as preconditions, while the shared goal can act as catalyst.

Contribution to purpose-oriented network literature Within the purpose-oriented networks literature, this study contributes to the understanding of how shared purpose is operationalised in fragmented stakeholder configurations. It supports the claim of Nowell and Kenis (2019) that collaboration should be viewed not as a fixed structural arrangement, but as a dynamic process shaped by continuous negotiation, interdependence, and adaptation. The findings show that individual and shared goals evolve over time, which makes the meta-condition dynamic. This causes their management to also be dynamic. It contributes to the current academic debate on the heat chain configurations in district heating networks by proposing that both integrated and fragmented heat chain roles can function well, as long as the parties work as a unified network where the shared goal is more important than each parties' individual goals. While integration does reduce complexity as there are less interfaces to manage, fragmentation enables market competition which prevents monopolistic behaviour. This emphasises the need for working as a unity over structural design debate. This supports findings from Martinez et al. (2023), but it also adds that 'working as a unity' requires continuous coordination. Moreover, this study argues that tensions are most impactful when linked to (1) heat chain operations, and to (2) end user engagement. The latter is under researched dimension in current literature. End user engagement should have a more important role in network development. This study finds that tensions related to end user engagement might be better managed at sector-level, not on project level. For example, if the government would set a standard bandwidth in which end user connection rates are set (related to T6 and T9), it would increase transparency and might diminish the mistrust in the market (INT5). Thus, the research suggest that tension management can be done at different management levels.

Contribution to collaborative governance literature From a collaborative governance (in short: CG) perspective, this research reinforces existing conceptualisation of authority as distributed across multiple actors, including (local) governments, network distributors, heat producers, suppliers, and end users (Emerson et al., 2009; Voets et al., 2021). This aligns with T3 (centralised versus distributed control) and shows that power asymmetries are negotiated throughout the collaborative process. The findings also confirm that collaboration does not happen in isolation, but is shaped by pre-existing relations, a history of cooperation or conflict, and incentives. The study extends CG-theory by demonstrating that collaboration in district heating networks is embedded in historical relationships and role distributions between stakeholders.

Implications for future research Methodologically, this research demonstrates that tensions can serve as a tool to conceptualise and understand the collaborative process. However, it also shows that tensions must be interpret combined with the regulatory environment and collaborative starting conditions. Future studies on district heating networks should therefore combine the tension framework with attention to the socio-technical and institutional environment. Also, future studies should not limit themselves to optimising the heat chain relations, but explicitly take into account the end users and (local) governments as well due to the high dependencies.

7.3. Methodological reflection

This section presents a critical reflection on the research design, data collection and analysis, as described in Section 1.6 and Chapter 2.

7.3.1 Research design and case selection

The study adopted a multiple embedded case study design, for which three operational district heating networks (DHNs) were chosen that differed in stakeholder composition and role division across the heat chain. The design provided a variation in governance structures. However, the inclusion of only operating networks introduced a survival bias. The findings reflect cases where the collaboration had not broken down, which skewed the analysis towards successful tension management. It would create well-rounded overview if also cases are analysed where collaboration had failed, to identify whether their key success factors and tension management strategies differed from these ones. In all cases, municipalities had significant involvement. Respondents from all three of them were actively presenting themselves as positive examples for the market and often host delegations from other municipalities. This pride aligns with one of the indicators of collaborative advantage identified by Vangen and Huxham (2013). Including failed or inactive cases would have increased the robustness of the findings by offering a comparative baseline. Moreover, all cases involved a relative strong public character. This reflects the current direction of the Dutch district heating market due to regulatory shifts proposed in the Heat Act, but it limits the applicability to configurations dominated by private actors. The public orientation likely influences the observed emphasises on trust and commitment, and may not reflect the dynamics in more commercially-driven district heating networks.

7.3.2. Data collection and interview protocol

The empirical data was primarily collected through semi-structured interviews, supported by grey literature and internal project documents. Multiple respondents were interviewed in each case, covering the main stakeholder roles as sub-units. To ensure minimal representation, a threshold of three interviews per case and at least two per role was applied. Respondents received the interview protocol in advance, along with explanations of tensions as paradoxical forces by (Berthod & Segato, 2019). This preparation aimed to make efficient use of interview time and depth, but may also have introduced strategic answering behaviour. Respondents could have coordinated their responses internally. The protocol included a second step, in which the respondents mapped the tensions into real project events, to make findings more robust. This part did improve understanding of the dynamic nature of tensions, but it was not a feasible method for evaluating the retrospective reflections. This is because tensions evolve over time and varied across stakeholder perspectives.

7.3.3. Data analysis and coding

Interviews were transcribed and the (summary of) the transcriptions were sent to participants for checking. All transcripts were coded inductively in Atlas.ti, using thematic coding and co-occurrence analysis. The cross-case synthesis (Chapter 5) followed the within-case analysis (Appendix B). This approach was transparent and replicable, but a certain level of subjectivity in qualitative coding remains a limitation inherent to this type of analysis.

7.3.4. Operationalisation of concepts

The study applied the abstract concepts of collaborations, tensions and key success factors through interview prompts. Most concepts were well understood by the participants, but some evoked some resistance. For example, T3 centralised versus distributed control over power resources was sometimes associated with hierarchy rather than structure. This occurred particularly among public and housing actors. To deal with this, extra questions were prepared to ask when needed, which can be seen at the end of the interview protocol in Appendix D. Attributions of tensions to specific roles in the heat chain proved to be difficult. Respondents often referred to DH company as a whole, without specifying whether a statement concerned production, supply or distribution

role. This ambiguity led to the integration of all heat chain roles in the co-occurrence analysis. In case 1 and 3, where respectively the supply and production role was outsourced, more role-specific data was available. However, because these roles were not consistently mentioned across all cases, a word-frequency-based analysis would inaccurately suggest limited relevance. This shows the complexities of linking tensions to actor-specific responsibilities when the organisational structures differ.

7.4. Limitations

This section outlines the main limitations of the study and reflects on the boundaries of the findings. It situates the research within the scientific cycle and clarifies the validity of the contributions.

7.4.1. Scope and generalisability

The study is situated in the Dutch district heating context and focuses on cases where both public and private actors collaborate. The findings are most applicable to single-system district heating networks that include municipalities or public entities in core roles. In a fully privatised system, such as industrial district heating with private end users, findings may not hold. All three cases were operational which introduced the survival bias. Failed initiatives were not included, which limits insights into the conditions under which collaboration breaks down. Additionally, the public character of two out of three cases likely reinforced themes such as trust and collective purpose. While the public characters reflect the direction of national policy, it may reduce the relevance of findings for international or liberalised market contexts. Findings may be relevant for comparable systems in other countries with similar governance structures, but generalisations should be done with caution as there might be differences in the local institutional, regulatory and technical contexts.

7.4.2. Sample and access limitations

Although role diversity was ensured in respondent selection, certain perspectives were under-represented. Some transcripts lacked explicit differentiation between heat chain roles due to organisational integration. Politically sensitive topics were also discussed cautiously, and pre-distributed interview protocols may have encouraged respondents to align their answers with organisational narratives. The research framework did not include regional and national government actors as stakeholder roles. However, in case 2, the absence of national government support during front-end of the project was explicitly mentioned as a barrier to network learning (T7). Their omission form the stakeholder analysis is therefore a limitation.

7.4.3. Temporal constraints

District heating governance is currently undergoing regulatory changes. While this study includes a scenario analysis of the two proposed acts that will effect the district heating market, the true effect will only be known after the laws come into effect. Moreover, collaboration and tension management are inherently dynamic processes. The current analysis is cross-sectional; a longitudinal design would have better captured the evolution of tensions, especially in cases such as case 3 where historical ownership transitions of the district heating company influenced current stakeholder roles. As a result, the findings may under-represent the adaptive character of collaboration over time. Lastly, the decline phase was not taken into analysis, which limits insights into how tensions develop when partnerships weaken or dissolve.

7.4.4. Theoretical boundaries

The study is based on purpose-oriented network literature and collaborative governance theories. These perspectives enabled analysis of dynamic, multi-actor coordination, but did not fully capture the interaction between tensions, key success factors and the identified meta-condition. The relation between these elements may be reciprocal, which the current analysis does not yet accommodate. Furthermore, not all tensions as identified in the literature review by Berthod and Segato (2019) were included. "Internal versus external legitimacy" and "diversity versus unity" were excluded from the analytical framework, although both emerged as relevant in the data. For instance, external legitimacy was linked to the public (mis-)trust in district heating sector, which was frequently raised as a sector-wide challenge. The choice of framework thus limited full exploration of legitimacy dynamics. Diversity and unity was mentioned by respondents in case 3, in which was stated that it was more important that the heat chain operated in a unity than whether it was one integrated district heating company or not.

7.4.5. Analytical constraints

First, the influence of tensions on collaboration was assessed based on their reported impact on the number of key success factors (KSFs). The tensions affecting most KSF-realisations were T2, T7 and T9. However, applying a different decision rule (e.g., frequency of total mentions over the interviews) would have highlighted other tensions (namely T6, T7, T8 and T9). This indicates the analytical outcomes are sensitive to measurement design. Future studies should triangulate influence metrics. Second, the analysis also shows that tensions are not mutually independent. Several respondents indicated that one tension could mitigate or exacerbate others. The most mentioned example is T9 (dialogue versus confrontation), for example affecting the starting conditions for T5 (interdependence versus autonomy) and T6 (transparency versus autonomy). T3 (distributed versus centralised control over power resources) had limited impact on KSFs but influenced the meta-condition significantly. This suggests that the relationship between tensions, performance and shared purpose is more complex than a linear model assumes. Third, while a co-occurrence analysis was conducted, word frequency is not always a valid proxy for importance. Role mentions were inconsistent across cases due to integration, making the results sensitive to coding boundaries. Giving equal weight to each mention can blur the influence dynamics. Fourth, this study did not analyse possible correlation within the tensions and within the KSFs. Multiple respondents mentioned tensions to have an impact on other tensions. For example, T9 dialogue versus confrontation has been mentioned a few times to mitigate the effect of other tensions such as T5 interdependence versus autonomy. Also, T5 (interdependence versus autonomy) and T6 (transparency versus autonomy) both have "autonomy" as a component. This suggest that these tensions are not always independent, which has validity implications for the results. Due to time constraints and limited data points, no correlation analysis was conducted.

7.4.6. Limitations of practical recommendations

The tool represents a first version that can already contribute to facilitating successful collaboration in district heating networks. However, several limitations should be acknowledged for future refinements. First, as each district heating project is highly context-specific, this tool does not provide direct solutions, but rather a framework for structured discussion. While this flexibility makes it widely applicable, it can also cause difficulties in implementation. Further iterations could refine the tool's applicability by offering more guidance on how to translate discussion outcomes into actionable steps. Second, the tool does not incorporate the effect of the proposed regulatory changes. While this study included an explorative analysis of two main regulatory changes, the actual impact on collaboration remains uncertain and will only become clear over time. Further versions could incorporate how regulatory developments influence tension management. Third, while the tool addresses that tensions are most likely to arise in certain phases, it does not yet capture the interdependencies between collaboration phases and stakeholder roles. Future iterations of the tool could incorporate longitudinal insights by analysing how tensions involve throughout the entire project lifecycle rather then focusing primarily on early-phase management. Finally, the accessibility of the tool is a important consideration. Even though the Market and Hybrid Expert (Evaluation session, 2025) agreed that this is effective for industry professionals, its professional language and setup may limit the usability for non-expert stakeholders. Given that end user engagement is a significant challenge in district heating networks, this represents an important limitation. A potential improvement could be the development of a simplified version, such as a B1-language poster designed for end user engagement. However, due to time constraints, this version was not developed within this study.

Summary 7: Discussion

This chapter discussed that collaboration in district heating networks is a **dynamic and multi-level process, shaped not only by key success factors, but also by process tensions and regulatory shifts**. The findings show that successful collaboration depends on a meta-condition in which individual goals can act as preconditions and the shared goal functions as a catalyst. This adds nuance to existing theories by linking tension management to broader structural alignment and goal interdependencies. While the **management of process tensions** in network development proved to be a valuable lens to analyse collaboration, their effects are neither linear nor universal; they depend on **stakeholder roles, their public/private nature, project phases, and the surrounding policy environment**. The discussion tool developed in this study provides a practical means to support early-phase awareness, but **future iterations of the tool** could better integrate long-term dynamics, sector-level influences and end-user engagement. Lastly, this study is situated in the research cycle as an **inductive research**. Its conclusions offer a basis for hypothesis formation and further empirical testing, which are presented in the next and final chapter.

8

Conclusion

The Netherlands faces a major environmental challenge in phasing out natural gas, a task made more difficult by increasing grid congestion. District heating offers an alternative for residential, (small) commercial, and industrial users. It can tap into unused sustainable heat sources, provide market flexibility to absorb shocks, and help stabilise the electricity grid through electricity storage. Due to the advantages, the Dutch government set a target to expand district heating networks by half a million new connections by 2030, compared to 2019 levels. However, the sector is currently in decline due to regulatory changes, policy uncertainties and market uncertainties. District heating systems depend on voluntary participation, which makes collaboration, along financial viability, an important factor in their development and operation. Successful collaboration can even help overcome financial constraints. In one of the case studies in this research, the stakeholders continued the project despite an unexpected subsidy loss, as they collectively chose to share the financial risks because of their commitment to the shared goal. The main challenges in scaling district heating are not only technological, but also structural and organisational. By identifying the conditions that make collaboration successful within a single-system district heating network, this study aims to reduce uncertainty and support renewed momentum in the sector. The main research question read:

"What conditions define successful collaboration during the construction, operation and exploitation of district heating?"

The study was grounded in collaborative governance and purpose-oriented network literature and applied a qualitative approach. The research methodology included a literature review, 4 expert interviews, 13 case study interviews, data analysis and the development of a practical tool. The findings are structured around the five sub questions and are synthesised below to answer the main research question.

SQ1: How is collaboration initiated and formalised in the setting up of district heating networks?
Collaboration in district heating networks progresses through two main phases: the formation and maturation of the network. The formation phase includes the initiation and formalisation phases, where the main stakeholders roles initiate and establish the network in contractual agreements. The main stakeholder roles are heat producers, distributors, heat suppliers, end users, municipalities, and regional and/or the national government. These parties can join the network because of legal mandates, resource dependencies or intrinsic motivations. The maturation phase involves constructing, operating, and exploiting the network, during which collaboration patterns stabilise.

SQ2: What types of process tensions arise while developing district heating networks?
Applying a process perspective, this study identifies process tensions that shape district heating network (DHN) development. Process tensions arise as dynamic forces influencing network collaboration. Nine tensions were analysed, which were (1) inclusivity versus efficiency, (2) integration versus fragmentation, (3) centralised versus distributed control over power resources, (4) network resources versus organisational resources, (5) interdependence versus autonomy, (6) transparency versus autonomy, (7) network learning versus organisational learning (8) stability versus flexibility and (9) dialogue versus confrontation. Most tensions are prevalent during the initiation and formalisation phases and tend to stabilise during later phases. However, they require active and reflective management. This increases the need for front-end tension management and awareness of its

effect during the maturation phase for long-term collaboration. Stakeholders experience the tensions differently. The heat chain roles (producer, distributor, supplier) and municipalities encounter the process tensions most frequently. However, it is interesting that on the one hand end users are less mentioned to be affected by or involved in tension management, while on the other hand end user engagement has been said to be the biggest challenge in the network collaboration.

SQ3: What are the key success factors for collaboration and how do process tensions affect them?
Each network operates in a case-specific context. There are different situational factors (e.g. the heat sources available), but also different stakeholders with its own incentives, history of cooperation or conflict and contractual structures. The findings show that there were three consistent KSFs, and multiple case-specific KSFs. The three consistent factors were:

1. **Goal alignment** explains that individual goals must be respected and require alignment;
2. **Trust** reflects how much trust there is in the shared goal, and the trust that others will safeguard their individual interests as well, especially in the relation with end user engagement;
3. **Commitment** describes the degree to which the parties prioritise the shared goal, even when it requires setting aside individual objectives.

The realisation of key success factors contribute to meeting the meta-condition, being: "Individual goals serve as preconditions, while the shared goal acts as a catalyst for the collaboration". The nine tensions arose during the initiation, formalisation, construction, operation and/or exploitation phase(s) and acted as levers to increase the realisation of key success factors. Which tensions should be the focus of tension management depends on case-specific context, as each case also had many case-specific key success factors. The tensions whose management had the most effect on KSF realisation were T2 integration versus fragmentation, T7 network learning versus organisational learning and T9 dialogue versus confrontation. Keep in mind that when there are other case-specific KSFs, the focus can shift depending on which KSF is the most important.

SQ4: How should the collaborative process in district heating networks be designed?
A process-based perspective is needed. This study developed a discussion tool consisting of nine discussion cards, each related to one tension, to facilitate awareness during the most tension-prone phases. It can be used to kick-start structured discussion on when tensions arise, what key success factors they affect and what trade-offs can be made in their management. The tool was positively evaluated by experts, who found it helped clarify expectations, align interests and establish design principles that serve as the foundation for collaboration across phases.

SQ5: How will the external changes in regulations affect the collaborative process tensions?
Two regulatory changes were examined that affect the Dutch district heating sector, which were the proposed Heat Act and the proposed Act Municipal Instruments for the Heat Transition" (in short: Wgiw). It can be concluded that there is a dependency of the collaboration on the regulations, but the exact extent of this dependency remains exploratory in nature. There are many scenarios that can arise. The largest effect of the Wcw cannot be found in tension management, but in the overarching meta-condition. This is because the individual goals of private parties are not safeguarded (enough) in the proposed new Heat Act. The second proposed act, the Wgiw, will have a direct effect on T3: centralised versus distributed control over power resources. This is because it proposes to give municipalities the power to designate areas to be disconnected from natural gas per a certain time period. With this law, there will be a need for other heating options than natural gas, which can improve the business case for district heating networks.

Main question: What conditions define successful collaboration during the construction, operation and exploitation of district heating?
Successful collaboration in district heating networks is not a static state, but a dynamic and context-specific process. It begins at the initiation phase and extends into the maturation phase of the network and requires coordination and adaptive management across all stakeholder roles involved in the construction, operation and exploitation of the system. This study finds that successful collaboration is defined by a meta-condition:

"Individual goals act as preconditions, while the shared goals act as a catalyst for the collaboration."

This means that all actors must see their own objectives as safeguarded before they can commit to shared ambitions, which was confirmed across all three cases. The meta-condition applies to all core stakeholder roles: the heat

chain roles (heat production, distribution, supply), end users and local, regional or national governments. How these roles are filled depends on contextual factors such as the available heat sources, the types of end users, the urban density of the area and the existing institutional landscape. To realise this condition:

1. All main stakeholder roles must be engaged as early as possible in the project;
2. Stakeholders must be aware that goals are dynamic and that success requires continuous goal realignment;
3. Collaboration must be treated as a process, not a static structure.

This study applied a process-oriented perspective, which shows that the way the collaborative process is set up and maintained during the project lifecycle shapes the realisation of the meta-condition. An important finding is that **process tensions** (paradoxical forces that can arise during the collaborative process) function as levers that can enhance or obstruct successful collaboration, depending on how they are managed. Tension management can thus play a central role in enabling successful collaboration. Tension management should begin as early as possible, as the initiation and formalisation phases were found the most tension-prone in the three cases. Although specific success factors varied across cases, three emerged consistently: goal alignment, trust and commitment. There were three tensions that had affected the most key success factors over the three cases: T2 (integration versus fragmentation), T7 (network learning versus organisational learning), and T9 (dialogue versus confrontation).

The findings show that the relevance of specific tensions depended on project-specific conditions, such as who was involved, at which project phase, and which success factors are important. Overall, the tensions should be differently handled for parties in the heat chain and for end user engagement. This underlines the dynamic nature of managing collaboration. A structured approach to tension management, such as the discussion tool developed in this study, can help align stakeholder interests early and prevent future misalignments.

More successful projects in the sector can help decrease market uncertainties affecting the meta-condition, which can help stimulate renewed growth in the sector. One major market uncertainty is the development risk associated with the voluntary connection of end users. This is one of the bottlenecks that can be addressed by tension management within a project. When there are more positive stories about district heating from the end user side, it can, for example, increase the trust in that their individual goals are safeguarded, which, through social success stories or other ways to communicate to possible end users, can increase the willingness to connect. However, the findings suggest that tension management is not limited to the project-level, but might sometimes rise to sector level stakeholders such as the government setting up an initiative to decrease the market mistrust beyond one project.

Applicability of findings The study was situated in the Dutch district heating context and focused on cases where both public and private actors collaborate. The findings are most applicable to single-system district heating networks that include municipalities or public entities in core roles. In fully privatised system, such as industrial district heating with private end users, findings may not be applicable. All three cases were operational which introduced the survival bias. Failed initiatives were not included, which limits insights into the conditions under which collaboration breaks down. Additionally, the public character of two out of three cases likely reinforced themes such as trust and collective purpose. While the public nature of the cases reflect the direction of national policy, it may reduce the relevance of findings for international or liberalised market contexts. Findings may be relevant for comparable systems in other countries with similar governance structures, but generalisations should be done with caution as there might be differences in the local institutional, regulatory and technical contexts.

Future research This research is situated in the inductive phase of the scientific cycle. It provides conceptual and empirical foundation for future research on collaboration in district heating networks. Several new research areas are identified. First, future research should include failed or discontinued cases to analyse whether breakdowns in collaboration result from the unmet meta-condition or inadequate tension management. This research should thus incorporate the decline phase, which was not incorporated in this study. It would allow for a more comprehensive understanding of failure mechanisms and refine the conceptual framework presented in this study. Second, longitudinal research is needed to explore how tensions, key success factors and stakeholder goals evolve over time. It could be analysed if there are significant differences between the project phases to describe more precisely what actions are needed in which phase to maintain or restore the meta-condition. A third research possibility is the investigation of the public-private dynamics in district heating. This study found that regulatory shifts influence the safeguarding of individual goals and thereby affect collaboration success. Further research could analyse how regulatory frameworks could better align incentives for private parties, including alternative designs

for market organisation, investment models or hybrid governance arrangements. Fourth, cross-country studies could provide interesting insights into how institutional differences shape the experiences and management of tensions. For instance, the role of municipal leadership or the configuration of heat chain responsibilities may differ considerably between countries, with implications for how collaboration is initiated and sustained. Fifth, there is a need to quantitatively model the relationship between tensions and key success factors. While this study used a Likert-scale and co-occurrence analysis, larger datasets or surveys could enable statistical evaluation of the proposed framework. Especially the potential interdependencies among tensions need further investigation. Sixth, it would be worthwhile to investigate additional process tensions beyond the nine studies here. Seventh, future research should move beyond the heat chain and focus more explicitly on the role of end users and governing actors. While many frameworks focus on system integration, this study suggests that 'working as a unity', operationalised through goal alignment, trust and commitment, is a more critical determinant of long-term collaboration success than integration. Thus, it is recommended to shift the current academic focus in Dutch district heating from the heat chain configuration to the end user engagement. Finally, this study suggests that not all tensions can, or should, be managed solely at the project level. Some challenges, such as market mistrust or end user scepticism, may require coordinated sector-level or national interventions. Future research could therefore explore which tensions are most prone at what governance level, and how this influences the overall success of the Dutch energy transition.

References

Agranoff, R. (2007). Managing within networks: Adding value to public organizations (Public Management and change. Georgetown University Press.

Altuna, O. K., & Arslan, F. (2016). Impact of the number of scale points on data characteristics and respondents' evaluations: An experimental design approach using 5-Point and 7-Point Likert-type scales. İstanbul Üniversitesi Siyasal Bilgiler Fakültesi Dergisi, (55), 1–20. https://doi.org/10.17124/iusiyasal.320009

Ansell, C., & Gash, A. (2007). Collaborative governance in theory and practice. Journal of Public Administration Research and Theory, 18(4), 543–571. https://doi.org/10.1093/jopart/mum032

Ansell, C., Doberstein, C., Henderson, H., Siddiki, S., & Hart, P. t. (2020). Understanding inclusion in collaborative governance: a mixed methods approach. Policy and Society, 39(4), 570–591. https://doi.org/10.1080/14494035.2020.1785726

Bakken, T., & Hernes, T. (2006). Organizing is Both a Verb and a Noun: Weick Meets Whitehead. Organization Studies, 27(11), 1599–1616. https://doi.org/10.1177/0170840606068335

Bentrup, G. (2001). Evaluation of a Collaborative model: A case study analysis of watershed planning in theIntermountain West. Environmental Management, 27(5), 739–748. https://doi.org/10.1007/s002670010184

Berenschot. (2024). De keuze voor warmtenetten of andere warmteoplossingen. https://www.nvde.nl/wp-content/uploads/2024/05/Finale-rapportage_Warmtenetten-in-vergelijking-met-andere-warmteoplossingen_24042024.pdf

Bertelsen, N., Paardekooper, S., & Mathiesen, B. V. (2021). Implementing large-scale heating infrastructures: experiences from successful planning of district heating and natural gas grids in Denmark, the United Kingdom, and the Netherlands. Energy Efficiency, 14(7). https://doi.org/10.1007/s12053-021-09975-8

Berthod, O., Grothe-Hammer, M., & Sydow, J. (2017). Network ethnography. Organizational Research Methods, 20(2), 299–323. https://doi.org/10.1177/1094428116633872

Berthod, O., & Segato, F. (2019). Developing Purpose-Oriented Networks: A Process view. Perspectives on Public Management and Governance, 2(3), 203–212. https://doi.org/10.1093/ppmgov/gvz008

Carboni, J. L., Saz-Carranza, A., Raab, J., & Isett, K. R. (2019). Taking dimensions of Purpose-Oriented networks seriously. Perspectives on Public Management and Governance, 2(3), 187–201. https://doi.org/10.1093/ppmgov/gvz011

Chen, J. (2024, August). What Are Real Assets vs. Other Asset Types? https://www.investopedia.com/terms/r/realasset.asp

Chi, M., Huang, R., & George, J. F. (2020). Collaboration in demand-driven supply chain: Based on a perspective of governance and IT-business strategic alignment. International Journal of Information Management, 52, 102062. https://doi.org/10.1016/j.ijinfomgt.2019.102062

Cole, M. (n.d.). Underground water pipe system [Vector illustration from Vecteezy].

Cooper, M. C., Lambert, D. M., & Pagh, J. D. (1997). Supply chain management: more than a new name for logistics. The International Journal of Logistics Management, 8(1), 1–14. https://doi.org/10.1108/09574099710805556

Daniels, S. E., & Walker, G. B. (2001, April). Working Through Environmental Conflict: the Collaborative Learning approach. http://ci.nii.ac.jp/ncid/BA52464664

De Bruijne, M. (2023, April). Academic Research and Research Design. https://brightspace.tudelft.nl/d2l/le/content/499269/viewContent/3146027/View

De La Croix, A., Barrett, A., & Stenfors, T. (2018). How to... do research interviews in different ways. The Clinical Teacher, 15(6), 451–456. https://doi.org/10.1111/tct.12953

De Ronde, K. (2023, February). Noodklok voor vertraging door discussie over warmtewet. https://energeia.nl/noodklok-voor-vertraging-door-discussie-over-warmtewet/

De Ronde, K. (2024a, June). Eneco stopt met ontwikkeling warmtenet Amstelkwartier. https://energeia.nl/eneco-stopt-met-ontwikkeling-warmtenet-amstelkwartier/

De Ronde, K. (2024b, June). Vattenfall doet boekje open over resultaten warmtebedrijf. https://energeia.nl/vattenfall-doet-boekje-open-over-resultaten-warmtebedrijf/

De Winkel, E., Lukszo, Z., Neerincx, M., & Dobbe, R. (2025). Adapting to limited grid capacity: Perceptions of injustice emerging from grid congestion in the Netherlands. Energy Research Social Science, 122, 103962. https://doi.org/10.1016/j.erss.2025.103962

Di Lucia, L., & Ericsson, K. (2014). Low-carbon district heating in Sweden – Examining a successful energy transition. Energy Research & Social Science, 4, 10–20. https://doi.org/10.1016/j.erss.2014.08.005

Diefenbach, T. (2005). Different Meanings of Intangible Assets and Knowledge: And their Implications for Management and Innovation. The International Journal of Knowledge Culture and Change Management Annual Review, 4(1). https://doi.org/10.18848/1447-9524/cgp/v04/59054

Dieperink, M., & Teulings, B. (2021, May). Doorbraak in Warmtewet vraagt om frisse blik op publieke belangen'. https://energeia.nl/doorbraak-in-warmtewet-vraagt-om-frisse-blik-op-publieke-belangen/

Diersen, P. (2022, June). Kabinet: 500.000 nieuwe aansluitingen in bestaande bouw in 2030. https://warmtenetwerk.nl/nieuws/item/kabinet-500-000-nieuwe-aansluitingen-in-bestaande-bouw-in-2030/

Dzebo, A., & Nykvist, B. (2017). A new regime and then what? Cracks and tensions in the socio-technical regime of the Swedish heat energy system. Energy Research & Social Science, 29, 113–122. https://doi.org/10.1016/j.erss.2017.05.018

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. Academy of Management Review, 14(4), 532–550. https://doi.org/10.5465/amr.1989.4308385

Emerson, K., Orr, P. J., Keyes, D. L., & Mcknight, K. M. (2009). Environmental conflict resolution: Evaluating performance outcomes and contributing factors. Conflict Resolution Quarterly, 27(1), 27–64. https://doi.org/10.1002/crq.247

Emmitt, S., & Ruikar, K. (2013, April). Collaborative Design Management. https://doi.org/10.4324/9780203819128

Eriksson, P. E., Larsson, J., & Pesämaa, O. (2017). Managing complex projects in the infrastructure sector — A structural equation model for flexibility-focused project management. International Journal of Project Management, 35(8), 1512–1523. https://doi.org/10.1016/j.ijproman.2017.08.015

Estampe, D., Lamouri, S., Paris, J.-L., & Brahim-Djelloul, S. (2010). A framework for analysing supply chain performance evaluation models. International Journal of Production Economics, 142(2), 247–258. https://doi.org/10.1016/j.ijpe.2010.11.024

European Commission, D.-G. f. E., Bacquet, A., Galindo Fernández, M., & Oger, A. (2022). District Heating and Cooling in the European Union: overview of markets and regulatory frameworks under the revised Renewable Energy Directive. https://irees.de/2021/10/18/district-heating-and-cooling-trend-interactive-report/

Gerlak, A. K., & Heikkila, T. (2006). Comparing collaborative mechanisms in Large-Scale Ecosystem Governance. Natural resources journal, 46(3), 657–. https://digitalrepository.unm.edu/cgi/viewcontent.cgi?article=1302&context=nrj

Gondia, A., Ezzeldin, M., & El-Dakhakhni, W. (2022). Dynamic networks for resilience-driven management of infrastructure projects. Automation in Construction, 136, 104149. https://doi.org/10.1016/j.autcon.2022.104149

Gonzalez-Castellanos, A., Thakurta, P. G., & Bischi, A. (2021). Congestion management via increasing integration of electric and thermal energy infrastructures. E3S Web of Conferences, 238, 05005. https://doi.org/10.1051/e3sconf/202123805005

Grafius, D. R., Varga, L., & Jude, S. (2020). Infrastructure Interdependencies: Opportunities from Complexity. Journal of Infrastructure Systems, 26(4). https://doi.org/10.1061/(asce)is.1943-555x.0000575

Guo, C., & Acar, M. (2005). Understanding collaboration among nonprofit organizations: combining resource dependency, institutional, and network perspectives. Nonprofit and Voluntary Sector Quarterly, 34(3), 340–361. https://doi.org/10.1177/0899764005275411

Hecker, J., & Kalpokas, N. (2025, February). Coding qualitative data for valuable insights. https://atlasti.com/guides/qualitative-research-guide-part-2/data-coding

Henrich, B., & Maas, N. (2020). The financial needs and benefits of Cooperative District Heating.

Herranz, J. (2009). Endogenous development dynamics of multisectoral network management. International Public Management Journal, 12(3), 370–397. https://doi.org/10.1080/10967490903094145

Heukmès, M., & Hofer, B. (2020). WP.T3.D1.6 Guide to governance and business models. Interreg Europe. https://guidetodistrictheating.eu/wp-content/uploads/2021/02/HeatNet-NWE_Guide-to-Governance-and-Business-Models_District-Heating.pdf

Huerta, T., Casebeer, A., & VanderPlaat, M. (2006). Using networks to enhance health services delivery: Perspectives, paradoxes and propositions. A Nudge Too Far? A Nudge at All? On Paying People to Be Healthy, 7(2), 10–26. https://doi.org/10.12927/hcpap..18551

Innes, J. E., & Booher, D. E. (1999). Consensus building and complex adaptive systems. Journal of the American Planning Association, 65(4), 412–423. https://doi.org/10.1080/01944369908976071

Kenton, W. (2024, June). What is an intangible asset? https://www.investopedia.com/terms/i/intangibleasset.asp

Keyton, J., Ford, D. J., & Smith, F. L. (2008). A mesolevel communicative model of collaboration. Communication Theory, 18(3), 376–406. https://doi.org/10.1111/j.1468-2885.2008.00327.x

Kokkonen, A., & Vaagaasar, A. L. (2017). Managing collaborative space in multi-partner projects. Construction Management and Economics, 36(2), 83–95. https://doi.org/10.1080/01446193.2017.1347268

La Forme, F.-A. G., Genoulaz, V. B., & Campagne, J.-P. (2007). A framework to analyse collaborative performance. Computers in Industry, 58(7), 687–697. https://doi.org/10.1016/j.compind.2007.05.007

Lygnerud, K. (2018). Challenges for business change in district heating. Energy Sustainability and Society, 8(1). https://doi.org/10.1186/s13705-018-0161-4

Ma, Z., Knotzer, A., Billanes, J. D., & Jørgensen, B. N. (2020). A literature review of energy flexibility in district heating with a survey of the stakeholders' participation. Renewable and Sustainable Energy Reviews, 123, 109750. https://doi.org/10.1016/j.rser.2020.109750

Marek, L. I., Brock, D.-J. P., & Savla, J. (2014). Evaluating collaboration for effectiveness. American Journal of Evaluation, 36(1), 67–85. https://doi.org/10.1177/1098214014531068

Martinez, S. H., Harmsen, R., Menkveld, M., Faaij, A., & Kramer, G. J. (2022). The Heat Transition in the Built Environment: Experiences from Local Planning and Implementation in a Learning Context. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4041280

Martinez, S. H., Harmsen, R., Menkveld, M., Kramer, G. J., & Faaij, A. (2023). Why go public? Public configurations and the supportive and divergent views towards public district heating in the Netherlands. Frontiers in Sustainable Cities, 5. https://doi.org/10.3389/frsc.2023.1220884

Michelsen, C. C., & Madlener, R. (2013). Motivational factors influencing the homeowners' decisions between residential heating systems: An empirical analysis for Germany. Energy Policy, 57, 221–233. https://doi.org/10.1016/j.enpol.2013.01.045

Ministerie van Economische Zaken en Klimaat. (2022, February). Gebouwde omgeving. https://www.klimaatakkoord.nl/gebouwde-omgeving

Netbeheer Nederland. (2024). Netbeheerders steunen voorstel Wet collectieve warmte. https://www.netbeheernederland.nl/artikelen/nieuws/netbeheerders-steunen-voorstel-wet-collectieve-warmte

Nezami, M. R., De Bruijne, M. L., Hertogh, M. J., & Bakker, H. L. (2024). Assessment criteria for inter-organizational collaboration in interconnected infrastructure projects. Engineering Construction Architectural Management. https://doi.org/10.1108/ecam-11-2022-1109

Nieuwenhout, C. T. (2022). There and back again. University of Groningen Press. https://pure.rug.nl/ws/portalfiles/portal/250296699/EnergyLaw_Part24.pdf

Nowell, B. L., & Kenis, P. (2019). Purpose-Oriented Networks: the architecture of complexity. Perspectives on Public Management and Governance, 2(3), 169–173. https://doi.org/10.1093/ppmgov/gvz012

Ospina, S. M., & Saz-Carranza, A. (2010). Paradox and collaboration in network management. Administration Society, 42(4), 404–440. https://doi.org/10.1177/0095399710362723

Paardekooper, S., Lund, R., Mathiesen, B., Chang, M., Petersen, U., Grundahl, L., David, A., Dahlbæk, L., Kapetanakis, I., Lund, H., Bertelsen, N., Hansen, K., Drysdale, D., & Persson, U. (2018). Heat Roadmap Netherlands: Quantifying the Impact of Low-Carbon Heating and Cooling Roadmaps. (tech. rep.). Aalborg University Denmark. Aalborg University Denmark. https://vbn.aau.dk/ws/portalfiles/portal/287931509/Country_Roadmap_Netherlands_20181005.pdf

Pamidimukkala, A., Kermanshachi, S., Adepu, N., & Safapour, E. (2021). Resilience in Water Infrastructures: A review of challenges and adoption Strategies. Sustainability, 13(23), 12986. https://doi.org/10.3390/su132312986

Provan, K. G., & Kenis, P. (2008). Modes of network Governance: structure, management, and effectiveness. Journal of Public Administration Research and Theory, 18(2), 229–252. https://doi.org/10.1093/jopart/mum015

Provan, K. G., & Huang, K. (2012). Resource tangibility and the evolution of a publicly funded health and human services network. Public Administration Review, 72(3), 366–375. https://doi.org/10.1111/j.1540-6210.2011.02504.x

Provan, K. G., & Milward, H. B. (1995). A Preliminary Theory of Interorganizational network Effectiveness: A comparative study of four community mental health systems. Administrative Science Quarterly, 40(1), 1. https://doi.org/10.2307/2393698

Rekenkamer, A. (2025). Een koud bad voor warmtenetten. https://www.rekenkamer.nl/publicaties/rapporten/2025/02/04/een-koud-bad-voor-warmtenetten

Renewable Energy Directive. (2023). https://energy.ec.europa.eu/topics/renewable-energy/renewable-energy-directive-targets-and-rules/renewable-energy-directive_en

RES, N. P. (n.d.). Warmte - Regionale Energiestrategie. https://www.regionale-energiestrategie.nl/energiesysteem/warmte/default.aspx

Rijksdienst voor Ondernemend Nederland. (2019). Transitievisie Warmte en Wijkuitvoeringsplan. https://www.rvo.nl/onderwerpen/aardgasvrij/transitievisie-warmte-en-wijkuitvoeringsplan#wijkuitvoeringsplan

Rijksdienst voor Ondernemend Nederland. (2024). Duurzaamheidsrapportage 2023. https://www.rvo.nl/sites/default/files/2024-11/Rapport-Duurzaamheid-warmtelevering-2023-Versie-2.pdf

Ring, P. S., & Van De Ven, A. H. (1994). Developmental processes of cooperative interorganizational relationships. Academy of Management Review, 19(1), 90. https://doi.org/10.2307/258836

Rose, T., & Manley, K. (2010). Motivational misalignment on an iconic infrastructure project. Building Research Information, 38(2), 144–156. https://doi.org/10.1080/09613210903503741

Saz-Carranza, A., & Vernis, A. (2006). The dynamics of public networks. International Journal of Public Sector Management, 19(5), 416–427. https://doi.org/10.1108/09513550610677753

Segers, R., Niessink, R., Van den Oever, R., & Menkveld, M. (2019). Warmtemonitor 2019.

Sydow, J., & Windeler, A. (1998). Organizing and Evaluating Interfirm Networks: A structurationist perspective on network processes and effectiveness on JSTOR. Organization Science, 9(3). https://www.jstor.org/stable/2640223

Tanujaya, B., Prahmana, R., & Mumu, J. (2022). Likert Scale in Social Sciences Research: Problems and Difficulties. FWU Journal of Social Sciences, 89–101. https://doi.org/10.51709/19951272/winter2022/7

The European Parliament. (2018). REGULATION (EU) 2018/1999 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL. https://eur-lex.europa.eu/legal-content/EN/TXT/?toc=OJ:L:2018:328:TOC%5C&uri=uriserv:OJ.L_.2018.328.01.0001.01.ENG

The European Parliament, The Council of the European Union. (2023). Energy Efficiency Directive. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_231_R_0001%5C&qid=1695186598766

Thollander, P., Svensson, I., & Trygg, L. (2010). Analyzing variables for district heating collaborations between energy utilities and industries. Energy, 35(9), 3649–3656. https://doi.org/10.1016/j.energy.2010.05.009

Thomann, E. (2023). Komex: Comparative Case Study Design. https://afww.uni-konstanz.de/en/komex-comparative-case-study-design-0

Thomson, A. M., & Perry, J. L. (2006). Collaboration processes: inside the black box. Public Administration Review, 66(s1), 20–32. https://doi.org/10.1111/j.1540-6210.2006.00663.x

Tsoukas, H., & Chia, R. (2002). On Organizational Becoming: Rethinking Organizational change. Organization Science, 13(5), 567–582. https://doi.org/10.1287/orsc.13.5.567.7810

TU Delft. (n.d.). MSc Construction Management and Engineering. https://www.tudelft.nl/onderwijs/opleidingen/masters/cme/msc-construction-management-and-engineering

Tweede Kamer der Staten-Generaal. (2023). Wetsvoorstel Wet gemeentelijke instrumenten warmtetransitie (tech. rep.). https://www.tweedekamer.nl/kamerstukken/wetsvoorstellen/detail?cfg=wetsvoorsteldetails%5C&qry=wetsvoorstel%3A36387#wetgevingsproces

Tweede Kamer der Staten-Generaal. (2024). Wetsvoorstel Wet collectieve Warmet) (tech. rep.). Tweede Kamer. https://www.tweedekamer.nl/kamerstukken/wetsvoorstellen/detail?qry=wetsvoorstel%3A36576%5C&cfg=wetsvoorsteldetails

Unruh, G. C. (2000). Understanding carbon lock-in. Energy Policy, 28(12), 817–830. https://doi.org/10.1016/s0301-4215(00)00070-7

Valize, J. (2024). Regels omtrent productie, transport en levering van warmte (Wet collectieve warmte). https://debatdirect.tweedekamer.nl/2024-10-16/klimaat/suze-groenewegzaal/regels-omtrent-productie-transport-en-levering-van-warmte-wet-collectieve-warmte-10-00/video

Van Der Lugt, H. (2024, September). In 2025 komen de echte beleidsvoorstellen energie. https://energeia.nl/in-2025-komen-de-echte-beleidsvoorstellen-energie/

Van der Molen, F., Langeveld, J., Herbstritt, C., Poorthuis, W., & Hoogervorst, N. (2023, June). Overzicht transitievisies warmte. https://www.pbl.nl/publicaties/overzicht-transitievisies-warmte#:~:text=Een%20van%20de%20middelen%20om,de%20gebouwde%20omgeving%20in%20kaart.

Van Heiningen, J. (2024, June). Warmtenetten voor dichtbevolkte wijken dertig procent goedkoper dan warmtepompen. https://www.ebn.nl/nieuws/warmtenetten-voor-dichtbevolkte-wijken-dertig-procent-goedkoper-dan-warmtepompen/

Vangen, S., & Huxham, C. (2003). Nurturing collaborative relations. The Journal of Applied Behavioral Science, 39(1), 5–31. https://doi.org/10.1177/0021886303039001001

Vangen, S., & Huxham, C. (2013, October). Building and using the theory of collaborative advantage. https://doi.org/10.4324/9780203752562-12

Voets, J., Brandsen, T., Koliba, C., & Verschuere, B. (2021). Collaborative governance. Oxford Research Encyclopedia of Politics. https://doi.org/10.1093/acrefore/9780190228637.013.1419

Warmtewet [Retrieved January 1, 2025, from Overheid.nl]. (2014). https://wetten.overheid.nl/BWBR0033729/2025-01-01

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

Wet gemeentelijke instrumenten warmtetransitie (36.387). (2024). https://www.eerstekamer.nl/wetsvoorstel/36387_wet_gemeentelijke

Woodland, R. H., & Hutton, M. S. (2012). Evaluating organizational collaborations. American Journal of Evaluation, 33(3), 366–383. https://doi.org/10.1177/1098214012440028

Yao, S., Wu, J., & Qadrdan, M. (2024). A state-of-the-art analysis and perspectives on the 4th/5th generation district heating and cooling systems. Renewable and Sustainable Energy Reviews, 202, 114729. https://doi.org/10.1016/j.rser.2024.114729

Yin, R. K. (2003). Case Study Research (3rd ed.). SAGE. https://iwansuharyanto.wordpress.com/wp-content/uploads/2013/04/robert_k-_yin_case_study_research_design_and_mebookfi-org.pdf

A

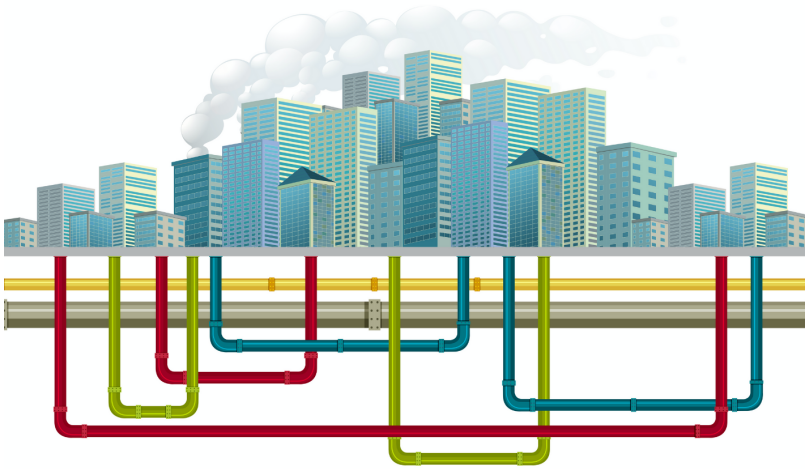
Practical tool

The following 11 pages show the introduction card, the 9 discussion cards and the disclaimer card, which is the last card. Its intended use is explained in Chapter 6 Practical recommendations

TU Delft

SAMENWERKING IN EEN WARMTENET: HOE PAK JE HET AAN?

Een hulpmiddel voor interactieve sessies bij de start van een warmtenet



Front of the introduction card, cover image from Cole (n.d.)

GEBRUIKSAANWIJZING

DOEL VAN DEZE TOOL?
Samenwerken is voor elk warmtenet anders, maar er zijn een aantal overkoepelende thema's. Deze tool bestaat uit 9 discussiekaarten bedoeld als gesprekstarters in een interactieve sessie. Aan de hand van de discussiethema's krijgen de deelnemers inzicht in hoe je het samenwerkingsproces kan opzetten. Deze uitgangspunten kunnen hepen bij de contractvorming en het verdere samenwerkingsproces.

WANNEER GEBRUIK JE DE TOOL?
De tool faciliteert de interactieve sessie, welke in de oriënterende fase moet worden georganiseerd, vóór de contractondertekening. Voorafgaand aan de sessie moeten de volgende stappen worden doorlopen:

- ☑ Bepaal het gezamenlijke doel
- ☑ Maak een lijst van betrokken partijen
- ☑ Analyseer de individuele belangen van de partijen

Zorg ervoor dat er minimaal twee partijen deelnemen die (1) toegewijd zijn aan het project en (2) verschillende hoofdrollen vervullen, zijnde warmteproducenten, netbeheerders, warmteleveranciers, gemeenten of woningcorporaties.

WAT STAAT ER OP ELKE DISCUSSIEKAART?
Elke kaart behandelt een spanning die invloed heeft op het realiseren van 1 of meerdere van de significante kritieke succesfactoren "doelafstemming", "vertrouwen" en/of "toewijding". De kaarten laten zien in welke fase deze spanning speelt en voor welke partijen dit relevant is. Dit wordt aangegeven met gekleurde blokjes (relevant) of lichtgrijze blokjes (niet relevant). De informatie is vergaard uit casestudies van drie Nederlandse warmtenetten.

HOE VOER JE DE DISCUSSIE?
Elke kaart bevat de sectie: "Waarover in gesprek?", waarin belangrijke overwegingen voor samenwerking worden benoemd. De kaart eindigt met een vraag om het gesprek te openen. Bespreek de kaarten één voor één en schrijf samen de belangrijkste uitgangspunten per thema op.

VERVOLGSTAPPEN?
Aan het eind van de sessie hebben de participanten een lijst met ontwerpuitgangspunten opgeschreven. Deze kunnen de basis vormen voor de contractvorming, de bouw en het gebruik van het net. Samen bepalen jullie de vervolgstappen, zoals het opstellen van een eerste contractconcept. Samenwerking is dynamisch, wat betekent dat continue evaluatie en bijsturing belangrijk is.

Back of the introduction card

DISCUSSIEKAART 1

INCLUSIVITEIT

EFFICIENTIE

Front of discussion card 1

INCLUSIVITEIT VERSUS EFFICIENTIE

INVLOED OP?

Doelafstemming

Vertrouwen

Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Efficiëntie en inclusiviteit kunnen in samenwerkingsprocessen soms tegenover elkaar staan. Technische beslissingen kunnen sneller worden genomen met een kleine groep, terwijl bijvoorbeeld het vroegtijdig betrekken van eindgebruikers het draagvlak en de afstemming van doelen kan versterken.

In de praktijk blijkt dat wanneer bewoners pas laat worden betrokken kan dit leiden tot wantrouwen en weerstand bij aansluiting op het netwerk. Andersom kan een te uitgebreid participatieproces de besluitvorming vertragen of frustreren. Een gebalanceerde aanpak vraagt om aan het begin strategisch te bepalen wie je wanneer betrekt.

Ook (regionale) overheden kunnen in de oriëntatiefase een rol spelen, bijvoorbeeld door mee te denken over financieringsmogelijkheden of het bepalen van een bandbreedte voor aansluitkosten. Dit kan bijdragen aan duidelijkheid voor eindgebruikers.

In welke fasen zien jullie het belang van efficiënt werken en in welke juist dat van inclusiviteit?

Back of discussion card 1

DISCUSSIEKAART 2

INTEGRATIE

FRAGMENTATIE

Front of discussion card 2

INTEGRATIE VERSUS FRAGMENTATIE

INVLOED OP?

Doelafstemming | Vertrouwen | Toewijding

IN WELKE FASE?

Oriëntatie | **Contractfase** | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | **Gemeente** | **Eindgebruikers**

WAAROVER IN GESPREK?

In een warmteketen kunnen partijen ervoor kiezen om één integraal warmtebedrijf op te zetten waarin productie, distributie en levering zijn samengebracht. Dit kan processen stroomlijnen en maakt interne afstemming eenvoudiger. In de praktijk kan gezien worden dat dit helpt bij bijvoorbeeld het flexibel herverdelen van financiële middelen, of snel handelen bij onverwachte gebeurtenissen.

Tegelijkertijd is volledige integratie van de rollen niet altijd noodzakelijk of wenselijk. Het hebben van verschillende partijen die verantwoordelijk zijn kan ruimte bieden voor innovatie of scherpe prijsafspraken. Wel vraagt dit om zorgvuldige afstemming van belangen. Bij gebrekkige coördinatie kan fragmentatie leiden tot misverstanden, vertraging of frustratie bij eindgebruikers, bijvoorbeeld wanneer beslissingen van de ene partij niet rekening houden met de (individuele) doelen van een ander.

Een grote uitdaging in deze spanning is het behartigen van de belangen van eindgebruikers. Het kan het helpen om een onafhankelijke vertegenwoordiger aan te stellen als aanspreekpunt zodat de belangen van eindgebruikers expliciet worden meegenomen in het keuzeproces.

Welke rollen willen jullie in het warmtebedrijf integreren?

Back of discussion card 2

DISCUSSIEKAART 3

CENTRALE MACHT

VERDEELDE MACHT PER PARTIJ

Front of discussion card 3

CENTRALE MACHT VERSUS VERDEELDE MACHT

INVLOED OP?

Doelafstemming | Vertrouwen | Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Deze spanning kan effect hebben op casus specifieke succes factoren. Bij het opzetten van een warmtenet moet in de contractfase de zeggenschap bepaald worden: wie bepaalt wat, wanneer, en op basis waarvan? De verdeling van macht, of dat nu financieel, juridisch of inhoudelijk is, kan liggen zijn bij één dominante partij (bijvoorbeeld bij het warmtebedrijf of bij de gemeente), of juist verspreid over meerdere stakeholders. Beide vormen hebben voor- en nadelen: centrale aansturing kan zorgen voor daadkracht, maar kan leiden tot wantrouwen of afhankelijkheid; verdeelde macht bevordert legitimiteit, maar kan besluitvorming vertragen.

In de praktijk blijkt dat formele zeggenschap (zoals eigenaarschap) niet altijd overeenkomt met feitelijke invloed. Het is minstens zo belangrijk hoe de expertise is verdeeld en hoe toegewijd de eindgebruikers zijn.

Problemen kunnen ontstaan wanneer de verantwoordelijkheden en zeggenschap niet goed verdeeld zijn. Wanneer bijvoorbeeld een aparte leverancier verantwoordelijk is voor het voorkomen van storingen, dan is het handig als deze ook invloed heeft op het onderhoud van het net.

Hoe willen jullie zeggenschap borgen in het netwerk?

Back of discussion card 3

DISCUSSIEKAART 4

NETWERK MIDDELEN

MIDDELEN PER ORGANISATIE

Front of discussion card 4

NETWERKMIDDELEN VERSUS ORGANISATIEMIDDELEN

INVLOED OP?

Doelafstemming | **Vertrouwen** | Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Binnen samenwerkingen ontstaat regelmatig spanning tussen het inzetten van eigen middelen en het gezamenlijk investeren op netwerk-niveau. Organisaties hebben vaak hun eigen prioriteiten, planningen en financiële kaders, wat samenwerking kan bemoeilijken als er geen (duidelijke) afspraken zijn over wie welke middelen inzet.

In de praktijk blijkt dat vooral ‘tijd’ vaak als netwerkmiddel wordt ervaren: partijen investeren bijvoorbeeld gezamenlijk in overleg, in de communicatie naar bewoners of projectcoördinatie. Financiële middelen blijven daarentegen meestal gebonden aan een organisatie.

Niet iedere partij hoeft op dezelfde manier bij te dragen. Bijdragen kunnen zowel financieel zijn, als in de vorm van inzet en expertise. Het is vooral belangrijk om de af te stemmen hoe elke partij zijn eigen middelen inzet naar het gezamenlijke doel, zonder dat er perse gedeelde netwerkmiddelen moeten worden aangemaakt.

Welke vormen van gedeelde inzet dragen volgens jullie bij aan het bereiken van het gezamenlijke doel?

Back of discussion card 4

DISCUSSIEKAART 5

SAMENWERKEN

AUTONOOM WERKEN

Front of discussion card 5

SAMENWERKEN VERSUS AUTONOOM WERKEN

INVLOED OP?

Doelafstemming | Vertrouwen | Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Alle partijen zijn sterk afhankelijk van elkaar om het geheel te laten functioneren. Tegelijkertijd is het belangrijk dat partijen autonomie behouden binnen hun eigen expertise om snel en efficiënt te kunnen handelen. Deze spanning speelt door de hele samenwerking heen, maar vraagt in elke fase iets anders.

Tijdens de oriëntatie- en contractfase kan het waardevol zijn om individuele belangen naar elkaar uit te spreken. Het expliciet maken van deze belangen creëert ruimte om later zelfstandig te opereren zonder het gezamenlijke doel uit het oog te verliezen. In de uitvoering kunnen partijen dan vertrouwen op elkaars expertise, zolang duidelijk is wat de gedeelde koers is.

Deze spanning kan belangrijk zijn bij het betrekken van eindgebruikers. Eindgebruikers bepalen uiteindelijk zelf of ze willen aansluiten, maar hun besluit hangt vaak af van méér dan alleen techniek of prijs. Het kan helpen om hun bredere belangen in het project mee te nemen, bijvoorbeeld door bij de aanleg van het warmtenet ook bij te dragen aan vergroening of de parkeergelegenheden.

Wat zijn de individuele belangen van de eindgebruikers en hoe kunnen die zo uitgebreid worden geborgd in het project?

Back of discussion card 5

DISCUSSIEKAART 6

TRANSPARANTIE

AUTONOOM WERKEN

Front of discussion card 6

TRANSPARANTIE VERSUS AUTONOOM WERKEN

INVLOED OP?

Doelafstemming

Vertrouwen

Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Transparantie kan bijdragen aan het creëren van vertrouwen en betrokkenheid, maar vraagt tegelijk om zorgvuldige afwegingen: hoeveel informatie deel je, met wie, en wanneer? Te veel transparantie kan autonomie beperken; te weinig kan wantrouwen oproepen of tot verkeerde aannames leiden. De spanning zit dus in het vinden van een balans tussen openheid en professionele bewegingsvrijheid.

In de praktijk blijkt dat het niet alleen gaat om óf informatie wordt gedeeld, maar ook hoe dit gebeurt. Relevante informatie, zoals financiële analyses of planningen, moet foutloos én begrijpelijk zijn. Het aanstellen van een persoon of team dat complexe informatie vertaalt naar toegankelijke taal kan helpen om intern en extern vertrouwen op te bouwen.

Het kan ook helpen om goed na te denken over welke financiële verwachtingen jullie transparant willen zijn en naar wie. Dit kan namelijk bijdragen aan vertrouwen. Als laatste is deze spanning relevant bij de communicatie naar eindgebruikers. Niet iedere eindgebruiker wilt dezelfde mate van transparantie. Sommigen hebben genoeg aan een website, anderen willen liever bijeenkomsten of persoonlijke communicatie.

Waar zien jullie het belang van (financiële) transparantie?

Back of discussion card 6

DISCUSSIEKAART 7

LEREN ALS NETWERK

LEREN BINNEN JE ORGANISATIE

Front of discussion card 7

NETWERKLEREN VERSUS ORGANISATIELEREN

INVLOED OP?

Doelafstemming | Vertrouwen | Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Er kan geleerd worden op twee niveaus in één project: in het bredere netwerk of binnen individuele organisaties. Beide zijn belangrijk, maar hebben verschillende doelen. Organisaties richten zich vaak op interne efficiëntie, terwijl leerinitiatieven op netwerk niveau kunnen bijdragen aan doelafstemming, vertrouwen, en toewijding. De spanning ontstaat wanneer de leerdoelen per niveau niet op elkaar zijn afgestemd.

Samen met het netwerk kan de leerfocus liggen op het optimaliseren van aansluitingen en het vergroten van het draagvlak onder eindgebruikers. Dit kan bijvoorbeeld door bewoners kennis te laten maken met warmtenetten via demonstratieprojecten, zoals via een voorbeeldappartement waarin bewoners de werking kunnen ervaren.

Binnen organisaties kan leren gericht zijn op interne procesoptimalisatie, zoals het verlagen van installatiekosten. Daarnaast kan het voor gemeenten waardevol zijn om ervaringen uit andere warmtenetten mee te nemen in de oriëntatiefase. Dit kan inzicht geven in organisatorische structuren en het politieke besluitvormingsproces.

Wat voor een gezamenlijke leerinitiatieven vinden jullie waardevol?

Back of discussion card 7

DISCUSSIEKAART 8

STABILITEIT

FLEXIBILITEIT

Front of discussion card 8

STABILITEIT VERSUS FLEXIBILITEIT

INVLOED OP?

Doelafstemming | Vertrouwen | Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Een warmtenet vraagt om langdurige samenwerking waarin stabiliteit en flexibiliteit in balans moeten zijn. Stabiliteit (zoals vaste partnerschappen, duidelijke contracten of langdurig betrokken partijen) kan zorgen voor vertrouwen, kennisbehoud en consistente besluitvorming. Tegelijkertijd is flexibiliteit nodig om te kunnen omgaan met onverwachte ontwikkelingen (zoals veranderende wetgeving, tegenslagen in het project of wijzigingen in het team).

In de praktijk blijkt dat stabiele structuren goed kunnen werken zolang de context voorspelbaar blijft. Maar bij onverwachte ontwikkelingen helpt het als er ruimte is ingebouwd om bij te sturen in zowel houding als contracten. Vasthouden aan gezamenlijke doelen, in combinatie met de bereidheid tot heronderhandeling, blijkt belangrijk om de samenwerking niet te laten vastlopen.

Ook energiezekerheid vraagt om dit evenwicht: zekerheid kan juridisch geborgd worden via contracten, terwijl operationele flexibiliteit ontstaat door het openstellen van het netwerk voor meerdere warmtebronnen.

In welke aspecten vinden jullie stabiliteit belangrijk, en waar is juist flexibiliteit nodig?

Back of discussion card 8

DISCUSSIEKAART 9

DIALOOG

CONFRONTATIE

Front of discussion card 9

DIALOOG VERSUS CONFRONTATIE

INVLOED OP?

Doelafstemming | Vertrouwen | Toewijding

IN WELKE FASE?

Oriëntatie | Contractfase | Constructie | Operatie | Exploitatie

VOOR WIE BELANGRIJK?

Warmteketen | Gemeente | Eindgebruikers

WAAROVER IN GESPREK?

Dialoog en confrontatie zijn beide belangrijk voor een goede samenwerking, maar vragen om timing en vertrouwen. Regelmatig overleg bevordert doel-afstemming, terwijl confrontatie kan helpen om elkaars drijfveren te snappen en impasses te doorbreken. Partijen verschillen vaak in communicatiestijl. Het creëren van een cultuur waarin zowel dialoog als constructieve kritiek mogelijk is, kan bijdragen aan een goede samenwerking.

Voor eindgebruikers kan herhaling en zichtbaarheid helpen. Hoe vaker zij in aanraking komen met (positieve associaties van) het warmtenet en de betrokken partijen, hoe vertrouwder en positiever hun beeld kan worden. Denk aan 'social success stories', waarin gemeenten bewoners aan het woord laten over hun positieve ervaring met het net.

Eindgebruikers kunnen verschillende communicatiebehoeften hebben, wat kan zorgen dat één standaard strategie niet voor iedereen werkt. Het draagvlak kan vergroot worden door de strategie aan te passen naar de verschillende type eindgebruikers.

Hoe richten jullie de communicatiestrategie in voor het betrekken van eindgebruikers?

Back of discussion card 9

DISCLAIMER

De informatie in deze tool is gebaseerd op wetenschappelijk onderzoek tijdens een afstudeerstage aan de Technische Universiteit Delft, binnen de master Construction Management & Engineering. Het onderzoek is uitgevoerd door E.M. van Dongen, met de titel: **"Developing Collaboration in District Heating Networks: a Process Perspective".**

Het betreft een eerste versie van de tool, met het doel om partijen die een warmtenet willen opzetten te ondersteunen met het inrichten van de samenwerking. De tool is gebaseerd op drie casestudies van Nederlandse warmtenetten. Binnen deze netwerken zijn 13 interviews afgenomen om de relatie tussen de processpanningen, de fases in het proces, de betrokken partijen en de te realiseren kritieke succesfactoren in beeld te brengen.

Deze tool is daarna geëvalueerd met twee experts op het gebied van publiek-private samenwerkingsvormen en warmtenetten.

Houd er rekening mee dat het gebruik van de tool kan bijdragen aan een succesvolle samenwerking, maar geen garantie biedt voor success. Elk warmtenet is een uniek process met een eigen context. Het behouden van een goede samenwerking is een dynamisch proces. Deze discussiekaarten bieden enkel handvaten voor het inrichten van een samenwerkingsproces dat in andere projecten als positief is ervaren.

Voor vragen en opmerkingen:
E.M. van Dongen
+316 21307071
elizemvd@gmail.com

Afbeelding op omslag: Cole, M. (z.j.).
Underground water pipe system [Vectorillustratie via Vecteezy].

TU Delft

Front of disclaimer card

Back of disclaimer card

TU Delft

B

In-depth within-case analyses

B.1. Within-case analysis of case 1

The key success factors (in short, KSFs) are defined during the interviews. It is also discussed how the tensions arose in the network, and how managing them affects the KSFs. This section describes how the respondents experience the tensions and the KSF realisation in case 1.

Case 1 role distribution

Case 1 describes a system that operates a district production pump with collective air heat pumps as the heat source. A district heating company was set up for the heat production and distribution, and had contracted another company for heat supply to end users. In this case, the district heating company was a public entity, meaning that both production and distribution were publicly governed, while the supplier was a private party. The end users were renters from a housing corporation. The municipality and the DH company were planning to expand the end users group to individual homeowners. During the development network, there were crucial moments in which collaboration went well and when it was challenging. During the formation phase, the network had a huge setback. An important subsidy did not get through (INT3). At that moment the project was in jeopardy: it was possible that the housing corporation would switch to individual solutions instead of going through with the collective heating. The organisations then came together and engaged in a discussion about their shared belief. "It would be crazy that we would cancel the project just because of a financial setback?" said INT3. The end of this crucial moment was the milestone of signing all contracts, the end of the formalisation phase. A moment where collaboration was challenging was connecting individual homeowners (INT3; INT4). Collaboration was difficult because the individual homeowners felt that they had been excluded from the decision-making process in the beginning of the project (INT2). This strained the project relationship, even though the individual relationships remained positive (INT2). The respondents mentioned the following key success factors for collaboration:

- Mutual goodwill (INT1, INT2);
- Trust (INT3, INT4);
- Dialogue (INT2);
- Commitment to the project (INT2, INT3, INT4);
- Belief in the end goal (INT3);
- Urgency (external pressure) (INT2, INT3);
- Goal alignment (INT2);
- Collaborative revenue model (INT1).

Link between tensions and KSFs in case 1

T1: Inclusivity versus efficiency This tension arose in specific decision rounds (INT2). Since all parties joined voluntarily, inclusivity was crucial in the initiation phase to form the consortium. The municipality, DH company, and housing corporation defined around ten boundary conditions together to ensure individual interests were accounted for before approving the project and moving into formalisation (INT2, INT3). However, the supplier was involved later and did not have its interests explicitly included (INT1, INT2). From this perspective, decision-making was not fully inclusive (INT1). Also, individual homeowners were not part of the initiation phase. This led to difficulties in collaboration in the district heating project, as they felt their interests were overlooked (INT2). Important note here is that collaboration on an individual level has always been good. The respondents agreed that the more (representatives of) parties were included early in the formation phase, the better the partial interests of organisations can be set as conditions, and the better the shared interests can be used as catalyst for the network realisation. If a DHN would try to work more efficient by not involving all parties, it could hinder the collaboration. T1 affected the level of goal alignment, commitment, and mutual goodwill.

T2: Integration versus fragmentation The tension between integration and fragmentation arose from that there are many stakeholder roles in the network that needed to be fulfilled in a certain way without centralised control. These roles were described in the analytical framework in section 3.2. Opinions on the whether the network was more integrated or fragmented varied: INT3 saw it as relatively integrated, while INT1 and INT2 perceived it as fragmented. This tension played out differently across stakeholder groups. Heat chain actors focused on fragmentation within the supply chain, whereas those working with end users noted fragmentation on the consumer side. In the heat chain, fragmentation was an issue in the initiation phase when roles are divided. The decision to separate the supplier role had the advantage of future competition on the network, but made it harder to create a viable business model for all parties (INT2). It also increased the number of contracts required (INT2, INT3). One respondent suggested standard contracts as a solution (INT2). Another challenge was the skewed role distribution: The supplier had no influence on the maintenance of the system as it was not the owner of the infrastructure, which made it difficult to be responsible for disruptions (INT1). This was thus a problem that arose during the operation phase, which was caused by how this tension is managed in the initiation phase. On the end user side, fragmentation initially included individual homeowners, but due to financial risks, the focus shifted to integrated end users with a housing corporation (INT4). This decreased initial financial risks, but made it harder to incorporate individual homeowners later on due to strained relation in the project (INT2). T2 influenced goal alignment and whether there was a collaborative revenue model.

T3: Centralised versus distributed control over power resources Power differences in district heating networks stemmed from CAPEX distribution, public-private positioning in the heat chain, and risk division. These factors were decided on in the formation phase, in which it was thus very important to be aware of their effects on the maturation phase. Respondents said that even though theoretically, the power lay with the largest shareholder of the DH company, but practically the success of the network depends on all parties. Decisions were made through consultation, with INT3 stating: "During shareholder meetings, we see no difference in percentages. It is very much on an equal basis." INT2 added that power shifts across project phases. In the formation phase for example, the end users had the power to give security whether they will connect or not (INT2). The DH company needed this approval to mitigate development risks for the DH company and to actually start the development (INT2, INT4). In the operation phase, control became more centralised within the DH company based on expertise authority (INT4). Power could also be distributed a certain way to protect end users. Here for example, the municipality kept veto right over tariffs to safeguard public values (INT2). The negative effect of power dynamics became evident when there was a mismatch between who invests and who bears responsibilities towards other parties. The supplier, that did not have infrastructure ownership, had no control over maintenance yet remained responsible for security of supply to end users. This could have been mitigated by internalising the supply role in the initiation phase (INT2) or refining role division in formation (INT1). T3 had no direct effect on the KSFs in this case, but neglecting the practical powers of all parties can hurt the collaboration.

T4: Network resources versus organisational resources Shared resources include time, people, finances, and infrastructure, but in this case, respondents mainly referred to shared time. During the formation phase, the DH company, municipality, supplier, and housing corporation collectively invested time to communicate with possible end users(INT1). The goal was to decrease unfamiliarity of DH and improve the overall image. This built more belief in the end goal, commitment, and gives clarity on how their individual interests are accounted

for. The other respondents agreed that time was a shared resource here and that it increased trust and dialogue (INT2, INT3). Other resources were not necessarily shared, and no conclusions can be drawn about their impact on collaboration based on this case. However, time investment also served as an indicator of commitment and priorities of parties (INT2). However, this relation was not deterministic; more time spent does not automatically indicate better collaboration, nor does spending less time necessarily indicate failure (INT2). T4 had an effect on the level of trust and dialogue.

T5: Interdependence versus autonomy Both working interdependent and working autonomous was preferred in different parts of the project. For end users to be satisfied, all parties of the network should work efficiently (from source to supply). This caused an urgency to work interdependent and to align goals between the individual organisations (INT2). Regular coordination between parties was very important to make sure end users were happy with the entire network (INT3). An example of this was that the DH company, municipality, supplier and housing corporation worked interdependent on the communication strategy to end users. Another cause for how autonomous or interdependent parties work was how fragmented or integrated the heat chain was. In this case, the supply role was fragmented. This caused the supplier to enact more on autonomous goals than on shared goals than the other parties in the DH company (INT3). An example was how user services were provided: the supplier contracted an external service company for economic reasons (INT3). However, the municipality was not positive about the choice of service company, but it had no influence on that decision. Working too autonomous caused a negative effect on collaboration on the goal alignment. It could have been improved by aligning goals more (INT3). Autonomy created flexibility, but only had a positive effect on the collaboration outcomes if there is commitment, dialogue and aligned goals. Daily tasks could for example be done autonomously (INT3). It can be said that autonomy must be enabled by working interdependently on a regular basis. T5 had a negative effect on the level of goal alignment.

T6: Transparency versus autonomy As the sector is based on voluntary participation, the focus on transparency was very important for a high quality of collaboration. If not enough information is shared, it is difficult to work autonomously while still realising the same shared goals. Especially during the formation phase where requirements is set. How much transparency there was, depended firstly on whether a party was public or private. Public parties had the obligation to be accountable, while private parties had more room for defining transparency for themselves (INT2). Every respondent found transparency very important and indicated that they felt they had been transparent to other parties. During the initiation and formalisation phases, transparency about goals led to the creation of ten boundary conditions, which eventually led all parties to approve of the project (INT2). The effect was that trust was build, parties felt more committed to the project and goals are more aligned. This also created the opportunity for reflection later on in the project. Reflection in maturation phase can help developing good collaboration patterns (INT2). "Everything hinges on transparency" - interview INT1. T6 influenced the level of trust, the goal alignment, and commitment.

T7: Network learning versus organisational learning This tension was handled differently in the formation and maturation phases. It depended on the expertise needed (INT1). During the formation phase, the parties focused on learning collectively, while in the maturation phase, the focus shifted to organisational learning for operational optimisation (INT1, INT2). Network learning becomes relevant again when the network expands or external factors arise (Ansell & Gash, 2007) (INT3). An example of network learning was the behaviour study on individual homeowners' choices, which helped the consortium on how to connect end users. However, the respondents explained that there were no network initiatives to learn about the proposed Heat Act during the maturation phase. The respondents did get enthusiastic when talking about these initiatives. INT1 said that parties were a bit reserved when it came to setting this network initiatives up, but that it could be positive for the group dynamic. INT2: "was super educational and fun to do with all parties; it gives a boost to the collaboration". As DH is a young market, learning must happen not only within organisations or networks but also between networks (INT3). This case often received visits from other municipalities lacking DHN expertise, allowing them to learn from successes and mistakes. T7 affected the level of commitment and the belief in the end goal.

T8: Stability versus flexibility As the district heating sector is still in the pioneering phase and require exhaustive investments, a certain level of stability in the stakeholder core was needed. This increased quality of collaboration. If there would be high flexibility in the core stakeholders, it would be challenging to keep interests aligned and to create a feasible business case. The collaborative structure was decided on in the formalisation phase by the contractual agreements (INT1). The main stakeholder core here was very stable. Having stability

in the core group made it possible to manage individual interests of the organisations involved, which was a condition for a good collaboration (INT2). INT3 did add the fact that contracts with shorter terms can create flexibility. Here for example, the supplier had a shorter contract term, which enables evaluation and flexibility when needed (INT3). Besides the core stakeholder group, there was a more flexible shell (INT2). The flexible shell consisted of organisations that can be added to manage complexities. For example, the external behaviour psychologist was added in the flexible shell to manage complexities between the involvement of end users in the network (INT2, INT3). A flexible shell of stakeholders helped with dealing with specific complexities. T8 influenced the mutual goodwill and the commitment of parties.

T9: Dialogue versus confrontation The importance of dialogue differed per project phase. Parties needed regular dialogue at the front-end to start-up the project (INT1). In the front-end, parties talked (bi-)weekly about: (a) what problems every party is facing, (b), what is a good next step, and (c) what should not be done et cetera (INT2). Regular contact had a very positive affect on collaboration, as it increased trust and mutual goodwill (INT2). Also, INT3 said that more dialogue enabled better goal alignment. However, when construction was finished and collaborative patterns stabilise during the operation and exploitation phase, dialogue was less important because every party knew their responsibilities (INT1). The cause and effect relation was thus asymmetric based on the different project phases. T9 affected the level of trust, mutual goodwill and dialogue. It also enabled goal alignment.

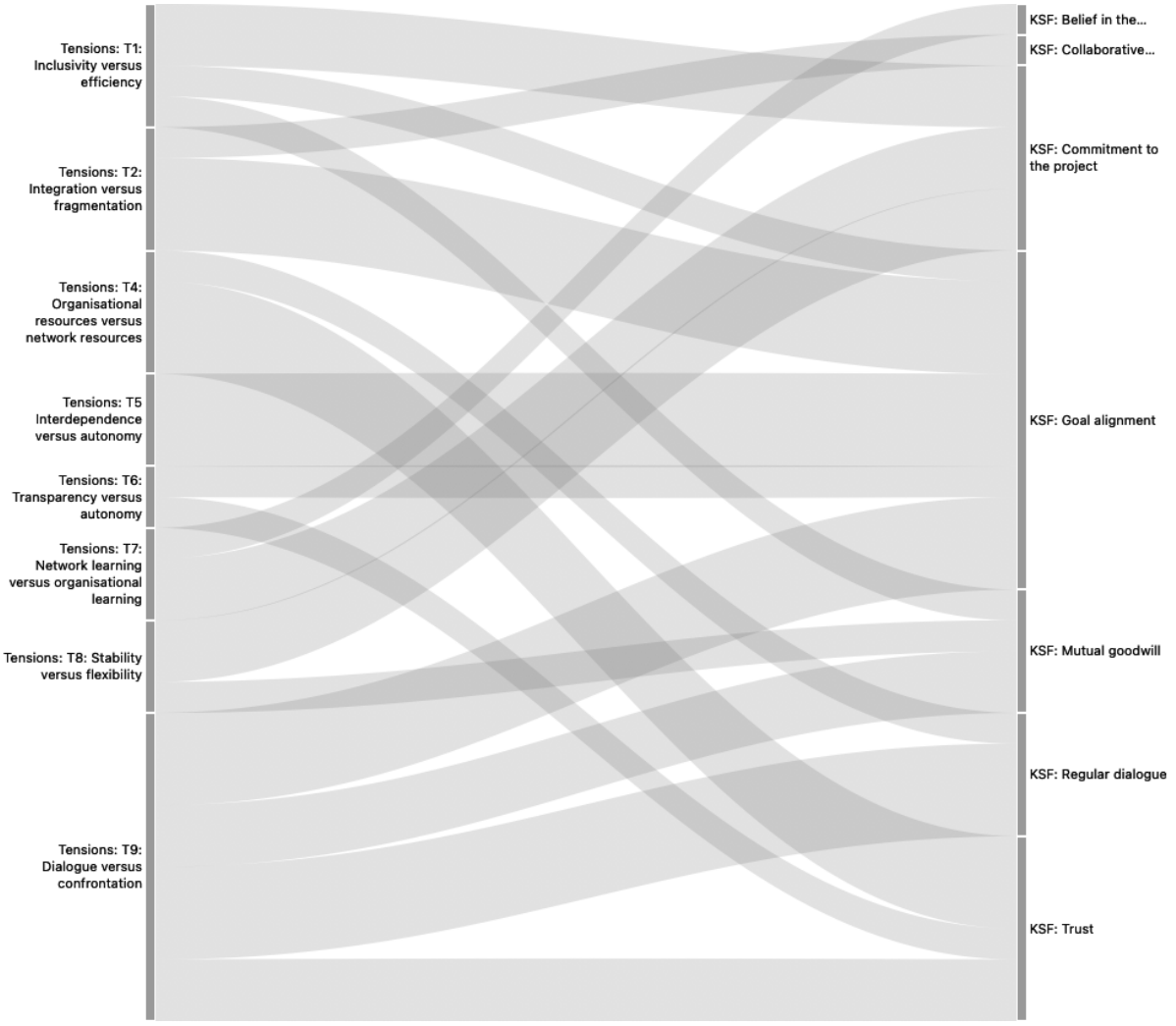


Figure B.1: Sankey diagram made using Atlas.ti: How the tensions have affected the KSF realisation in case 1

The figure above visualises the findings by explicitly linking which tensions affected which KSFs. It is interesting

that the respondents did not mention T3 to have a direct effect on the KSFs. What was mentioned by T3, was that theoretically the largest shareholder of the DH company has diffuse power. However, as these systems are based on voluntary connection of end users, the actual power is still distributed over the different roles in the network. In the formation phase it was especially important that each party was treated as equal, because each party owns some sort of blocking, diffusing or production power.

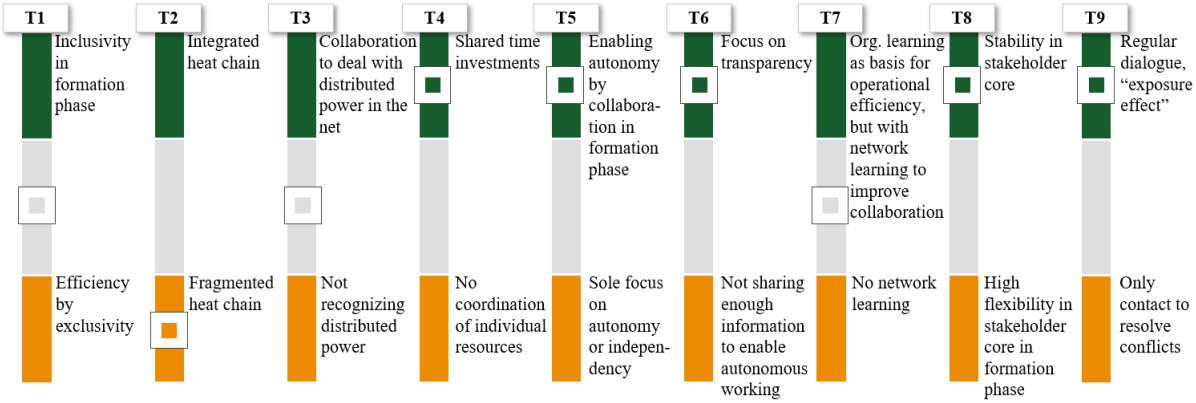


Figure B.2: How the tensions influence KSFs in case 1 - figure made by author using Atlas.ti

Figure B.1 shows what general positive and negative indications per tension for this case. The green area indicates how managing the tensions had, or would have had, a positive effect on collaboration. The grey area indicates that there was no data available, or no clear effect on the success of collaboration. The orange area indicates that managing the tensions in a certain way had, or would have had, a negative effect on collaboration in case 1.

B.2. Within-case analysis of case 2

The system in case 2 was operated by one public district heating company that in-houses the heat production, distribution, and supply. Thus, all the roles in the heat chain were publicly governed. However, the system did make use of some private energy sources, such as solar energy parks, which were connected to the network through external contracts. The end users were mostly housing corporations, some individual homeowners, industry and services.

Case 2 role distribution

This network also endured a huge setback during its development. The network wanted to connect a geothermal energy source, but the plan was cancelled due to complexities in the soil situation (INT7). This decision had a large impact which shook the confidence in the project (INT5). In such situations, when a solution is not immediately clear, there is the risk that stakeholders start pointing fingers at each other (INT5). Yet, the commitment between the parties here caused the project to continue (INT6). A decision was made to use another temporal heat source despite the original sustainability alternative. The parties trusted each other that another sustainable heat source would be found while construction continued. This was only possible because the parties continuously discussed and aligned individual goals with each other (INT5). One party stepped out of the consortium because that party had prioritised the use of the geothermal energy source as an individual goal. This situation resonated with what happened in case 1, in which there was a financial set-back that was overcome by having a certain quality of collaboration. The respondents mentioned the following key success factors for collaboration in this case:

- Trust (INT6, INT7);
- Mutual goodwill (INT7);
- Commitment (INT5);

- Clear role division (INT5);
- Knowledge retention (INT6);
- Goal alignment (INT5, INT6);
- Stakeholder-aligned business case (INT8).

Link between tensions and KSF in case 2

T1: Inclusivity versus efficiency The respondents found this tension most prominent in the inclusion or exclusion of end users. Housing corporations had been involved from the beginning and the collaboration went really well, but individual homeowners not so much (INT7). This resulted in that the individual persons felt subordinated, which led to difficult collaboration between the end users and the DH company (INT7). The network did try to improve this relationship by involving a psychologist from the first phases to identify motives for end users to connect (NT5). The network parties could then use these motives to nudge end users into joining the network (INT7). Two respondents pointed out that this was not necessarily a tension. In this case inclusivity led to efficiency, said respondents INT5 and INT6. They elaborated both that in the district heating sector, the voluntary natureof connection is decisive for success and that as long as there is no mandatory connection for end users, inclusiveness leads to efficiency. Inclusivity enabled goal alignment and built mutual goodwill. Here, because the individual end users had been included in the first phases, it strained the relationship, even though the collaboration with housing corporations went well (INT7). If there would be no inclusion, there probably still would not be a DHN (INT5). Whether there was a focus on inclusivity or on efficiency affected the mutual goodwill and the goal alignment between stakeholders.

T2: Integration versus fragmentation The tension between integration and fragmentation arose from that the many stakeholder roles in the network that need to be fulfilled in a certain way. The degree of fragmentation or integration of parties affected the clarity of the role division. Having a more fragmented network makes coordination difficult and requires strong leadership (INT5). Integration of the heat chain roles here improved the financial feasibility of the network. This was because it made it possible to re-allocate subsidies/investments across different system components while fragmentation forced each organisation to be more self-sustaining (INT6), which affected how aligned the business case was between the stakeholders. The respondents agreed that this network was somewhat more integrated than fragmented. End users were still fragmented (INT8), and heat sources could be fragmented (INT6). The respondents concluded that optimally, the network should be party integrated and partly fragmented so that financial spread is possible, but at the same time, roles would be divided based on expertise (INT6, INT7). The respondents wree quite satisfied with how it was done in this case. Whether the network was more integrated or more fragmented, affected the clarity of the role division and how stakeholder aligned the business case could be.

T3: Centralised versus distributed control over power resources The tension between centralised or distributed control over power resources arose from differing levels of authority among stakeholders. The respondents had different views on this, but all recognised the importance of coordinating the responsibility over governance and technical expertise. INT5 argued that power was naturally fragmented, as each party, including heat producers, individual homeowners, and housing corporations, made independent decisions based on self-interest. Since participation was voluntary, no single entity could enforce cooperation. In the contractual structure, INT6 saw control as centralised, with only two stakeholders making key decisions: the municipality and DH company. If disagreements arose, they were resolved internally, which worked because both parties shared the same goal: "Delivering affordable and sustainable heat" (INT6). INT7 explained that in this 2-party-power-structure view, power was formally centralised with the municipality, but expertise laid with the distributor. Even though there was collaboration, the municipalities ultimately made the final call, partly because in case of issues, public complaints were directed at them, not at the distributor (INT6). The parties seemed relatively content with the way this tension was handled (acknowledging distributed power over end users, with centralised power in the network roles to make decisions and respect knowledge partners). INT5 stated that clear upfront agreements were necessary to create a good role division. Another aspect of the power resources was the financial risk distribution. INT5 explained that the municipality took on occupancy risk for assuring enough end users connect to the system, which gave the DH company more financial security to develop the system. It encouraged some participation and caused realisation power, but did not necessarily help getting more end users connected. The distribution of power resources T3 was not mentioned to directly affect the KSFs for collaboration.

T4: Network resources versus organisational resources The tension was caused by having a shared responsibility over the network of delivering heat, but with individual financial responsibilities and infrastructure (INT6). Some financial resources were shared, especially in the heat chain, because those roles are in-housed in one DH company (INT6). However, financial assets were not shared and belonged to individual organisations (INT8). INT7 agreed with the last statement: each party had separate budget responsibilities. For instance, the heat producer financed its own infrastructure, and once operational, their revenue model was independent (INT7). There was also some shared personnel such as a traineeship (INT5), which enabled knowledge retention, but respondents did not specify whether this effect was significant. It could be seen that the focus here was not necessarily having network resources, but to allocate the resources to realise the shared goals instead of realising individual goals. Whether the focus was on network resources or organisational resources influenced the clarity of role division.

T5 Interdependence versus autonomy This tension arose from the need for collaboration to realise shared goals that could not be achieved individually, while each party simultaneously aimed to achieve individual interests. This tension caused problems in the collaboration when the major set-back of the geothermal heat source happened. It was uncertain how the project would continue. For one party, the individual goals were more prioritised than the shared goal of delivering sustainable heat to end users, which caused this party to step out of the consortium (INT6). The other parties trusted each other that another sustainable heat source would be found while the construction went on (INT6). This was only possible by continuously aligning individual goals (INT5). Another area where this tension created problems was in the relationship between end users with other stakeholders in the network. "Connecting individual homeowners depends entirely on the trust that you will handle their interests properly" (INT5). Some end users feared long-term dependency on a single heat provider, which was why it was very important to educate end users on how their individual interests would be safeguarded (INT8). The parties built an 'example apartment' to visualise what will change for the end users when switching to district heating (INT6). They could walk through the apartment, see the internal installation, but also actually try out the induction hob and how to adjust the heating. Another way of safeguarding individual interests was by explaining that when the network is constructed, the parking areas would also improve and more green would be added in the street. Thus, it helped to visualise how individual interests would be safeguarded, even for the interests outside the scope of the DHN (INT6). Working interdependent and working autonomous was both important in different phases of the network development according to the respondents in case 2. In the first phases, parties worked together often, for example to set requirements, build relationships and agree on the contents. Contents were for example the (a) heat source, (b) financial aspects and (c) end user. However, after that, autonomy was possible (within clear boundaries INT7), where the parties had the most expertise (INT6). INT7 stated that the network should be "cut" into logical parts, which meant the role and responsibility division should be done logically in the front-end. Visualisations of how individual interests were safeguarded helped nudge end users. The respondents did not conclude on specific KSF realisations, expect stating that both ends of the dilemma are important.

T6: Transparency versus autonomy This tension arose during decision-making when parties chose between sharing information and efficient operations. The different stakeholder roles had different transparency requirements (INT6), For example, the municipality operated as a "glass house", with maximum transparency especially in participatory processes. However, INT7 and INT8 stated that the quality of transparency matters just as much as the extend of what is shared, as sharing information with good quality increased trust between parties. Clarity on details such as cost implications for end users was important to share in every step of the process (INT8). INT7 warned that too much information can be inefficient. In this case, respondents indicated that transparency had not always been optimal, not because of a lack of information, but due to unsatisfying quality in what was shared (INT6, INT8). Respondents agreed that the level of accountability is largely set in agreements made in the formalisation phase. In the construction phase, the importance of planning transparency arose, because that enabled coupling opportunities (e.g. integrating street renovations, greenery and parking improvements) to maximally align individual interests (INT5, INT6), INT7). Respondents wanted high-quality transparency rather then full disclosure. First, in front-end, it was important to discuss and decide together on the required level of transparency and accountability (INT5). Then, in the construction phase, INT5 and INT6 indicated that the most important aspect was transparency about planning. This allowed realisation of more interests outside of the scope of DHN (as stated in the previous tension), for example renovation of parking spots and greenery (INT7). Structuring transparency efficiently, with a focus on high-quality and integration of planning, improved trust and goal alignment.

T7: Network learning versus organisational learning The tension between organisational learning and network learning arose from balancing internal expertise development with knowledge-sharing across stakeholders. One respondent noted that this tension does not necessarily have to exist. INT5 stated that learning within the organisation is a prerequisite for an organisation to work effectively. This was especially relevant for the DH company role in the network, as they were quite new (INT5). However, network learning played a large role in improving the collaboration, especially in the relation to end users. In this case, network learning was used to counteract the negative image of DHNs, for example by building the example apartment (T5), by "social proof" through success stories, and by user-focused training sessions such as an induction cooking class. These actions helped build trust. Besides trust-building, network learning was also used to understand end user motivations, which made it easier to align individual incentives with shared goals. In this case, a psychologist was hired that categorised the four drivers for end users to connect: (1) lower costs; (2) desire to contribute to a better world; (3) a sense of belonging; and (4) a better future for their grandchildren (INT7). These intrinsic motivations (from section 3.2) were then used to design a communication and promotional strategy. Even though network learning efforts were enthusiastically mentioned by multiple respondents, the connection rate among individual homeowners was still low. Again, the network-2-network learning was mentioned in this case, similar to case 1. It was used to share best practices between municipalities, about the political process, risk management and the technical system design (INT6). The respondents agreed that network learning and organisational learning should complement each other. A foundation of organisational learning should first be laid, after which network learning could be used to build trust and align goals with especially end users. Lastly, DHN were pioneering projects. This meant that even though they were costly, these projects could be used as 'stepping stones' for more efficient DHN development in the future (INT7). Both network learning and on organisational learning affected the level of trust, the knowledge retention within the project on and the goal alignment.

T8: Stability versus flexibility This tension arose because district heating networks require long-term commitment and consistency, while also needing to adapt to changing situations. Stability in organisations involved was needed to make it possible to align goals and to increase commitment (INT7). If the parties would often change, then new goals and interests would have to be managed every time a party changes. In this case, there was a stable core of involved persons from the decision-making parties (two individuals from municipality and two individuals from DH company), which enabled knowledge retention (INT6). They worked based on the 2012 TVW objectives of affordability, accessibility and sustainability (INT6). However, the DHN required flexibility in execution of works. When unexpected developments took place, parties had to think of alternatives for then (un)known challenges (INT8). In this case, when the geothermal source was cancelled, instead of abandoning the project the parties implemented temporary solutions for two years before transitioning to a new sustainable source (INT5). From the respondents it could be concluded that stability was important in the stakeholder core for knowledge retention and to make goal aligning easier. On the other side, flexibility was needed because district heating sector was still a relatively young sector. Therefore, flexibility in work and in dealing with uncertainties was important for a successful collaboration. Whether there is a focus on stability or flexibility affected the knowledge retention, goal alignment and commitment.

T9: Dialogue versus confrontation Lastly, having regular dialogue and conflict improved commitment in the project (INT8). Between all stakeholders, dialogue was the goal, but sometimes confrontation was necessary to address friction (INT6, INT7). Dialogue was regulated at operational and strategic levels (for example, on tariff development, technical issues, investment planning (INT5)). Tension management was really important in the communication strategy between end users and the other stakeholders in the network (INT6, INT7, INT8). Not all end users wanted or needed dialogue - some preferred general information such as a simple website, than direct engagement (INT8). This called for 'effective dialogue', in which end users who need in-depth discussions have access to the right persons for it, while other get standard information through websites and written notices (INT6). INT6 also explained that there was a third group of end users that often do not want any dialogue at all, which can for example be persistent critics of DH that will not be convinced to connect. Overall, the responses were that regular dialogue improves commitment to the project (INT8), but dialogue should be effective rather than excessive (INT6, INT7). Also, confrontation should be accepted when necessary, because it could help get through dead-locks and challenges (INT6). Regular dialogue improved the level of commitment to the project.

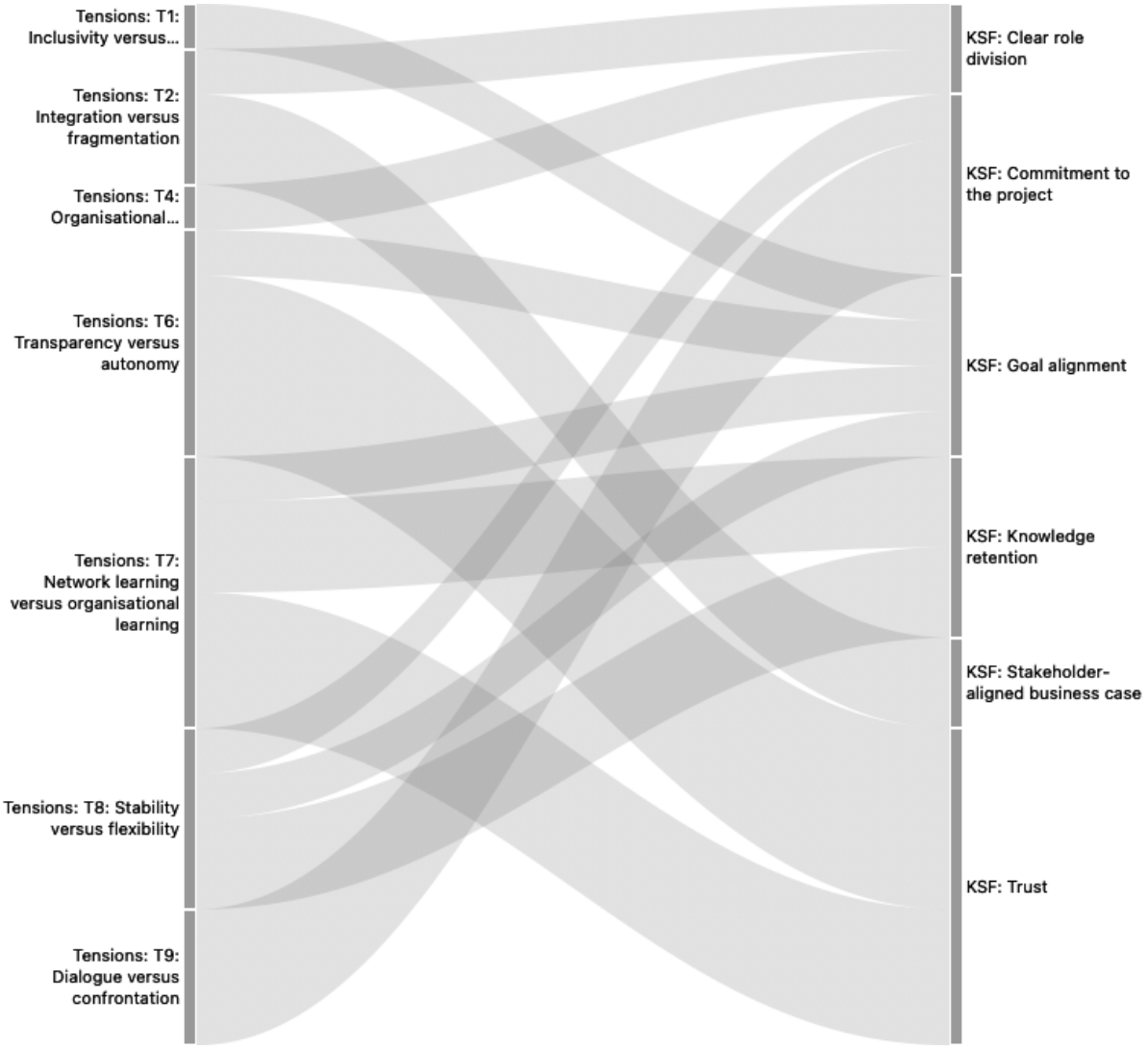


Figure B.3: Sankey diagram made using Atlas.ti: How the tensions have affected the KSF realisation in case 2

Figure B.3 shows what general positive and negative indications per tension for this case. The green area indicates how managing the tensions had, or would have had, a positive effect on collaboration. The grey area indicates that there was no data available, or no clear effect on the success of collaboration. The orange area indicates that managing the tensions in a certain way had, or would have had, a negative effect on collaboration in case 2.

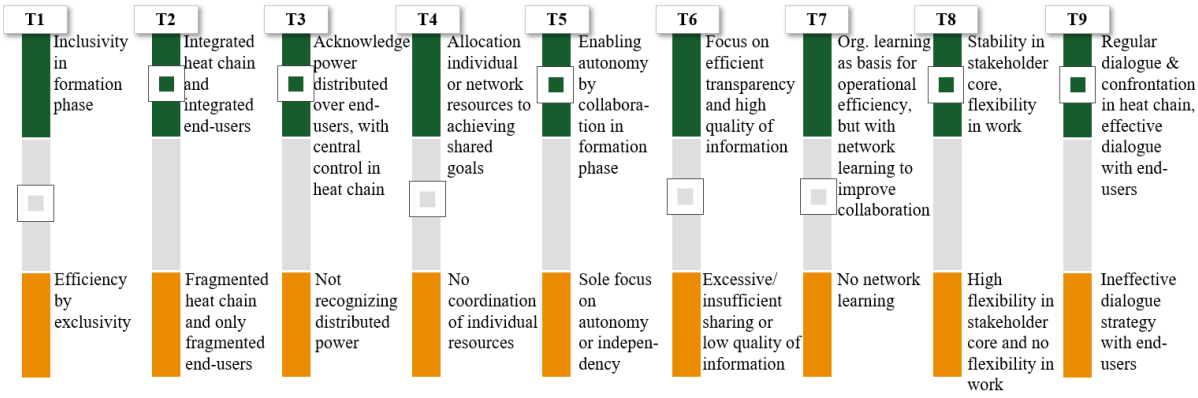


Figure B.4: How the different tensions should be managed to optimise the realisation of KSFs in case 2

B.3. Within-case analysis of case 3

The system in case 3 was operated by a district heating company that in-housed the distribution and supply role, but outsourced the heat production to another company. The district heating company was a joint-venture between the municipality and a private party, making it a hybrid governance model. The production role was carried out by an external public party.

Case 3 role distribution

In this case, an interesting metaphor emerged: **"the district heating network can be seen as a marriage"** (INT13). Parties joined in a long-term commitment, with shared responsibilities and inevitably unknown challenges that arise during the network development. Similar to committing to a marriage, stakeholders committed without knowing the future what the future would hold, including unexpected changes such as policy shifts, financial problems, or technical setbacks. The key success factors mentioned were:

- Patience (INT11);
- Relationship management (INT11);
- Trust (INT9, INT10);
- Clear role division (INT13, INT12);
- Equality between stakeholders (INT11);
- Telling the right story (INT11, INT12);
- Commitment to the project (INT11);
- Goal alignment (INT11, INT13).

Link between tensions and KSF in case 3

T1: Inclusivity versus efficiency This tension surfaced during the initiation phase, involving diverse stakeholders with varying interests and influence. As INT9 noted, inclusivity means considering all perspectives, not necessarily including every party at the table. While this ensured recognition of individual interests, it can slow decision-making. Conversely, efficiency through exclusion may speed up the process but strain relationships. This balance was critical during the formation phase. For instance, the interaction between the heat producer (HP) and the district heating (DH) company leaned toward efficiency (INT10), whereas engagement with end users was more inclusive and positively received (INT13). The DH company–municipality–end user "triangle" operated inclusively, largely thanks to two committed municipal actors (INT12). Still, the absence of actual end users in discussions (INT10) hindered collaboration (INT11). Excluding key actors like housing corporations risked resistance due to their influence. Managing this tension well supported clearer role division, stronger alignment, and better relationships. For successful collaboration, inclusivity should guide the triangle's decisions, while interaction within the heat chain can remain more efficiency-oriented. T1 affected the quality of relationship management, the clarity of the role division and the level of goal alignment.

T2: Integration versus fragmentation The choice between integration and fragmentation was made during initiation phase and formalised in the formalisation phase. The decision depended on: (1) which parties were involved, (2) what heat sources were available, (3) what types of end users were expected to connect, and (4) how the financial and legal structure of the heat network was set up (INT12). This tension could cause problems because integration streamlines parts of operation but can create monopolistic behaviour, but on the other hand fragmentation makes competition possible but also brings complexities and potential inefficiencies. Respondents indicated that integration streamlined operations and reduced interface risks. INT9 stated that fragmentation would lead to more interfaces, which would complicate operations and trust-building. INT9 also stated that this tension affects commitment to the project. INT13 perceived integration as essential during the construction phase to align investments and rollout. However, INT12 noted that the network was legally integrated, but economically still fragmented, which required financial transactions between entities. Not all agreed that integration was

necessary. INT11 stated a fully integrated system could hinder collaboration by reducing incentives to work together. Fragmentation on the other hand could lead to "cherry-picking," where only profitable projects proceed while complex ones stall. It can be summarised that it is important that the system works as a unity, where a high level of integration is applied (but not necessary) for trust building and relationship management (INT9, INT10), but with a checks-and-balances to prevent monopolistic behaviour (INT11). T2 affected the quality of relation management, and the level trust and commitment.

T3: Centralised versus distributed control over power resources This tension arose because land ownership influenced power distributions. In this case, the municipality owned the land and managed leasehold agreements (INT12), which gave the municipality diffuse power. Also, the tension was impacted by whether the heat chain was fragmented or integrated. An integrated chain requires a certain degree of central steering (INT9). INT10 agreed and stated that central coordination in the heat chain was necessary. This tension was most prominent until the construction phase and affected the level of equality between parties (INT11). Once the infrastructure was in place, further development became less relevant. INT13 added that participation was voluntary, and that even though power might be central, all parties must still find a way forward together (which aligned with the marriage-analogy). Additionally, authority was tied to expertise and decision-making power, as those with the necessary knowledge and competencies held more influence over specific areas (INT13). Here, T3 influenced the level of equality.

T4:Network resources versus organisational resources This tension arose from organisational structures, (INT12) and role division (INT11). Each organisation had its own financial priorities, and while they worked towards a shared goal, there was no common fund in this case (INT9). They aimed to optimise individual resources efficiently (INT10) and perceived it as going well. Two respondents added that shared resources could be important to build equality between parties (INT11, INT12), but that this does not need to be financial; it could also be in time or personnel. In this case, for example, the heat producer used to contribute two full-time equivalents when involved in the DH company, but indicated that this was too little time shared to build equality. Another example of shared personnel was the collective hiring of an independent project leader to keep neutrality in discussions (INT13). "Skin in the game matters" (INT12). However, this does not need to be finances, can also be time or personnel. Whether there was a focus on network resources or organisational resources effected equality.

T5 Interdependence versus autonomy District heating network demand interdependence, from production to distribution to end users, as each step relies on the previous one (INT13). However, at the same time, each party needs autonomy to operate effectively within its expertise (INT11). A shared overarching goal unites stakeholders (INT12). In this case, housing corporations were true "believers" (INT12), which made the expansion to specific areas easier. However, problems arose between the heat producer and the DH company (INT11). During the exploitation phase, these parties had operated on a supplier-client basis. However, because of the high dependencies, they are now collaborating more intensely which works better (INT11). Respondents agreed that both sides of the tension were important, and that it was more about alignment than on control. Ultimately, collaboration was a long-term commitment (INT13) where dialogue was important to align the goals and to safeguard autonomy. T5 had an effect on the level of trust, goal alignment and commitment to the project.

T6: Transparency versus autonomy Respondents valued transparency highly. However, it had its limits. This tension was mostly caused by whether parties were public or private and how the organisational structure is designed. The municipality was co-shareholder of the DH company together with the distributor, which enabled full transparency between these two parties on the project basis (INT9). However, the heat producer was a private party. The DH company monitored the heat producer, while the heat producer lacked visibility into the DH company (INT11). Not being open about finances could fuel scepticism, which was especially relevant in the relation with end users and the other parties of the network. The DH company did aim to keep the public informed by being transparent about annual reports, but little effect was mentioned of its effect (INT9). INT12 added that the quality of the information was important. The respondent stated that what helped within the municipality, is that there were persons who rewrote difficult texts and reports into understandable reports and presentation, to ensure all individuals within one organisations are on the same page. It helped in telling the right story, but also in getting all hands on deck. Respondents agreed that transparency should be maximized, where relevant. INT13 stated that transparency is needed on (a) what a party can, (b) what a party cannot do, (c) what parties need from other parties and (d) which roles parties take on them (INT13) in the initiation phase. Based on that, a good role

division can be made. Also, INT12 explained that open financial discussions were necessary for trust building. INT9 and INT10 agreed that they did not want more transparency from a certain party; they were satisfied with how everything was done. T6 affected role division, telling the right story, and the level of trust.

T7: Network learning versus organisational learning INT13 explained that the challenge of DHN is that there is limited and fragmented expertise. Respondents agreed that learning was important, but differed on where the focus should be; whether learning should take place within organisations or across the entire network. According to INT13, two main aspects were currently important to learn more about, which were reducing installation costs and maximizing connection rates. Learning with the parties in the heat chain to **(1) reduction installation costs** is important as these costs accounted for 80% of the expenses, particularly street excavation. Learning between parties in this case had been open and honest (INT9), but financial barriers remained (INT10). The respondents both stated that the lack of clear national policy guidelines created uncertainty in the financial viability. INT10 stated that their engagement with the national government had started too late in the process, which the respondent found one of the biggest bottlenecks in learning. The lesson learned is that government involvement should have happened earlier to define necessary frameworks. Secondly, learning should be used for **maximizing connection rates** (INT13). The respondent said that it was important to connect users as fast as possible. Faster connection would reduce financial risks and could enhance the attractiveness to other end users (INT13). One strategy would be to create certainty around the phasing out of natural gas: if municipalities can set clear deadlines (e.g. "gas will be phased out in this district within eight years"), which can encourage households to connect sooner. Learning should also target end user management. INT12 states that collective learning initiatives helped bridge the gap between the end users and other parties in the network, making the transition more relatable. For example, DHN parties provided free induction cooking kits and organised cooking courses to familiarise end users with electric cooking. This network initiatives gave the transition a more "human face" (INT12) and reassured end users about their individual benefits. T7 affected the relationship management and role division.

T8: Stability versus flexibility Respondents had different perspectives on how this tension occurred and how it was managed. INT12 plotted the tension from the heat source perspective, while INT9, INT10, and INT11 plotted it from the stakeholder perspective, and INT13 from a daily-work perspective. Despite these different viewpoints, they agreed that certain aspects require flexibility, while others demand stability. First, INT12 said that there should be stability in supply security, but flexibility in which heat sources are connected to the network. From a stakeholder perspective, INT9 and INT10 stated that a stable core of stakeholders was important, as DH is not a "hit-and-run business" but requires long-term commitment, which can be enabled by stable stakeholders. INT11 agreed that there should be stability in the persons involved to enable long-term commitment, and also in terms of relationship continuity. The respondent gave the example of a newly appointed municipal official who replaced another person. This disrupted the established relationships, caused delays in building new ones, and negatively affected knowledge retention. The respondent did note that the significance of staff turnover depends on the organisation's size and role within the network. Lastly, INT13 found that flexibility was important in daily operations, since the sector was still in its pioneering phase. In this case, respondents indicated that a stable stakeholder core and secure heat supply enabled long-term commitment, while flexibility in daily operations and connected heat sources helped deal with uncertainty. It affected the quality of the relationship management, the level of commitment, and supported knowledge retention.

T9: Dialogue versus confrontation Respondents agreed that dialogue is essential for long-term collaboration in DHN. Dialogue is needed due to the newness of DH (INT13). However, respondents disagreed over the role of confrontation. For example, INT9 explained that continuous dialogue within the DH company improved information sharing and prevented hidden agendas. However, past conflicts between housing corporations and end users still impacted how satisfied end users were with the network operations (INT10). INT11 argued that confrontational dialogue can be productive, as it could help get through impasses. If looked at the metaphor of the marriage: commitment should be well enough to enable confrontation to get through difficult parts. INT12 stated that the biggest confrontations in the net were external, between DH networks and competing technologies such as individual heating solutions or gas, which were only resolved through structured dialogue and agreements. The respondent did not view this as productive form of confrontation, but perceived that this should be prevented by changing external regulations. A well thought out communication strategy helped build trust and relations (INT13). What was really important, was that difficult content was rewritten in a understandable way. Simple reports worked well because it helped to tell the right story. T9 had an effect on whether parties tell the right story and the level of trust.

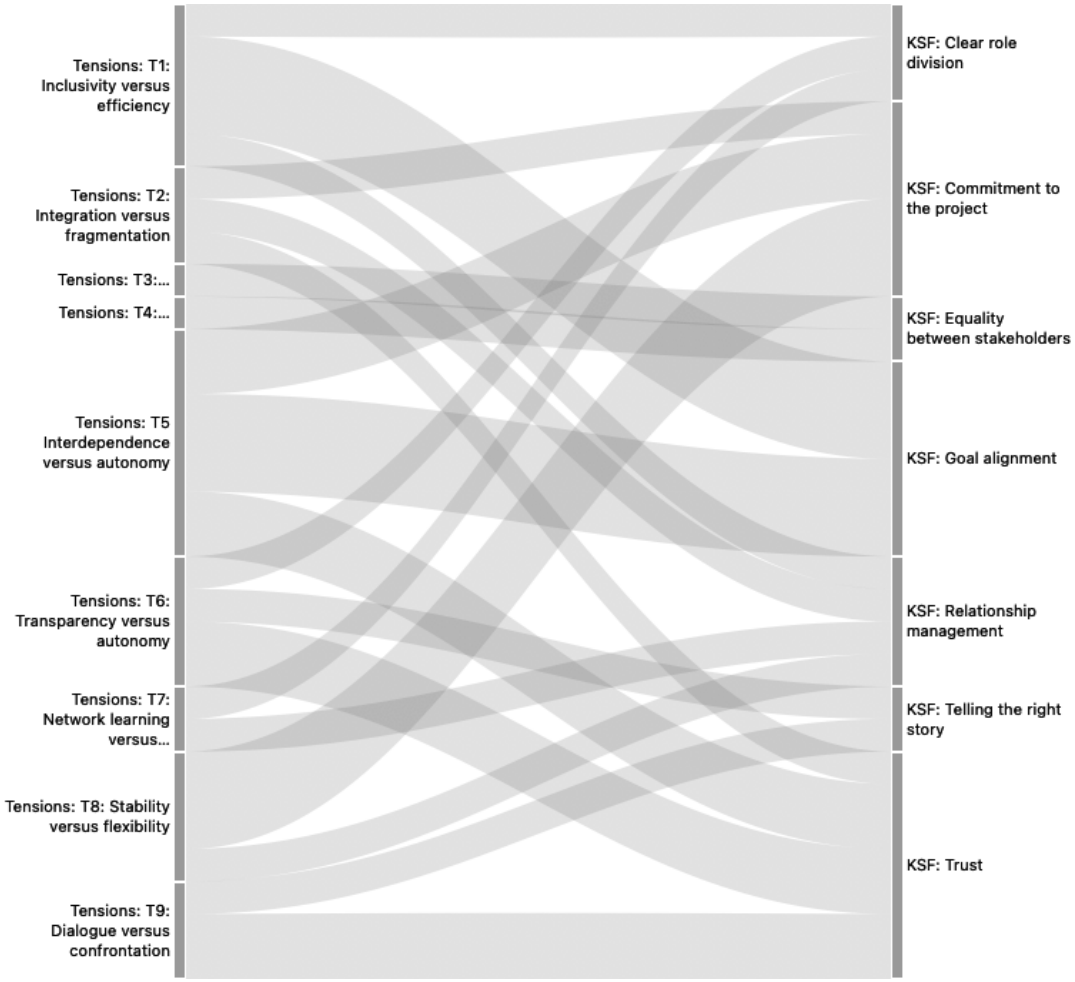


Figure B.5: Sankey diagram made using Atlas.ti: How the tensions have affected the KSF realisation in case 3

Figure Figure B.5 shows what general positive and negative indications per tension for this case. The green area indicates how managing the tensions had, or would have had, a positive effect on collaboration. The grey area indicates that there was no data available, or no clear effect on the success of collaboration. The orange area indicates that managing the tensions in a certain way had, or would have had, a negative effect on collaboration in case 3.

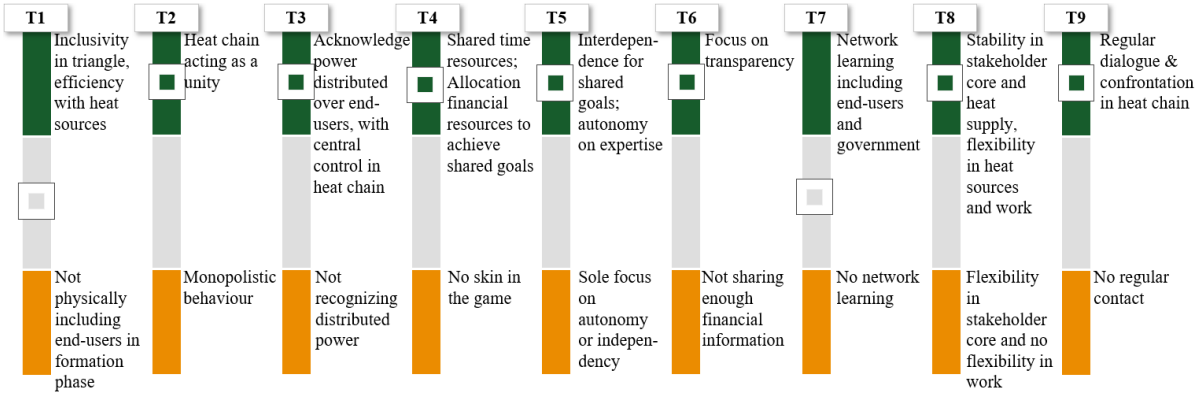


Figure B.6: How the different tensions should be managed to optimise the realisation of KSFs in case 3

C

Codebook for the interview transcripts in Atlas.ti

Codebook Atlas.ti

Code group	Code	Code group	Code
Tensions	T1 Inclusivity vs. Efficiency	**Key success factors**	Belief in the end goal
	T2 Integration vs. Fragmentation		Clear role division
	T3 Central vs. Distributed control over power resources		Collaborative revenue model
	T4 Network resources vs. Organisational resources		Commitment to the project
	T5 Interdependence vs. Autonomy		Equality between stakeholders
	T6 Transparency vs. Autonomy		Goal alignment
	T7 Network learning vs. Organisational learning		Knowledge retention
	T8 Stability vs. Flexibility		Mutual goodwill
	T9 Dialogue vs. Confrontation		Patience
			Regular dialogue
			Relationship management
			Stakeholder-aligned business case
			Telling the right story
			Trust
			Urgency
Phase	Initiation phase	**Stakeholders**	Heat chain roles
	Formalisation phase		End users
	Construction phase		Municipality
	Operation phase		
	Exploitation phase		

D

Interview protocols

D.1. Interview protocol experts for validation analytical framework

The purpose of these interviews was to triangulate data from the analytical framework. For the energy expert, the focus was on explaining the district heating market and the collaboration process. For the legal expert, the semi-structured interview focused on how collaboration is formalised in contractual structures. The template below (in Dutch) was used for both interviews. Each interview lasted approximately 45 minutes.

Introductie (10 min) Doel: Informatie verzamelen over de rol van de geïnterviewde

- Korte introductie en uitleg van de onderzoeksdoelen: context en doel. Informed consent check.
- Zou u zich kunnen introduceren en aan kunnen geven wat uw rol is binnen je organisatie en affiniteit met warmtetransitie?

Hoe en waarom komen partijen samen (15 min) Doel: Informatie verzamelen over de prikkels en veranderingen van prikkels Rollen bij een warmtenet: Warmteproducent; netbeheerder; leverancier. Meerdere rollen kunnen door 1 stakeholder worden vervuld.

- Wat zijn in jouw perspectief de kritische succesfactoren voor het opzetten van een samenwerkingsconsortium?
- Welke redenen zijn er voor stakeholders om betrokken te worden bij een warmtenet?
  - Omdat het moet (wet)? Omdat het nodig is (resources: gedeelde infra; geld; kennis)? Omdat ze het willen (intrinsiek)? Andere reden?
- In hoeverre worden samenwerkingsprocessen vastgelegd in contracten?
- Hoe werkt de contractformingsfase over het algemeen?
- Tussen welke partijen ligt (vaak) de bottleneck waar met samenwerken het meest te behalen valt?

Wetsvoorstel Wcw (10 min) Doel: Informatie verzamelen over nieuwe wet en hoe rollen gaan veranderen

- Voor welke stakeholderrollen verwacht u de grootste verandering door het nieuwe wetsvoorstel?
- Welk effect gaat dat hebben op hoe de stakeholders onderling gaan samenwerken?
- Wat zijn naar uw idee de belangrijkste samenwerkingsspanningen door de nieuwe wet?

Conclusie, extra vragen en vervolg (10 min) Doel: Informatie verzamelen over de rol van de geïnterviewde

- Zijn er nog andere punten die u over dit onderwerp aan wilt geven?
- Korte samenvatting van mijn kant en uitleg vervolgstappen

D.2. Interview protocol for stakeholders in the case studies

This protocol was used for all stakeholders interviewed in the case studies. The interview protocol is in Dutch, because all respondents are Dutch. The interviews lasted approximately 60 minutes.

1. Introductie (10 min)

- Korte introductie en uitleg van de onderzoeksdoelen.
- Wat is uw rol binnen uw organisatie?
- Hoe werd uw partij betrokken in dit warmtenet?
- Sinds wanneer bent u betrokken bij het warmtenet?

2. Vragen per dilemma (20 min) In dit deel worden vragen gesteld om de 9 tensions in kaart te brengen. De interview krijgt het bestand in figuur 18 te zien en wordt gevraagd om een kruisje te zetten waar in hoe volgens hen met deze spanning wordt omgegegaan. Per spanning wordt dit figuur afgelopen en er worden dan deze drie vragen gesteld:

- Hoe worden deze dilemma's ingevuld in uw warmtenet? Kunt u een kruisje zetten op de plek die u passend vindt? Waarom?
- Wanneer er meer sturing/duidelijkheid nodig is in het gesprek, dan staat hieronder een lijst met vragen waarin de spanningen worden geoperationaliseerd. Deze vragen geven houvast om terug te kunnen vallen op de operationalisatie, maar hoeven dus niet perse gesteld te worden.

3. Empirische analyse (15 min) Doel: Het voorgaande deel is een reflectie van de samenwerking. In dit blok wordt juist gekeken naar empirisiche situaties (dus toegepast op daadwerkelijke momenten). Dit dient als extra toets voor de voorgaande informatie en hier kan onderzocht worden hoe dynamisch de de processkeuzes zijn.

- Wat waren voor jullie cruciale momenten dat het project heel soepel ging?
  - Wat gebeurde er toen, wie deed wat? Zijn de 9 spanningen anders ingevuld dan wat we net bespraken? Of is er op dat moment uberhaupt een keuze veranderd?
- Wat waren voor jullie cruciale momenten dat het project heel moeizaam/slecht verliep?
  - Wat gebeurde er toen, wie deed wat? Zijn de 9 spanningen anders ingevuld dan wat we net bespraken? Of is er op dat moment uberhaupt een keuze veranderd?
- Wat zijn in uw mening de kritieke succesfactoren van samenwerken in een warmtenet?
- Als u het samenwerkingsproces opnieuw zou kunnen ontwerpen, wat zou u dan anders doen?

4. Nieuw Wetsvoorstel en Toekomstige Situatie (10 min) Doel: Informatie vergaren over hoe de toekomstige situatie eruit gaat zien en hoe het design daardoor zal veranderen.

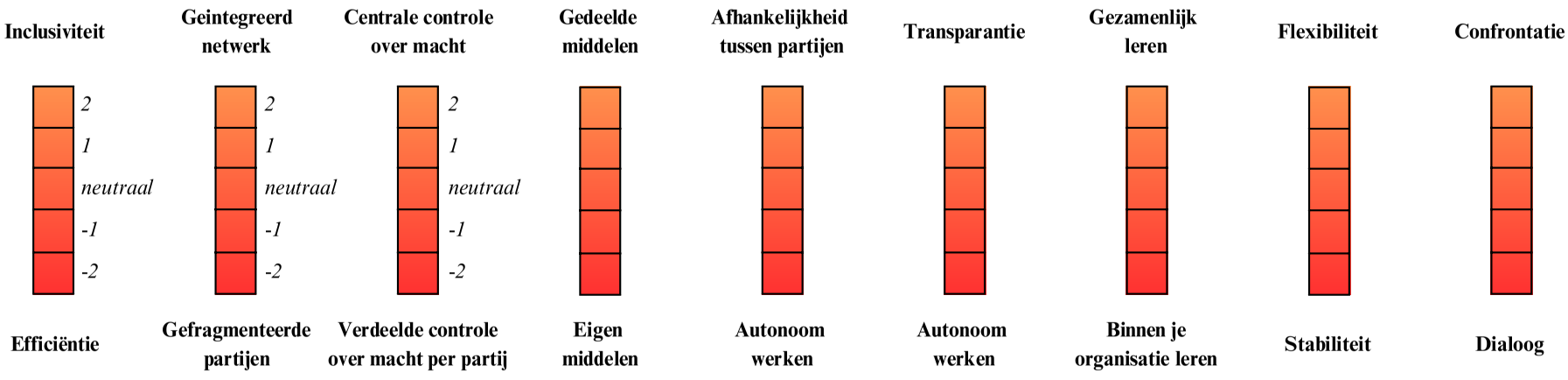
- Welke veranderingen verwacht u in samenwerkingsstructuren door de Wcw?
- Denkt u dat het bepaalde problemen gaat verminderen of intensiveren, en waarom?
- Wat zijn de belangrijkste veranderingen van uw warmtenet voor de Wcw?

5. Afronding (5 min)

- Zijn er andere punten die u nog wilt aangeven over dit onderwerp?
- Vervolgstappen uitleg: Na het interview wordt een samenvatting van het interview naar de geïnterviewde gestuurd om te controleren of deze akkoord gaat met de samenvatting.

Dilemma's in het inrichten van de samenwerking in een warmtenet

Hieronder staan 9 typische dilemma's voor het inrichten van de samenwerking binnen een warmtenet. Hierbij is er geen goed of fout, de invulling zit ergens tussen de twee uitersten. U wordt gevraagd om per dilemma een **kruisje** te zetten op de plek die volgens u het beste de samenwerking in uw warmtenet karakteriseert.



Template interviews that is filled in with the respondents

Extra vragen bij de dilemma's

Wanneer er extra sturing nodig is bij het gesprek kunnen de onderstaande vragen per dilemma gebruikt worden.

Inclusiviteit vs Efficiëntie

- Met welke partijen werkt u samen om het warmtenet te realiseren?
- Vanaf welk punt zijn de partijen aangesloten?
- Wat zijn de belangrijkste voor- en nadelen aan het betrekken van een breed scala aan partijen?

Integratie vs Fragmentatie

- Waarom werkt u samen met partij 1 en 2 (incentives)?
- Hoe wordt gekozen welke rollen binnen het warmtebedrijf worden opgenomen en welke worden uitbesteed?
- Welke voor- en nadelen ervaart u hierbij?

Gecentraliseerde vs Gedistribueerde Controle over Macht

- Hoe wordt besluitvorming in het net gestructureerd?
- Wat zijn de voordelen en risico's van hoe de besluitvorming nu is ingericht?

Netwerk Resources vs Organisatie Resources

- In hoeverre delen de partijen middelen voor het project? Geld, infra, mensen?
- Welke voordelen en uitdagingen ziet u hierin?

Interdependentie vs Autonomie

- In hoeverre merk je dat partijen hun eigen doelen nastreven versus het gezamenlijk belang?
- Hoe pakken jullie problemen die eruit voortkomen aan?

Verantwoording vs Autonomie

- Hoe zit het met transparantie over werkzaamheden?
- Zijn er spanningen tussen verantwoording geven en het behoud van autonomie?

Netwerkleren vs Leren Binnen een Organisatie

- Hoe leren partijen van elkaar?
- Zijn er gezamenlijke leerinitiatieven (bijvoorbeeld voor de Wcw)?

Stabiliteit vs Flexibiliteit

- Is er wat veranderd aan de samenwerkingsstructuur gedurende de operatie van het net?
- Hoe flexibel zijn de samenwerkingsstructuren in reactie op veranderingen zoals de Wcw?

Dialoog vs Confrontatie

- Hoe verloopt de communicatie in het net?
- Hoe wordt conflict binnen het netwerk beheerd? En wat gebeurt er dan?

E

Data review checklist for case study data collection

This checklist was used to enable data verification within each case study. This page is an overview. The next pages are the checklists filled in for the cases [committee version only]

- Interviews performed?
  - ✓ With ≥ 1 representative of the party responsible for heat production?
  - ✓ With ≥ 1 representative of the party responsible for heat distribution?
  - ✓ With ≥ 1 representative of the party responsible for supply?
  - ✓ With other key stakeholders outside the heat supply chain (e.g., municipality)?
- ✓ Literature research performed?
  - ✓ Any scientific literature already conducted on this case?
  - ✓ If yes, any relevant information for triangulation?
- ✓Grey literature analysis done?
  - ✓ Municipal documents reviewed?
  - ✓ News articles reviewed?
- ✓ Other observations?
  - Any other source of information used? If yes, which of the following:
    - Participatory meeting
    - Visitations to the system
    - Other ...
  - No other observations
- ✓ Triangulation of data sources
  - ✓ Can cross-references be made between interview data, documentation, and archives?
  - ✓ To what extent is there alignment in data from different sources?
  - ✓ To what extent is there conflict in data from different sources?

F

Data Management

F.1. Data Management Plan

Plan Overview

A Data Management Plan created using DMPonline

Title: The effect of Inter-Organisational Collaboration in District Heating Systems

Creator: Elize van Dongen

Affiliation: Delft University of Technology

Template: TU Delft Data Management Plan template (2021)

Project abstract:

District heating is a viable and interesting alternative for heating to achieve Europe's climate goals, particularly in reducing greenhouse gas emissions and transitioning to renewable energy sources. However, in the Netherlands, DH systems face challenges due to low market penetration, high construction costs, and regulatory uncertainties. This research aims to assess the conditions that influence effective inter-organisational collaboration in Dutch DH systems under the new Heat Act (Wcw), which mandates a vertically integrated heat company structure. Using a comparative case study approach, the research will identify the factors that facilitate or hinder effective collaboration among key stakeholders in the DH supply chain. These stakeholders can be public entities, private companies, and municipalities. By employing theoretical frameworks like Collaborative Governance literature, Collaboration Characterisation Model and Collaboration-Oriented Performance Model, this study will evaluate what collaborative incentives drive stakeholders to collaborate, how they actually collaborate (practices) and how this impacts collaborative outcomes.

Once it is analysed how the practices impact collaborative outcomes and it is known how the incentives will change in the new situation, a generic, optimal collaboration strategy can be designed to help industry stakeholders to optimise their collaboration efforts. Ultimate goal is to accelerate the energy transition.

ID: 161249

Start date: 18-10-2024

End date: 01-03-2025

Last modified: 05-11-2024

The effect of Inter-Organisational Collaboration in District Heating Systems

0. Administrative questions

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

Lora Armstrong

2. Date of consultation with support staff.

2024-11-04

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
Personally Identifiable information(PII): participants name, occupation, email, company name.	.pdf .xlsx .docx	Contact information will be found through professional network and desk research	Communicating with potential respondents, obtaining informed consent	TU Delft OneDrive	The researcher (Elize van Dongen); and the TU Delft graduation committee (Marian Bosch-Rekveldt; Magchiel van Os; Wijnand Veeneman); and the company supervisor (Max ten Cate)
Video recordings of interviews with companies involved in three district heating systems (e.g. heat producer, distributor, supplier, municipality). Interviews are about the incentives to collaborate, the collaborative practices and the effect on operational outcomes.	.mp4	Online interviews will be recorded on MS teams and stored as .wav files.	Analysing collaborative incentives and practices and their effect on intermediate outcomes.	TU Delft OneDrive	The researcher (Elize van Dongen)
Transcriptions of interviews with companies involved in three district heating systems (e.g. heat producer, distributor, supplier, municipality). Interviews are about the incentives to collaborate, the collaborative practices and the effect on operational outcomes.	.txt	MS Teams will be used to make a transcription of the interview	Creating an overseeable format for analysing the interviews	TU Delft OneDrive	The researcher (Elize van Dongen)
Fully anonymized summaries of interviews	.pdf	Through summarization of interview transcripts	To create an anonymous version of the interview that can be referenced in the report and used for validation of policy recommendations	TU Delft OneDrive	The researcher (Elize van Dongen); and the TU Delft graduation committee (Marian Bosch-Rekveldt; Magchiel van Os; Wijnand Veeneman); and the company supervisor (Max ten Cate)
Signed informed consent forms	.pdf	Through correspondence with respondents, by email, in person or other methods.	To ensure ethics standards are met. Stored for 10 years by the first supervisor.	TU Delft Project Data Storage (U)	The researcher (Elize van Dongen) and the first TU Delft supervisor (Magchiel van Os)

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?

- 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?

- 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.

- No, I will not work with any confidential or classified data/code

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 datasets underlying the published papers will be publicly released following the TU Delft Research Data Framework Policy. During the active phase of research, the project leader from TU Delft will oversee the access rights to data (and other outputs), as well as any requests for access from external parties. Anonymous results will be shared in MSc thesis.

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

- Photographs, video materials, performance appraisals or student results
- Other types of personal data - please explain below
- Signed consent forms
- Email addresses and/or other addresses for digital communication
- Telephone numbers
- Names and addresses

Job function; seniority in function; company name. Also, opinions on the impact of collaborative practices on certain collaborative outcomes and opinions on incentives to collaborate.

11. Please list the categories of data subjects

Interviews will be held with stakeholders that are involved in the supply chain of three different district heating systems in The Netherlands. These are the heat producers, network distributors, energy suppliers and the municipality. Also, interviews are held with Dutch market experts to triangulate and/or expand the information gathered.

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:

All study participants will be asked for their written consent for taking part in the study and for data processing before the start of the interview. It is sent over email and the consent form is digital.

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 only one of the options listed below applies, your project might need a DPIA. Please get in touch with the privacy team: privacy-tud@tudelft.nl to get advice as to whether DPIA is necessary.
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?

- Personal research data will be destroyed after the end of the research project
- Anonymised or aggregated data will be shared with others

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
- All other non-personal data (and code) underlying published articles / reports / theses

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

- My data will be shared in a different way - please explain below

Anonymized data will be shared in the appendix of the report which will be published in the MSc Thesis repository.

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

- < 100 GB

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?

- Other - Please explain

Data shared in MSc Thesis repository

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

Together with PwC Advisory N.V., with the team: Capital Projects and Infrastructure.

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

My first supervisor, Magchiel van Os, will be responsible for the data when I leave the TU Delft.

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

- There are no costs for data sharing or management.

F.2. Informed consent form for the Interviews

Toestemmingsformulier
U bent uitgenodigd om deel te namen aan een onderzoek genaamd: “Developing Collaboration in District Heating Systems”. Dit onderzoek wordt uitgevoerd door Elize van Dongen, aan de Technische Universiteit Delft, in samenwerking met PwC Capital Projects & Infrastructure.

Inhoud
Dit interview is onderdeel van een afstudeeronderzoek als afsluiting van de master Construction Management & Engineering. Er wordt antwoord gezocht op de volgende vraag: *Welke condities bepalen succesvol samenwerken tijdens de bouw, exploitatie en exploitatie van warmtenetten?*

De implementatie van de nieuwe warmtewet zorgt voor een verandering in de verdelen van de rollen tussen de betrokken partijen in een warmtenet. Dit biedt de kans te analyseren hoe de samenwerking opgezet zou moeten worden om de kwaliteit van de samenwerking te zo hoog mogelijk te krijgen. Dit wordt gedaan aan de hand van negen dilemma's die opspelen bij het inrichten van het samenwerkingsproces. In dit onderzoek wordt 'dilemma' gedefinieerd als paradoxale kracht in het systeem, zoals de tegenstelling tussen autonomie van versus de afhankelijkheid tussen de partijen.

Methode
Voor dit onderzoek worden drie casestudies uitgevoerd met interviews. Er zijn drie nederlandse warmtenetten gekozen waarbij de rolverdeling tussen de partijen verschilt. Binnen elk system wordt met representatieven van meerdere partijen gesproken naar hun ervaringen binnen de casus. Dit gaat op een semigestructureerde manier, wat betekent dat een kader gevolgd wordt om het interview wat sturing te geven, maar dat er tegelijkertijd een open gesprek blijft met ruimte om het kader uit te breiden.

Praktische zaken
Dit interview wordt getranscribeerd door middel van MS Teams. Deze transcriptie wordt vervolgens door de onderzoeker gecodeerd waardoor de belangrijke punten geanalyseerd kunnen worden. Het interview wordt uitsluitend gebruikt voor het beschreven onderzoek voor de TU Delft. Dit betekent dat de informatie uit de interviews in verwerkte vorm terug te vinden is in het eindrapport van het onderzoek, dat zal worden gepubliceerd in de repository van de TU Delft. Namen van personen en projecten zullen in deze versie worden weggelaten, en worden alleen ter verificatie gecommuniceerd aan de leden van de afstudeercommissie. PwC heeft geen toegang tot de persoonlijke data betrokken in dit onderzoek.

Dit alles wordt gedaan op basis van een data management plan dat is opgesteld volgens de richtlijnen van de TU Delft. U wordt hiervoor gevraagd een formulier ‘geïnformeerde toestemming’ te ondertekenen, waarbij u aangeeft akkoord te gaan met de manier waarop in dit onderzoek met uw data wordt omgegaan.

Elize van Dongen
E.M.vanDongen@student.tudelft.nl
elize.van.dongen@pwc.com
+31 6 21307071

A: General consent: research goals, participants tasks and voluntary participation	Ja	Nee
Ik heb de informatie over het onderzoek gedateerd …/…/… gelezen en begrepen, of deze is aan mij voorgelezen. Ik heb de mogelijkheid gehad om vragen te stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.	☐	☐
Ik doe vrijwillig mee aan dit onderzoek, en ik begrijp dat ik kan weigeren vragen te beantwoorden en mij op elk moment kan terugtrekken uit de studie, zonder reden.	☐	☐
Ik begrijp dat mijn deelname aan het onderzoek de volgende punten betekent: • Een audio of video opgenomen interview via de telefoon of teams, met als doel data te vergaren om samenwerking tussen bedrijven in warmtenetten te optimaliseren; • De transcripties van de interviews worden geanonimiseerd. Enkel geanonimiseerde data worden meegenomen in het onderzoek. Na het maken van de transcriptie wordt de audio en/of video-opname direct verwijderd.	☐	☐
Ik begrijp dat de studie 01/04/2025 eindigt en dat de resultaten gepubliceerd kunnen worden	☐	☐
B: Potential risks of participating (data protection)	**Ja**	**Nee**
Ik begrijp dat mijn deelname het risico op een datalek met zich meebrengt. Ik begrijp dat deze risico's worden geminimaliseerd door enkel anonieme data te gebruiken in het onderzoek en door de interviewopnames & transcripties op te slaan in een beveiligde omgeving	☐	☐
Ik begrijp dat mijn deelname betekent dat er persoonlijke identificeerbare informatie en onderzoeksdata worden verzameld, met het risico dat ik hieruit geïdentificeerd kan worden.	☐	☐
Ik begrijp dat binnen de Algemene verordening gegevensbescherming (AVG) een deel van deze persoonlijk identificeerbare onderzoeksdata als gevoelig wordt beschouwd	☐	☐
Ik begrijp dat de volgende stappen worden ondernomen om het risico van een databreuk te minimaliseren, en dat mijn privacy op de volgende manieren wordt beschermd: • Data wordt enkel opgeslagen in een beveiligde map op de TU Delft OneDrive; • De interviews worden getranscribeerd en geanonimiseerd. Betrokken onderzoeksmedewerkers van de TU Delft en PwC hebben alleen toestemming om de geanonimiseerde data in te zien; • Na transcriptie worden alle audio- en videofragmenten direct verwijderd.	☐	☐
Ik begrijp dat de persoonlijke informatie die over mij verzameld wordt en mij kan identificeren, zoals naam, organisatie, functie en email-adres, niet gedeeld worden buiten het studieteam.	☐	☐
Ik begrijp dat de persoonlijke data die over mij verzameld wordt, vernietigd wordt 01/04/2025.	☐	☐
C: Research publication, dissemination and application	**Ja**	**Nee**
Ik begrijp dat na het onderzoek de geanonimiseerde informatie gebruikt zal worden om samenwerkingsprikkels, processen en de impact ervan tussen organisaties in een warmtenet te analyseren en optimaliseren. Dit kan gepubliceerd worden in de master thesis.	☐	☐
Ik geef toestemming om mijn antwoorden, ideeën of andere bijdrages anoniem te quoten in resulterende producten.	☐	☐
D: (Long-term) data storage, access and use	**Ja**	**Nee**
Ik geef toestemming om de geanonimiseerde data die over mij verzameld worden gearchiveerd worden in TU Delft Repository opdat deze studie gebruikt kunnen worden voor toekomstig onderzoek en onderwijs.	☐	☐

Naam deelnemer **Handtekening** **Datum**

_____ _____ _____

Ik, **de onderzoeker**, verklaar dat ik de informatie en het instemmingsformulier correct aan de potentiële deelnemer heb voorgelezen en, naar het beste van mijn vermogen, heb verzekerd dat de deelnemer begrijpt waar hij/zij vrijwillig mee instemt.

_____	_____	_____
Naam onderzoeker	Handtekening	Datum

Elize van Dongen
+31 6 21307071
E.M.vanDongen@student.tudelft.nl
elize.van.dongen@pwc.com