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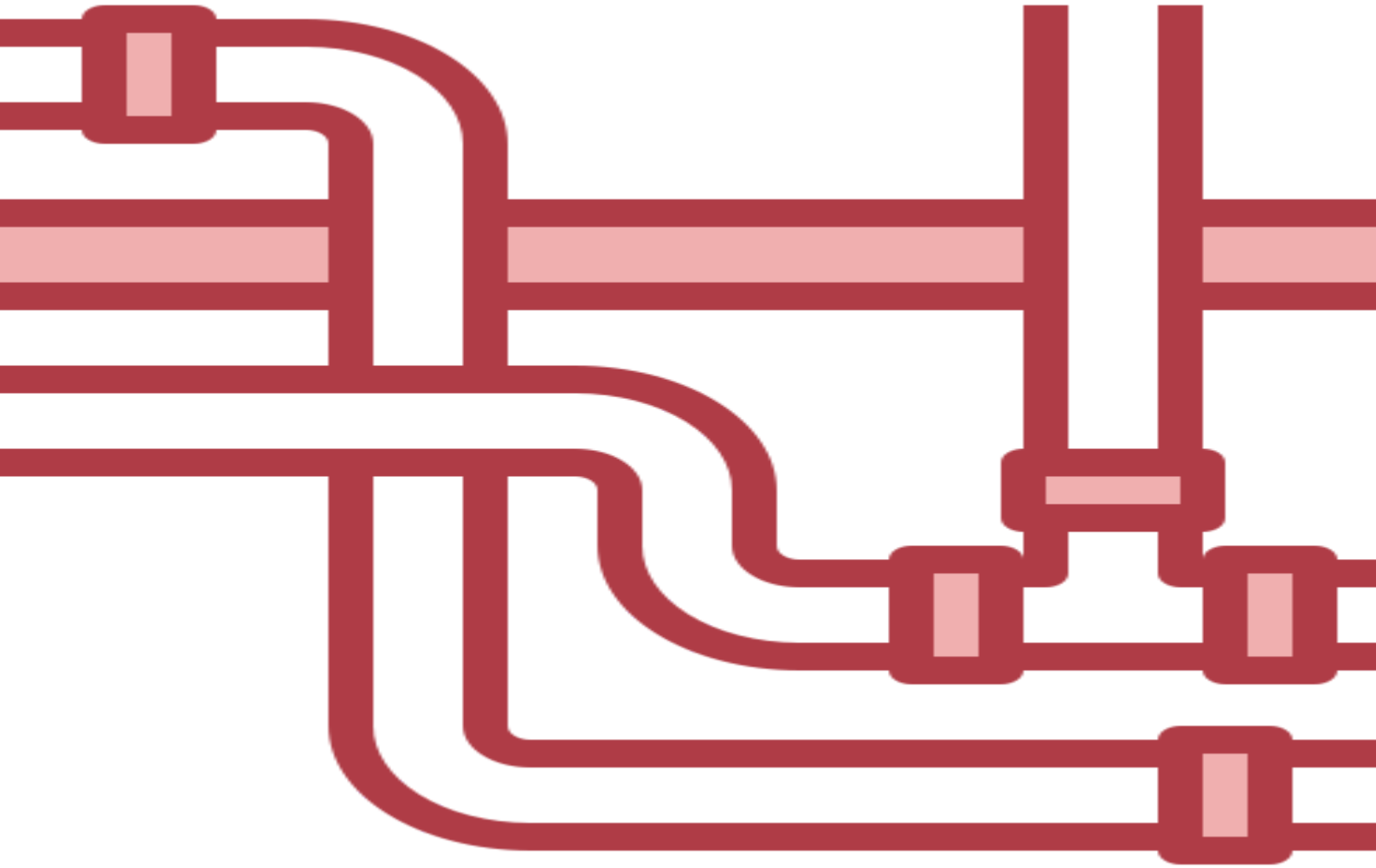
Dutch District Heating: The Influence of Public-Private Collaboration on Municipal Goal Achievement



Master thesis Environmental and Infrastructure Planning

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Colophon

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Preface

Dear reader,

Eight years ago, as I was present in the Academy Building of the University of Groningen during a graduation ceremony, I encountered the existence of the Faculty of Spatial Sciences for the first time. I immediately knew that this was where I needed to belong. As I had always been intrigued by topography and spatial planning, the idea of exploring and contributing to the field of spatial sciences captivated me. Six years ago, I started my bachelor study and now I am presenting to you my final piece for my master's in Environmental & Infrastructure Planning.

I am very grateful to my supervisor, Jort de Vries, for his support throughout the writing of this thesis. His guidance and quick and valuable feedback were of great importance in shaping the direction and quality of my research. Our meetings were very motivating and his expertise provided great insights and ideas for my work.

I would also like to show my thanks to Arcadis, the company where I had the privilege to do an internship. Arcadis offered me a glimpse into the practical applications of my studies in the professional world. The supportive environment and the opportunity to work alongside experienced professionals were very educational. I want to explicitly thank Nick Schasfoort for his guidance during my internship.

This thesis focuses on the topic of district heating networks, an element of sustainable infrastructure that has interested me due to its relation to sustainable energy solutions and spatial planning. I hope that you will find this subject as interesting as I do and that the results will eventually contribute to a more sustainable environment.

Thank you for taking the time to read this thesis. Enjoy!

Sincerely,

Sjoerd Duim

Abstract

The Dutch Climate Agreement (2019) dictates: "*in the pursuit of becoming natural gas-free, that district heating should become one of the main sources of warmth in the Netherlands*". These district heating networks are realised through different forms of public-private collaboration. New legislation prescribes that all district heating needs to have a public majority interest in the future, changing the current state of organisation within the district heating realm. This research investigates the influence of the ratio of public and private interference on the achievement of municipal heating goals. On the basis of the interpretation of different generations of district heating, principles of 'collaborative governance' and institutional governance and the exploration of the frameworks of collaboration within district heating of Elsman (2024) and Sanders et al. (2016), a conceptual framework was developed. Cases of municipal heating in the Neherlands were selected for analysis based on this conceptual framework. Three subgroups were used in which all district heating networks can be categorised: public majority interest, private majority interest and 50/50 interest. A literature review, document analysis and interviews with municipal public servants, responsible for the heat networks or sustainable energy, were conducted about the influence of their collaboration with private parties on the achievement of the goals presented in their Heat Transition Vision. The analysis reveals that public-majority models excel in aligning with municipal sustainability and social equity goals, benefiting from strong public oversight. However, municipalities in public majority district heating with shares of lower than 50% are not able to align their policy as much as municipalities that have at least 50% of the shares. Private-majority models increase operational efficiency and innovation, but municipalities struggle with aligning their social objectives with the companies' objectives. The 50/50 collaborative model uses the strengths of both sectors, but requires good communication and conflict resolution in agreements to succeed. Overall, the findings show the importance of tailor made PPPs that balance efficiency, innovation and social costs to effectively achieve district heating goals in Dutch municipalities. The Dutch government wants to shift all district heating to public majority interest models and although that model offers the best way to implement municipal policy and achieve the municipal goals, it should be approached with awareness of the pitfalls for small stakeholding municipalities.

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Abbreviations

Abbreviation	Meaning
4GDH	Fourth generation district heating
5GDH	Fifth generation district heating
HEq	Home Equivalents
HTV	Heat Transition Vision
PPP	Public-Private Partnership
RES	Regional Energy Strategy
Wcw	Wet collectieve warmte / Law on Collective Heat Supply

Introduction

The Netherlands stands at a critical juncture in its energy transition journey. The Dutch energy system needs substantial transformation in the next few decades to align with the goals of the Paris and national Climate Agreement (Netbeheer Nederland, 2021). With increasing awareness of environmental concerns and the resulting urgency to mitigate climate change, the need to reevaluate and revolutionise existing energy infrastructures has emerged (Bustamante et al., 2023). District heating, a technique that has existed for longer than a century, is going to be crucial for enhancing energy efficiency and reducing greenhouse gas emissions in the Netherlands. It offers a reliable and cost-effective heating solution for urban areas, decreasing dependence on individual heating systems. Additionally, district heating relieves the congestion of the power network. Hence, it is why the implementation of district heating networks is pursued in the Netherlands.

The Dutch national government wants two million dwellings to have a sustainable alternative to natural gas by 2030 and by 2050, space heating must be completely carbon-neutral (EZK, 2016). A large role for district heating lies here, because the Dutch Climate Agreement (2019) addresses the great potential of district heating and states that it must be implemented to its full potential, which is about half a million extra connections by 2030 and 2,6 million by 2050 (Klimaatakkoord, 2019). The main other technique to reach the goals is all electric solutions (heat pumps) (Klimaatakkoord, 2019). Because of the nature of heat pump systems, it can only be used in new, well insulated construction, whereas district heating is suitable for less insulated and older homes that need higher temperature heating. All electric heat pumps are relatively easy to install in comparison to the complex heat networks that often, depending on the size, cost years to complete. However, heat networks are a cheaper alternative for society: due to a lack of capacity on the power grid, it is cheaper for the government to invest in district heating than in the enlargement of the power network capacity that is needed for installing heat pumps (Berenschot, 2024).

Nevertheless, the implementation of district heating in the Netherlands can be quite complex. As a result of the costs of the networks, it is only viable to implement them in areas with ample customers, which are almost always (neighbourhoods of) cities. The actual implementation involves digging in the streets, laying pipes and coming into resident’s houses to connect their house to the heating network. The number of stakeholders is therefore often high, increasing the risk of resistance. Another complex factor is the fact that practical knowledge on the subject is often not present within the organisation of the municipality which means that a private actor with knowledge in this field of expertise is generally of importance. This implies the need for public-private collaboration. However, new legislation, the Wcw (Wet collectieve warmte/ Law on Collective Heat Supply), aims to increase public majority interest by limiting the extent to which public-private collaboration is possible. Through this law, the Dutch national government dictates that governments must own the majority of shares in district heating companies (Rijksoverheid, 2024). The role of public parties will increase and private parties will not be as prone to collaboration in district heating projects due to the lack of income and control (Gemeente Amsterdam, 2024; Vattenfall, 2024; Volkskrant, 2024). By researching the influence of public-private collaboration on the achievement of sustainability goals, the influence of the new legislation on district heating can be envisioned.

In the Netherlands, several thousand heat networks exist, 90% of which are small-scale (less than 50 Home Equivalents (HEq)) and mostly organised via owners associations or small private agreements

(NPLW, 2024). The larger networks need (heating) companies that (help) establish the network and have experience with the implementation process of district heating. Practice shows that this happens in different arrangements of collaboration. In some cases, the municipality takes the lead and implements and exploits the network by itself, in other cases private heating companies are asked to implement and exploit the network. Intermediate forms exist as well. Remarkably, research about the effects of the form of collaboration on the achievement of municipal goals is limited.

Research aim

As mentioned, district heating will be a vital part in the Dutch energy transition. In recent years, the expansion of district heating throughout the Netherlands has not come to the preferred level and the government therefore tries to improve this by introducing new legislation in which there is a smaller role for private parties, while the influence of the collaboration on the achievement of the Heat Transition Visions (HTVs) has not been researched.

Hence, this study aims to gain insights into the influences, downsides and benefits of different models of public-private collaboration. These results are gathered through the use of a literature review, document analysis and semi-structured interviews conducted with public servants of several Dutch municipalities, responsible for the HTV in their municipality.

To fulfil this aim, this study answers the following main question:
What is the influence of different forms of public-private collaboration in the implementation of 4th&5th generation district heating on achieving Dutch municipal district heating goals?

Since the main question has several aspects, sub questions are formulated in order to provide a clear and elaborate answer. The sub questions are the following:

1. *How can forms of public-private partnerships, generations of district heating and Dutch municipal heating be conceptualised?*
2. *Which forms of public-private collaboration exist within the heating district domain?*
3. *What are the goals that the government aims to achieve with the implementation of district heating networks?*
4. *What are the differences between the intended effects of the contract expected by municipalities and the actual experienced effects?*

Reading guide

In order to get an understanding of the dynamics of Public-Private Partnerships (PPPs) in district heating projects, the next chapter explores the foundational concepts and academic literature relevant to district heating, including collaborative governance and institutional theory. It also provides an answer to sub questions 1 and 2. The methodology chapter introduces the research design, data collection and analysis used in this study. This chapter provides transparency on how the research was conducted and shows which ethical considerations were taken into account. sub question 3 is also answered. The findings of this research are presented in the chapter ‘Results’, offering a detailed comparison of the different forms of public-private collaboration and their impacts on achieving municipal HTV goals and providing an answer to the last sub question. This chapter shows several tables in which the municipalities can be compared. A concluding chapter will summarise the findings of chapter 4 and will answer the main research question. This thesis ends with a discussion on the implications of the findings and recommendations for policymakers to make the connection between academic research and the practical implementation.

Theoretical Framework

In the field of urban development and sustainability, the collaboration between public and private sectors is of great importance for meeting municipal objectives. District heating networks are no exceptions (Mollisi, 2016; Sanders et al, 2016; Svistunov & Kurkina, 2019). The efficiency and effectiveness of public-private collaborations depends partly on the dynamics at play. Theories from several disciplines can offer insights into the factors that influence different forms of public-private collaboration. By looking into existing theories, the underlying mechanisms that shape the outcomes of public-private collaboratives can be analysed, which serves as a basis for the analysis about their relation to municipal goal achievement.

First, general theory about generational district heating is introduced. To get an understanding of the theoretical basis on which collaboration is built, institutional theory and collaborative governance are introduced. After the advantages and disadvantages of public private collaboration in sustainable infrastructure projects in Europe have been shown, forms of public-private collaboration in district heating are touched upon by looking at different models and extracting three main models of collaboration. This is concluded by a conceptual framework, linking the theories with each other and with the purpose of this research.

Generations of district heating

Although forms of district heating existed earlier, their broader application began in the late 19th century when steam-powered systems, typically fueled by coal or wood, became common (Lund et al., 2014; Abugabbara, 2021). In the 20th century, district heating networks improved: steam-powered systems fueled by cheaper coal were replaced by those using oil or gas (Ibid.). The new capacity linked with urban heat networks, designed as 2nd generation district heating (an advancement from large combined boiler houses and cast iron or steel pipes), brought significant improvements in operational efficiency (Ibid.). These included better matching of demands, adherence to building design efficiency standards, and the availability of advanced technologies such as condensing boilers, which revolutionised the field (Ibid.). These systems allowed greater thermal efficiency, higher temperature differentials, and longer distances than previous components, making return flows less dangerous and more reliable (Ibid.). However, burning fossil fuels caused environmental problems like air pollution, climate change, and resource depletion, necessitating cleaner and more sustainable heating solutions (Famiglietti et al., 2021). The second half of the 20th century marked the beginning of more sustainable and environmentally friendly district heating systems, a concept referred to as Third Generation District Heating (Lund et al., 2014; Abugabbara, 2021). While fossil fuels remained the primary heating source, renewable energy sources, waste heat recovery, along with greater efficiency were all embraced by such systems to reduce carbon emissions while improving air quality and enhancing resilience via delivering sustainable and reliable power (Ibid.). Third generation district heating networks integrated biomass, geothermal and solar-thermal energy sources and district heating networks started to rely on lower temperatures (Ibid.).

Fourth generation district heating, also referred to as 4GDH, combines a mixture of renewables and low-carbon heat sources, energy storage technologies (so you can capture those periods where there is plenty of renewable electricity), together with smart grid solutions enabling demand response and network stability (Fabozzi et al., 2022). Typical features of these systems include new heat generation technologies such as biomass boilers, combined heat and power (CHP), geothermal heaters, solar thermal collectors but also advanced storage solutions like hot water tanks or demand side strategies

for efficient energy usage (Ibid.). The ambition of 4GDH is to reduce heat demand, improve energy efficiency and integrate renewable sources in a way that secures both climate mitigation and resilience targets (Lund et al. 2014; Fabozzi et al, 2022). Unlike earlier district heating systems that heavily depend on the use of fossil fuels, 4GDH is a logical way to provide urban heat supply by combining all available energy sources through decentralised generation, while reducing negative environmental impact.

Simply put, 5th generation district heating (5GDH) is a new proposed paradigm for urban heat infrastructure, one that combines new technology to achieve maximum efficiency, and sustainability (Calise et al., 2023). Based on the principles of earlier generations of district heating, 5GDH adopts an approach towards managing existing and future resources as efficiently as possible by using, for example, digital solutions to optimise energy production, distribution of warmth ánd cold and consumption (Ibid.). Lund et al. (2021) argue that 5GDH is not a new generation, but still a part of 4GDH because the generations “are common in the overarching aim and share essential abilities”. The primary motivation behind the development of 5GDH has been a significant emphasis on integrating both heating and cooling functionalities, using a shared network operating at near-ambient temperature levels as a collective heat source or sink for heat pumps at the building level. The 5GDH is seen as a promising option because of its unique advantages (Calise et al., 2023; Gong et al., 2023). Nevertheless, Lund et al. (2021) note that it should be considered a complementary and additional technology to 4GDH. However, "generation" implies a sequence and so, to some, the term 5GDH seems inconsistent with existing terminology going from 1GDH to 4GDH. Despite the discussion on the validity of the term 5GDH, it is widely used in literature. The EU (2022) has subsidised several projects to specifically roll out the concept of 5GDH in North-West Europe, also in the Netherlands .

In the Netherlands, district heating has emerged as a promising solution for reducing carbon emissions from heating and cooling systems, particularly in densely populated urban areas (Klimaatakkoord, 2019). As heating in the Netherlands has been based on natural gas over the last decades, Dutch policy initiatives and climate goals promote the transition to the renewable or at least low carbon 4th generation district heating (Ibid.). 5th generation district heating concepts are also gaining attention in the Dutch context, with pilot projects and research initiatives focusing on decentralised energy systems, smart grids, and digital platforms to optimise energy use, enhance system flexibility, and empower consumers (Interreg North West Europe, 2023).

This research focuses on 4GDH and 5GDH because these networks, unlike earlier generations, apply to the sustainability standards that are pursued in most recent policy.

Institutional Theory

Institutional theory provides a lens for understanding how organisations are influenced by the formal and informal rules, norms, and cultural beliefs of their environment (Berthod, 2018). This is of importance for this research to understand why, within the district heating domain, certain models of collaboration exist. By examining the institutional environment, it can be identified how formal and informal rules either have an influence on collaborative processes, impacting the overall success in reaching municipal goals.

This theory suggests that institutions shape organisational behaviour and structures (Scott, 2001). It assumes that organisations seek legitimacy by conforming to these institutional pressures, which often leads to ‘isomorphism’, where organisations within a field become more similar over time (DiMaggio & Powell, 1983). The Wcw could cause isomorphism in the field of district heating, because it

decreases the opportunities of public-private collaboration. Isomorphism could also happen due to the advantages and disadvantages of forms of collaboration in district heating that appear from this research. Initiators of district heating networks could potentially collectively favour one form of collaboration over the other forms because of its effects on municipal goal achievement.

In the case of public-private collaboration in infrastructure projects such as district heating projects, institutional theory can help explain the varying forms and structures these collaborations can take (Schomaker, 2014). Regulatory frameworks are part of the forces established by governments that delineate the playing field in which collaboration takes place: they are the regulations governing safety, environmental sustainability and public welfare to which infrastructure projects must adhere (Eberlein, 2000). Professional best practices, for example, exert normative pressure on shaping these collaborations by encouraging the use of methods and technologies that are more effective and efficient (Scott, 2001). Institutional theory, in addition to normative pressures, emphasises cultural-cognitive elements as well, which refer to the common beliefs and values determining organisational behaviour (Ibid.). In PPPs, these may consist of social expectations regarding sustainable development (Ibid.). With growing public awareness and expectation for sustainable energy solutions, both private as well as government organisations are facing pressure to include green technology or environmentally friendly practices in their projects (Almagtome et al., 2020). This is especially evident in the case of district heating systems where a trend towards more sustainable sources can be observed (RVO, 2023).

There are many models of public-private collaboration, ranging from traditional contracting to partnerships like joint ventures and PPPs. Variations in these collaborations are explained by institutional theory through the notion of institutional entrepreneurship, where actors create new forms of collaboration using existing institutional frameworks to better fit with both current and potential institutions (Battilana et al., 2009). For example, in district heating projects, institutional entrepreneurs might include local government officials and private sector leaders who collaboratively design new models for collaboration which combine and enhance the control of public oversight with benefits from the efficiency and innovation of private actors.

Forms of collaboration in district heating are influenced by regulatory frameworks that promote sustainable energy, normative pressures and cultural-cognitive elements (Scott, 2001). By understanding these institutional influences, district heating systems could be implemented that are both efficient and sustainable.

In this research, institutional theory is used to recognise informal and formal rules, norms and structures that influence organisational behaviour as well as individual behaviour. This awareness allows us to discover the potential constraints and enablers of collaboration. For example, it can explain how much the existing regulatory and organisational environment, as well as historical practices, influence the capacity of collaborative efforts. Next to this, it is possible to understand the impact of power relationships on collaboration, decision making and the pursuit of shared goals. In this way, potential barriers and enablers to collaboration can be observed. By implementing questions relating to institutions in the interview guide, these insights are used to establish the forms of collaboration of the cases. The coding guide is also created using these characteristics of institutional theory in order to determine the influence of the organisational environment on achieving municipal goals.

Collaborative governance for infrastructure development

Collaborative governance and institutional theory are interconnected, as institutional theory explains how formal and informal rules, norms, and structures shape stakeholder interactions in collaborative processes. What these interactions and processes entail is described in the following.

Infrastructure construction projects, as noted by Pryke et al. (2018), are inherently complex, with significant environmental impacts, and involve multiple actors forming networks (Hastie et al., 2017). These networks possess crucial characteristics that make them related to functioning systems. Networks are conceptualised by Provan & Kenis (2008) as systems composed of various interconnected actors. These systems are dynamic entities that can take on different forms such as linear, circular, or open networks (Verhees, 2013). Provan and Kenis (2008) highlight that networks are integral to economic activities, where collaborative governance is crucial for managing these interconnected systems.

Governance can be defined as activities that are used to steer, coordinate and monitor individual and group behaviour, in public, private and civic sectors (Ostrom, 1990; O'Leary et al., 2006; Bryson et al., 2006). But what does collaborative governance entail? The topic of collaborative governance is widely studied and several opinions and definitions about the term exist, it is a ‘fuzzy concept’ (Voets et al., 2021). Ansell & Gash (2007), writers that are influential in the collaborative governance debate, describe collaborative governance as "a governing arrangement where one or more public agencies directly engage non-state stakeholders in a collective decision-making process that is formal, consensus-oriented, and deliberative and that aims to make or implement public policy or manage public programs or assets.” This definition, however, does not capture all stakeholders or relationships that could be considered within the definition of collaborative governance. Emerson et al. (2011) use a broader definition, collaborative governance being “the processes and structures of public policy decision making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished”. This definition fits the purpose of this research better, with a broader focus that also encompasses PPPs, the forms of collaboration used in district heating, but also community based collaboratives (Agrawal & Lemos, 2007; Emerson & Murchie, 2010; Emerson et al., 2011). The adaptability of this definition allows it to serve as an overarching term to facilitate discussions on various forms of public-private collaborative governance. As such, this is the definition used in this study.

This definition of collaborative governance helps identify the relevant stakeholders involved in the context of this research, their roles, and their interests and their manner of communication. Understanding who the key players are, how they act and how they can contribute to goal achievement within the studied forms of collaboration is crucial for finding an answer to the research question. Therefore, the elements of the collaborative governance definition of Emerson et al. (2011) were used to establish an interview guide, with questions that try to discover what the collaborative governance per case consists of. For the creation of the coding guide, used for the analysis, these same elements were used.

Public-private collaboration in district heating in Europe

Public-private collaboration in district heating also exists throughout Europe. These collaborations can positively and negatively impact the achievement of sustainability goals.

Positive Impacts

PPPs can become effective tools for sustainability when they draw the private sector's efficiency and innovation to its projects. Private sector experience with advanced technologies and management practices can in turn increase performance on multiple fronts ranging from energy efficiency to waste-management as well as renewable-energy deployment (Hodge & Greve, 2007). For example, there may be advanced renewable energy technologies that private developers can introduce in district heating projects that cities do not know how and could also never have the resources to deliver them on their own. In some cases PPPs can provide access to private capital. Through incentivising private investments they will allow municipalities to start ambitious projects that fit with their sustainable targets like installing district heating networks (EIB, 2020). Furthermore, PPPs also help in risk management between the public-private partners. Transferring some of the financial, technical and operational risks to their private partners could result in municipalities starting more projects with greater confidence (Grimsey & Lewis 2004).

Negative Impacts

Private sector profit motives may contradict public sector sustainability goals. Private partners want to pursue projects and practices that recover their costs, which can be at the expense of sustainability objectives (Hodge & Greve, 2007). In district heating projects, private companies might have incentives to choose solutions that are cost-effective for them in the longer term, but may not be very long-term sustainable. Besides, PPPs are prone to accountability and transparency problems. The intricate nature of these partnerships makes it difficult to monitor and make sure private partners are following specified sustainability standards (Siemiatycki 2010). Strong governance frameworks of municipalities can help in governing these partnerships more efficiently and make sure private actions are consistent with public sustainability goals. sustainability goals often include long-term commitments and the ability to adapt based on changes or shifts in technology. Yet PPPs often are based on a single, long-term contract, which is not ideal when a strategy has to be changed along the way. If initial agreements do not take this into account properly, the achievement of future sustainability goals may be hard (Jooste et al., 2011).

In Europe, the impact of PPPs on municipal sustainable goal achievement is significant. On one hand they can provide efficiency and innovation whilst mobilising the required capital, on the other they bring with them difficulties with aligning profit motives with public sustainability goal-setting. Municipalities can leverage the private sector by helping design and manage PPPs to both capture the benefits of efficient project delivery, while ensuring sustainability goals are met. This research investigates the value of the different sorts of PPP in Dutch district heating.

Forms of public-private collaboration in district heating in the Netherlands

To get a better grip on reaching climate goals and control heating tariffs, the Wcw aims to strengthen the role of municipalities in organising and coordinating district heating systems (Rijksoverheid, 2023). With this law, municipalities must designate 'heating cadastres' where collective heat supply will be developed. Within these heating cadastres, collective heat supply will in principle only be allowed with a designation by the municipality, that only assigns heat companies with a public majority interest or heat cooperatives (Wcw, 2024). To provide investment security, designated heat companies get an exclusive concession to supply heat within the heating cadastre for the duration of the designation (Wcw, 2024). Building owners can opt-out of connection to the collective system, but in that case, they have to provide their own alternative sustainable heating solution (Wcw, 2024).

These new arrangements have their implication on organisation and public-private collaboration. The Wcw (2024) offers four different organisational models:

1. Publicly:
    a. Public heating company: A heating company in which more than 50% of the shares are owned by one or more public parties, often the municipality and/or the water supply company. Public parties have a decisive say in this type of heating company.
    b. Joint venture: A joint venture between a heat supply company and a heat network company. For this organisational model, the heat network company must be over 50% publicly owned, and public parties must have decisive control over the heating company.
2. Heat community: a small local heat network, operated and financed by shareholders or members in the form of a cooperation (NPLW, 2024).
3. *Only for small collectives (<1500 consumers)*
   Private heating company: a heating company in which a majority stake is held by private shareholders, those being civilians or other entities like companies. This is an additional model allowed only for small collective heat systems with a maximum of 1,500 consumers.

Frameworks

Although not much research exists within the field of collaboration in district heating in the context of the Netherlands, two main frameworks on this topic exist. These frameworks provide analyses of the state of collaboration in District heating with Elsman (2024) focusing on the positions of district heating organisations in a coordinate system of collaboration and Sanders et al. (2016) providing a governance typology of district heating.

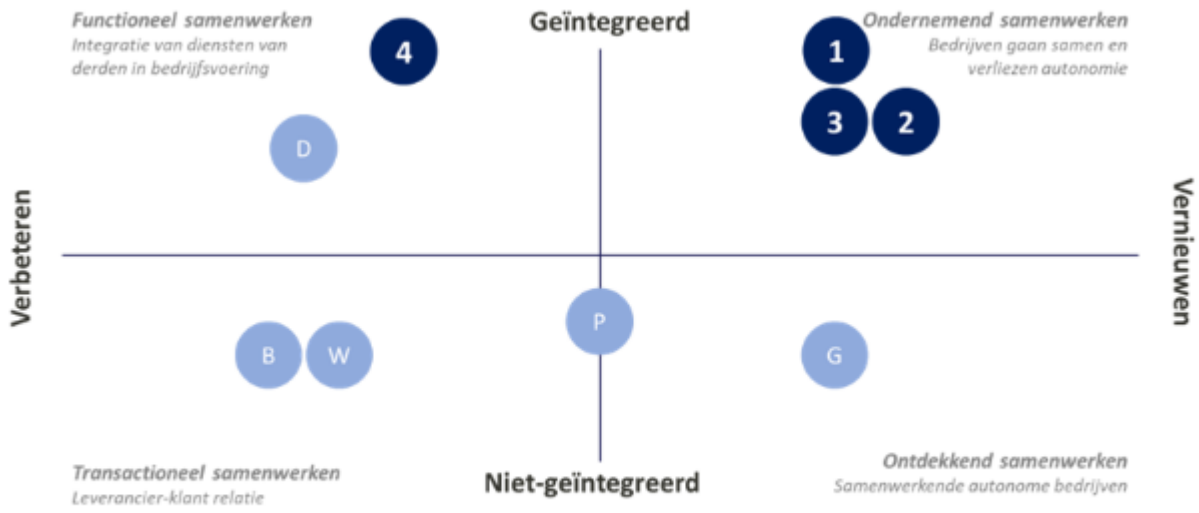
Framework Elsman (2024)

Elsman (2024) proposes a framework/axis based on the main pillars of the Wcw, degree of integration and degree of innovation, building on the four ground forms of collaboration between organisations of Kaats & Opheij (2021). As can be seen in figure 1, number 1 (Public heating company), 2 (Heat Community), 3 (Joint Venture) and 4 (Private heating company) are all presented in the upper part of the figure. This is because infrastructure management, heat supply and heat production or purchasing are all integrated into one organisation. Furthermore, the first three forms of collaboration have a more innovative character, because these forms have not been realised on a large scale. Number 4 can be seen on the left side of the figure, because private heat companies have existed extensively.

In accordance with the ground forms of collaboration by Kaats & Opheij (2021), the roles of the most important stakeholders have been plotted in this scheme as well. The four ground forms of collaboration are:

1. Functional collaboration (left upper): This type of collaboration involves integrated cooperation focused on improving business processes and efficiency. It is associated with the organisational model of the private heating company and service providers.
2. Entrepreneurial collaboration (right upper): This form of collaboration involves integrated and innovative cooperation focused on developing new business with a common goal. It relates to the innovative forms of collaboration under the Wcw.
3. Transactional collaboration (left under): This collaboration type involves non-integrated cooperation with a focus on improving efficiency within the supply chain. Residents and housing corporations operate in this field.

4. Exploratory collaboration (right under): This form of collaboration involves non-integrated and innovative cooperation, emphasising autonomy, openness, and transparency. This is the field in which the municipality operates.



Legend: 1) Public heating company, 2) Heat Community, 3) Joint Venture, 4) Private heating company, B) Resident, W) Housing corporation, P) Producer, D) service providers, G) Municipality

Figure 1: Diagram of the four forms of collaboration linked to the Wcw organisational models. (Elsman, 2024)

Elsman (2024) asked several heat network projects to elaborate on their experiences and they found that partnerships develop which makes the different stakeholders move into the positions they expect to take during the exploitation phase. This creates more distance between the parties in the scheme and greater differences in the way they collaborate. Note that municipalities also face a complex dilemma: they can act as a shareholder in heating companies, but at the same time also as a collaborative partner which can bring challenges, especially in the areas of transparency and advocacy (Elsman, 2024). The influence of these challenges on the municipal goal achievement are researched in this thesis.

Framework Sanders et al. (2016)
Sanders et al. (2016) underscore the complexities and diverse interests involved in establishing regional heating networks, necessitating an organised approach to collaboration for their realisation. The typology presented in figure 2 is a framework developed to categorise and understand different governance structures and complexities of heating networks. It distinguishes between two dimensions: the nature of the network regime and the complexity of the network function. The nature of the network regime refers to whether the infrastructure is publicly or privately owned (indicators being legal form, ownership, autonomy, activities, financing, market environment and value orientation), while the complexity of the network function refers to the functional properties that influence the complexity of the multi-actor configuration involved in the heating network (indicators being scale, production, distribution, transport, customers, energy source). The typology categorises four ideal types: a public and private regime with low complexity, and a public and private regime with significant complexity. It also acknowledges that in practice, hybrid forms of these ideal types exist

The typology aims to guide decision-making in orchestrating collaboration for the implementation of heating networks, particularly in the context of PPPs.

		Aard van het netregime		
		Publiek	**Hybride vormen**	**Privaat**
Complexiteit van de net-functie	Gering	Ideaaltype 1 Publiek/Eenvoudig		Ideaaltype 2 Privaat/Eenvoudig
	Hybride vormen			
	Omvangrijk	Ideaaltype 3 Publiek/Complex		Ideaaltype 4 Privaat/Complex

Figure 2: Typology of governance structures in district heating (Sanders et al., 2016)

Relation of frameworks to this research
Elsman's framework helps in understanding how different collaborative forms impact the efficiency and innovation of district heating projects. The efficiency gains that private sector participation can bring are indicated in functional collaboration (left upper), while entrepreneurial collaboration (right upper) shows how innovative cooperation can bring new business developments regarding municipal targets. This examination into the ways in which municipalities navigate in their simultaneous roles as shareholders and collaborators sheds light on the tensions that emerge when it comes to ensuring transparency, accountability and alignment of interests, impacting goal achievement.

The typology created by Sanders et al. (2016) then extends this insight, categorising heating networks based on the type of network regime and the complexity in terms of scope. The framework reveals different layers of complexity among public and private regimes, offering an insight in the challenges faced related to organisation and governance. The notion of hybrid forms recognises the practical aspects associated with PPPs and how these mixed governance structures can influence both implementation and performance for district heating. For example, a high-complexity public regime might be the best fit to serve public policy goals but suffer coordination problems in comparison with a low-complexity private regime that reduces operational costs of business and struggles to reach broader social objectives.

What becomes clear of the two frameworks, also in relation to the arrangements to the new law, is that the district heating initiatives can be divided in several different groups. By comparing and summarising these frameworks, three models of collaboration can be identified:

- The public majority interest model, linked to public ownership and high integration corresponds with Elsman's public heat companies as well as Sanders' public nature of the grid regime.
- The private majority interest model, with private ownership and operational efficiency corresponds to Elsman's private heat companies and Sanders' private nature of the grid regime.
- The 50/50 interest version of ownership which comes with shared governance is used for the purpose of equitable partnership, balanced ownership that reflects in joint ventures mentioned by Elsman and hybrid forms used in Sanders' typology.

Conceptual Model

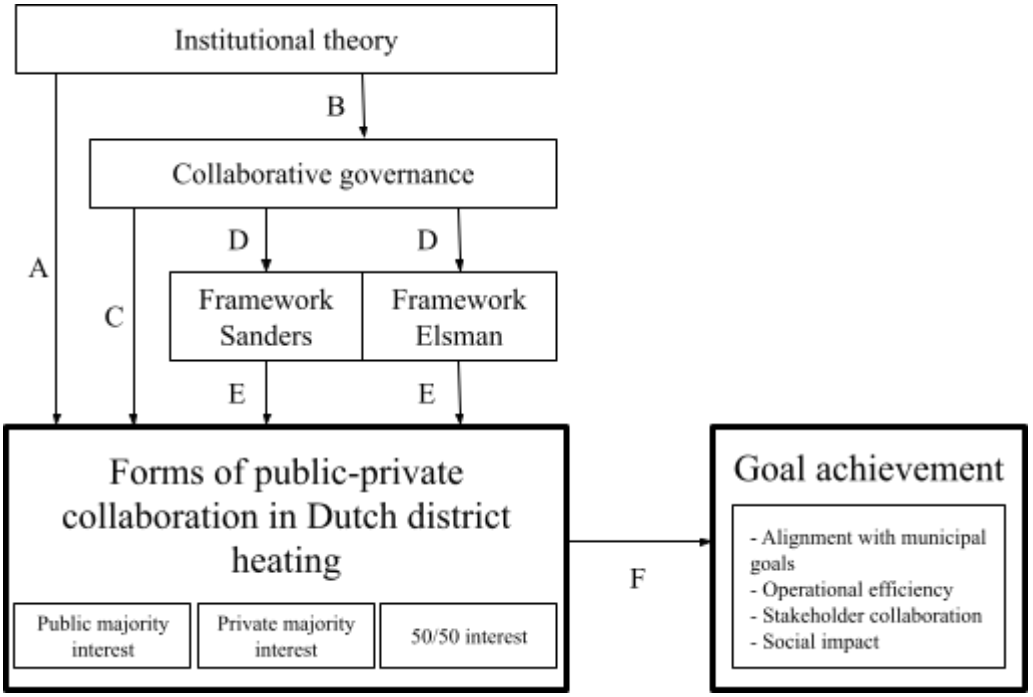


Figure 3, conceptual framework. (Author, 2024)

The model presented in figure 3 comprises the conceptual framework for this research. This research aims to get an insight into the effects of forms of public-private collaboration in Dutch district heating on the achievement of municipal goals as is shown by the bold sections.

As discussed before, the regulatory frameworks and the forms of organisation from institutional theory shape the forms of collaboration that are used in this research, as can be seen in figure 3 (A). It also influences the aspects of collaborative governance that have been discussed in this chapter (B). This is relevant for this study because institutions create a framework for the processes and structures that form the public-private collaborations of this research (C). Different sorts of collaborations have been studied by Sanders et al. (2016) and Elsman (2024). Collaborative governance has determined the way the axes of these frameworks are set up (D) and, as reasoned before, the forms of collaboration that are researched in this thesis are derived mainly from these models (E). This background forms a basis for understanding the influence of the form of collaboration on the achievement of municipal goals (F). The goals in the section on the right of the figure are derived from literature in the field of collaboration in district heating throughout Europe.

Methodology

In order to gather insights in the public-private collaboration within the district heating domain, this research uses qualitative data analysis: literature review, document analysis and semi-structured interviews are conducted and used to answer the main research question: ‘What is the influence of different forms of public-private collaboration in the implementation of 4th & 5th generation district heating on achieving Dutch municipal district heating goals?’. In this chapter, the reasons for selecting the research design, methods for data collection and analysis and ethical considerations are discussed.

Philosophical underpinnings

Ontology, or the understanding of the nature of reality, plays a crucial role in framing the worldview of this research, because it helps to understand and define the fundamental nature of the concepts involved in this study. This study has a social constructionist ontology. This means that reality is perceived as constructed by individual interactions and interpretations. This recognises the context-specific nature of district heating networks and their forms of collaboration, understanding that how public-private collaboration influences district heating implementation is subject to social, economic and political factors. From an epistemological perspective, this research adheres to a constructivist view of knowledge as something that is constructed through interaction with the world and experiences and interpretations made by individuals. Next to a literature review and a document analysis, the data for this research is gained through semi-structured interviews with Dutch municipality officials that explore the participants' perspectives, experiences and understandings concerning collaboration in district heating initiatives. This method shows the complexities in achieving municipal sustainability goals showing differing views in understanding and tackling the objectives. However, it is important to see the constraints in seeking truth within this research. Perspectives based on interviews are subject to the subjective interpretation shaped by individual experiences and biases. Therefore, results are contextual and these findings may not be generalisable across populations. Second, the social and political context are always changing which limits generalisability to contexts other than those of these specific Dutch municipalities. Because the concepts in this study are subject to change and complexity, a qualitative approach that emphasises contextual understanding is the most appropriate method to use.

Choice of methods

According to Yin (2009), the type of question posed plays a crucial role in determining the appropriate research strategy. Questions with a focus on explaining mechanisms particularly suggest that a case study is a suitable method (Ibid). Consequently, employing a qualitative comparative case study is viewed as an appropriate research approach to address the research question of this thesis. The reason for choosing a qualitative comparative case study in this research is its capability to gather data within each case and to compare data across cases, thereby establishing a robust basis for identifying variations in outcomes across different forms of public-private collaborations. The comparative case study method allows for a detailed investigation from diverse viewpoints of complex and distinctive projects or systems, specifically focusing on district heating networks in this instance (Simons, 2009; Rijkeboer 2022).

Bowen (2009) states that at least two research methods should be applied in the case of a qualitative study. This comparative case study will be executed through the use of three methods: literature review, document analysis and semi-structured interviews. The overview can be seen in figure 4, with the methods coloured in light green.

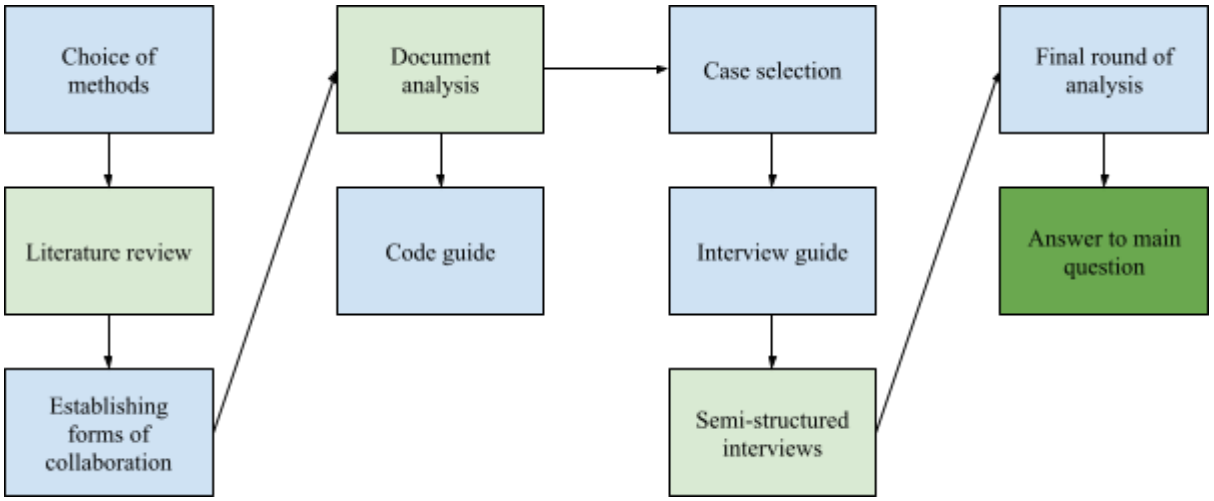


Figure 4: Research method overview (Author, 2024)

The literature review has started after the methods for this research were chosen. This review established three forms of collaboration. This research aims to identify the effects of different forms of collaboration, therefore a document analysis of municipal HTVs was executed that established the estimated forms of collaboration of several cases. “Estimated”, because nuances could be added after the interviews. For the code guide, the most important municipal goals from municipal HTVs were also established through this document analysis. This code guide was used during the final round of analysis. Based on the estimated forms of collaboration, cases were selected, after which an interview guide was created. This interview guide consists of aspects and knowledge retrieved from the theoretical framework (literature review) and the document analysis. Semi-structured interviews were then conducted, after which a final round of analysis followed, using the code guide. Based on this analysis, an answer to the main question has been formulated.

Literature review

The initial stage of this research involved conducting a literature review to refine the theoretical foundation and construct a conceptual model. The literature review concentrated on concepts related to district heating generation, theories concerning PPPs, and governance structures. The literature search utilised search engines such as SmartCat and Google Scholar, combining terms in various ways to gather relevant articles. Additionally, snowballing was employed. The three main forms of collaboration in district heating are established after which the chapter was concluded with a conceptual model that illustrates the relationships between the concepts within the theoretical framework. Subsequently, an interview guide was developed based on the findings of the literature review to gather information in the next phase of the research. Furthermore, indicators for analysing interviews and documents were identified based on the literature review.

Document analysis

Examining relevant organisational and institutional documents in qualitative research enhances understanding of the cases and their contextual backgrounds being studied (Bowen, 2009). These documents, such as policy papers or reports, lack a scientific foundation but are valuable for triangulation when combined with other research methods, as in this study. Document analysis is particularly suitable for qualitative case studies (Bowen, 2009). Multiple policy documents are analysed to deepen comprehension of the selected cases. This method has been used in two instances. First, after the literature review and the establishment of the forms of collaboration. Documents of

potential cases of district heating networks have been looked into in order to establish their provisional form of collaboration (it could be changed after input from the interviews). In the second instance, this method was used to establish which goals municipalities in the Netherlands strive to achieve. These goals are presented in table 1 and are used in the interview guide and the coding guide. In both instances, these findings have had their influence on the establishment of the interview and coding guide. It's important to note that these documents are influenced by political shifts.

Main goals of HTVs in Dutch municipalities
Collaborating with stakeholders
Insulation
Affordability
Sustainable heat techniques
Network reliability
Technical matching opportunities
Social matching opportunities

Table 1: Main goals of HTVs in Dutch municipalities. (Author, 2024)

Semi-structured interviews

Semi-structured interviews are employed to gather insights and viewpoints regarding the forms of collaboration within the district heating projects. The choice of semi-structured interviews, as opposed to other interview formats like focus groups, is deliberate. Every interviewee responds to the identical guiding questions, enabling the researcher to compare responses (Clifford et al., 2016). This format gives both the researcher and respondent flexibility. It allows the interviewer to guide the talk with predefined questions while also providing room for diving into certain questions a bit more. This flexibility allows interviewees to describe a particular topic in more depth and leaves room for asking follow-up questions, which generates conversation, hopefully leading to richer responses (Longhurst 2016). Furthermore, qualitative research allows researchers to compare data from different cases in order to help generalise findings across like contexts for understanding (Longhurst, 2016; Onwuegbuzie & Leech, 2010).

The interviews were conducted in April and May of 2024. Semi -structured interviews were used to answer the sub questions in a structured manner, while also allowing for deeper exploration of answers to gather even more information. The district heating projects are chosen on the basis of the size of the project and the in advance expected form of public-private collaboration based on the document analysis. The interviews are conducted with public servants, responsible for or involved in the realisation of the district heating network, who have knowledge about the municipal goals and have experienced the public-private collaboration in the process of implementing the heat network. The participants were interviewed individually via video call or in person and permitted a recording of the interview. Problems with the internet connection had a slightly negative impact on the recording, as sometimes a fragment was lost. This, however, appeared to be no major problem in answering the research questions. For this master thesis, six interviews were conducted.

Three extra interviews were conducted with representatives of heating companies. Because these people are not affiliated with municipal goals, these interviews are not within the scope of the research. Some notions of heating company representatives are shortly touched upon in the results.

The interviewees remain anonymous. The data that has been collected through the analysis of the interviews is traceable and therefore potentially harmful for the interviewees or other entities. Interviewees or their employers are only named if there is explicit confirmation to quote them in a specific context.

Case selection

Proper selection of cases is essential for conducting a comparative case study. A first prerequisite for selecting cases in this study is the generation of the heat network. As can be read in the foregoing, this study is focusing on sustainable district heating, which starts from the 4th generation onward. Therefore, cases are selected on the basis of the sources of their heat, indicating the generation of the district heating network. Secondly, the goals of the cases must be comparable, so the policy documents must be the same. A third characteristic of the cases that has been taken into account in the selection process is the varying nature of the PPP. As this research aims to find out what the differences in outcomes are when different sorts of collaboration are in place, it is of importance to select cases that have variable structures of partnerships. The form of public-private collaboration is a priori determined on the basis of literature review, for the broader context, and document analysis for a more specific context. For all partnerships must be seen in their own context and differ even if they seem similar in the first place, a further inspection of the partnership takes place during the semi-structured interviews. A last characteristic is willingness to participate in this research.

(Inter)national, regional and municipal goals

The Dutch national government aims to achieve several overarching goals through the implementation of district heating networks, aligning with broader energy transition and climate objectives of the Paris Agreement (2015) and the national Climate Agreement (2019). The levels of policy can be seen in table 2.

Scale	**Policy document**
International	Paris Agreement
National	Climate Agreement, Wcw
Regional	Regional Energy Strategy (RES)
Municipal	Heat Transition Vision (HTV)
Neighbourhood level	Neighbourhood Implementation Plan

Table 2: Applicable policy in the Netherlands regarding heat transition. (Author, 2024)

Municipalities play a pivotal role in the fulfilling of the international climate agreements made in Paris (2015), both regionally through the Regional Energy Strategy (RES) and locally through the Heat Transition Vision (HTV) (‘Transitievisie Warmte’ or ‘Warmtevisie’) and the Neighbourhood Implementation Plan (Wijkuitvoeringsplan). In the RES, numerous national commitments outlined in the Climate Agreement are put into practical action, divided in 30 regions. Within the RES,

governmental bodies collaborate with various stakeholders including grid operators for gas, electricity, and heat, along with businesses and residents. Together, they make regional decisions concerning sustainable electricity generation and transitioning heating methods to sustainable sources. These decisions are translated into specific regions, projects, and subsequent implementation and execution plans. The RES primarily focuses on the implementation of energy infrastructure, but in case a region desires, tasks from other policy fields like mobility, industry, or agriculture can also be integrated into the RES. Moreover, ongoing efforts within the region regarding different energy plans are taken into consideration. While these parallel processes are taken into account as the RES is drafted, there isn't a prescribed general standard for managing these processes.

The HTV assigns municipalities as directors of the heat transition within the built environment, collaborating with property owners, residents, grid operators, and other authorities (RVO, 2022). A sustainable coalition of local stakeholders is very important. This coalition drives collaboration throughout the process, from the RES to the HTV and subsequent implementation plans. Together, they guide the transition vision to approval by the municipal council and board, ensuring effective implementation through an agreed-upon strategy. In 2021, all municipalities have created a HTV (RVO, 2022). This vision encompasses proposals for sustainable and natural gas-free heating and, offering a strategic direction and a neighbourhood-specific action plan for all involved parties. The Neighbourhood Implementation Plan follows the RES and the Heat Transition Vision, involving residents and building owners in determining the plan for their neighbourhood. Consideration of costs, both for residents and building owners, along with local conditions, is important in this process (RVO, 2022).

Forms of collaboration

In this research, the frameworks presented by Elsman (2024) and Sanders et al. (2016) were instrumental in guiding the case selection, creation of the coding guide, and data analysis. Elsman's framework helped identify relevant district heating projects within a type of public-private collaboration. This provided a variety of different collaborative models, each with unique characteristics. Elsman's collaboration types classification and Sanders' typology of network regimes served as the foundation for constructing an interview and coding guide and doing document analysis. This enabled the systematic comparison of cases using a particular type of collaborative model which shed light on how differences between these collaborative models impact in reaching municipal goals concerning sustainability and district heating. The analysis could illustrate patterns and divergences in collaborative governance using these two frameworks, providing important insights into the dynamics around PPPs in district heating.

Data analysis

The literature review has been established in the previous chapter. Three main forms of collaboration were established that are used throughout the thesis. Based on the concepts presented in the theoretical framework, documents were analysed.

The documents have been analysed in an explorative manner. Several policy documents have been looked into to get an idea of the form of collaboration and goals of HTVs. Later, the interviews elaborated on these preliminary findings.

Immediately after each interview, the conversations were transcribed. During the interviews, only minimal notes were taken to ensure participants received full attention. After transcription, the data was coded. In this study, analysing the coded data will reveal to what extent municipal goals were

achieved and to what extent this related to the form of public-private collaboration. Deductive coding was used to create codes. Next to the concepts of the theoretical framework that have been used to create the coding guide, the most important municipal goals have also been added to this guide. These goals were derived from a document analysis of HTVs of the municipalities that were selected. The coding guide is available in Appendix 1.

The logic of data comparison can be viewed in figure 5.

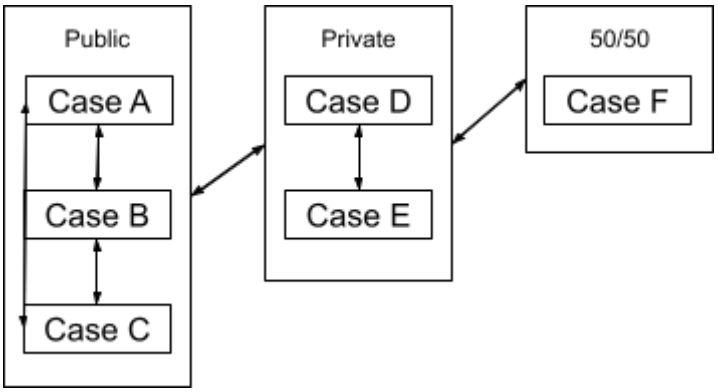


Figure 5, Logic of data comparison. (Author, 2024)

Ethical considerations

Ethical considerations were carefully addressed throughout the research process. One ethical aspect pertains to the researcher's role. In this instance, the researcher was an intern at Arcadis. All respondents were briefed about the researcher's identity, the role of Arcadis and the purpose behind the study prior to the interviews, ensuring transparency regarding the study's objectives. To safeguard respondents' rights and privacy, informed consent forms were distributed before each interview, detailing data usage and storage procedures, asking about preferences concerning the use of names, and the recording of interviews. All respondents consented to these terms. Access to the gathered data was restricted to the researcher alone. Before each interview, the researcher reiterated their identity and the topics to be discussed, reaffirming the agreed terms to ensure respondents' understanding and addressing any queries they might have. Respondents had the option to terminate the interview at any point and were offered the opportunity to review and verify the interview transcripts. Additionally, respondents were asked about relevant project documents to enhance document analysis. Certain documents containing sensitive information were utilised solely for background context, with no inclusion in the thesis. The data collected was strictly utilised in accordance with the pre-approved purposes and without further use or dissemination without prior consent from the respondents.

Furthermore, Artificial Intelligence (AI), ChatGPT 4o was sporadically used in order to create ideas of how to present or structure certain chapters, findings or references. No output of this AI was copied or directly used into this thesis.

Results

This chapter shows the results of the research. Several forms of district heating projects with differing public-private collaboration have been incorporated. These forms have been subdivided in three categories: public district heating, private district heating and other forms. The sections all address the form of collaboration in detail, followed by a summary of what has been accomplished related to their relative municipal goals. Any remarkable details are pointed out. Hereafter, significant remarks from the point of view of heating companies are presented. This chapter is concluded by a section that compares the cases.

The cases are anonymised.

Public District Heating

Three cases have been identified as 'public' district heating networks. These municipalities all have a heating company within their borders that are owned by public shareholders. An overview of the characteristics of the cases based on the output of the interviews can be seen in table 3.

Municipality A

Description

The first case has a network within its borders of a larger regional, public district heating company. The heating company started as a waste incineration plant but wanted to use the excess heat for the heating of houses. In collaboration with municipalities and housing corporations, a district heating network was established. This network relies on several sources, mostly on a waste incineration plant. New, more sustainable sources were implemented over the years.

Municipality A has a Heat Transitional Vision (HTV) that has been written in collaboration with an external bureau. The anchor points comprise freedom of choice (of heat source), affordability and lowest social costs.

PPP

The heating company is a stand-alone company. However, as it first operated solely as a waste processing company for the region, regional governmental entities were already stakeholding. Municipality A is a shareholder in the heating company. The heating company has several dozen shareholders, all public entities. The shares are not evenly divided.
A general agreement between all stakeholders determines the course of the business operations.

Municipal goals

For municipality A, an external bureau has written the HTV in collaboration with the municipality. This company has incorporated the interests of citizens of municipality A, because the HTV is politically sensitive. People are concerned about the affordability and their freedom of choice of their source of energy. These are also the points that municipality A values the most.

The heating company maintains direct contact with citizens, ensuring that community needs and concerns are addressed, a role not directly undertaken by the municipality itself. Housing corporations are also involved, taking a larger role than the heating company in certain aspects, further integrating the community into the heating network initiatives. The pricing strategy ensures affordability and

adherence to the ‘niet meer dan anders’ principle (‘not more than usual’ principle), which means that you do not pay more for district heating than you would for heating by gas. The cost of heating is set at 10% lower than the ACM (Authority for Consumers and Markets) regulated price. This price cap is established in contracts with the shareholders, providing financial relief to residents and aligning with the goal of maintaining the lowest social costs.

The heating company has independently integrated biomass as a newer energy source, demonstrating its entrepreneurial spirit and commitment to sustainability. Additionally, the heating company operates wind turbines, further diversifying its renewable energy portfolio. Without The heating company’s presence and efforts, Municipality A mentions it would not have achieved its current level of progress in sustainable heating. The company's proactive measures and public orientation significantly contribute to the municipality's environmental and social goals.

Municipality B

Description

This municipality has a 5th generation district heating network which is providing more than 10.000 home equivalents. The most important source is waste heat from a data centre, but sources such as solar thermal collectors and a, soon to be hydrogen powered, generator for peaks in heat demand also exist. The heat network is completely located within the boundaries of municipality B.

Because the municipality is collaborating in a European CO_2- neutral programme, the HTV of municipality B aims for natural gas-free neighbourhoods before 2030, while the national goal is aiming for 2050. With these goals, municipality B is a frontrunner in the heat transition. The main pillars of the HTV, that has been written by the municipality internally, are affordability, reliability and fairness.

PPP

The heating company has been established by municipality B. In order to get enough technical knowledge within the organisation, some colleagues of the regional drinking water company were attracted. This resulted in shared ownership of the municipality and the drinking water company, each having 50% of the shares of the heating company. Although the drinking water company is a separate organisation, it is a public organisation, which means that all shares are owned by public entities. Municipality B is also a shareholder in the drinking water company.

The heating company acts as a regular company. It has to make a profit to be successful. However, the company is owned by two completely public parties. Municipality B, that dictates the heat policy, is in close contact with the heating company on all levels. Staff of the strategic levels of the municipality is in close contact with the board of the heating company and the maintenance department knows where to find the technical staff of the heating company.

Municipal goals

Municipality B has set itself rather big goals by bringing the national goals forward by 20 years. The municipality points out that this goal is very optimistic, but also feasible. The latest forecast is that this goal will be reached in 2032. Municipality B said that this would not have been possible without the public heating company. Although clashes do exist, sustainable policy implementation and making a profit do not always go hand in hand, the tight-knit interrelationship of municipality and heating company allow for quick communication and therefore clashes can be averted quickly. Another perk of the way of collaboration pointed out by Municipality C is the fact that other pressing policy themes

that are affected by or related to the implementation of district heating, e.g. social issues or maintenance tasks, can be handled more quickly and easily in consultation with the heating company.

Municipality C

Description

The heat network in question operates using a 5th generation district heating system powered by a regional public heating company. This advanced system, made possible by a European subsidy for pilot projects, initially intended to be part of social housing projects to enhance energy efficiency and reduce costs. However, the high expenses associated with the project impeded its progress. The system's reliance on natural gas for operation further complicated its deployment, as it faced several technical and strategic challenges.

The HTV was written up by the municipality itself in collaboration with its residents. The local heating company was not asked to contribute. Municipality C has a lot of poverty within its borders, which was a priority in writing up the HTV. Social issues must be addressed before district heating is being implemented.

PPP

The heating company is a public heating company because the main stakeholders are public entities: the province and the local electricity company. Municipality C is a municipality within the province and is also a stakeholder in the electricity company indicating a complex web of financial and operational interdependencies.

Municipal goals

The PPP arrangement had great implications on the ability to reach municipal goals, above all concerning social issues and affordability. The need of solving social problems was more important than making sure that the heat network was up and running, demonstrating the priority of social improvement over sustainable infrastructure projects. Next to that, its dependence on the big municipalities and unfortunate experiences with technical problems and bad communication and weak pressure on the heating company further complicated it. The need to rely on natural gas generators demonstrates the disconnection between the aims and execution of the project. The process of engaging with residents and understanding their concerns through kitchen table discussions provides an example of the municipality's commitment to addressing social issues as a step towards broader energy savings and sustainable development.

(Dis)similarities

Similarities in the impact of PPPs (PPP) on achieving municipal goals exist across all three cases in some way. All municipalities hold shares in the heating companies so they can govern the activities and development of these companies according to their municipal goals. In Municipality A, the public shareholders aligned in a general agreement that fostered sustainable development, although occasional clashes between shareholders occurred. Municipality B worked closely with the local water company, achieving ambitious goals for CO_2 neutrality and a natural gas-free future. This demonstrates how good communication can serve as an accelerator of sustainability objectives. In Municipality C, the network is of public nature and very complexly owned and organised in a manner that does not allow for social objectives to be integrated into existing heat network operations. In their Heat Transitional Visions (HTVs), all three municipalities stress social considerations and affordability, demonstrating how PPPs might help to bring the best of district heating also for groups at risk. Municipality A focuses on freedom of choice, price and least social costs.The HTV of

municipality B strives for natural gas-free neighbourhoods by 2030 including affordable, reliable and fair heat networks. Municipality C addresses social problems as most important, above implementation of heat networks. These municipalities want to prevent the disproportionate influence of the transition to sustainable district heating to low-income or vulnerable residents by embedding social considerations into their HTVs. Although the methods of implementation and problems encountered may differ, in all these instances collaborative governance is highlighted as a key mechanism for progressing sustainable development and social cost reduction through public district heating networks with PPPs. This collaborative approach allows the district heating implementation to be well connected with other policies of municipalities, enabling broader efforts towards sustainable societies, allowing for more coordinated efforts regarding sustainability or social goals.

But PPP (PPP) in the three cases has also exposed some negative features that impact municipal goal achievement. In every instance, the complexity of joint ownership by various public entities can result in conflicts and misaligned goals. This has been observed in Municipality A, where differing interests among shareholders sometimes has a negative impact on the progress in terms of disagreements that slow down processes. In this manner, Municipality B has a partnership with the public drinking water company which has allowed for strong ambitions but also occasions of tension when profit goals do not go well together with sustainability targets. Municipality C faces even more significant challenges, with technical and strategic issues within its heating company exacerbated by the complex web of public stakeholders. This complexity often results in delays and underperformance, notably illustrated by the reliance on natural gas due to the network's inefficiencies. Across all municipalities, these PPP structures can complicate decision-making and slow down the implementation of critical projects, highlighting the inherent difficulties in aligning diverse public interests with cohesive and effective municipal action plans.

Public	**Municipality A**	**Municipality B**	**Municipality C**
Generation of District Heating			
Special Goals			
Form of public-private collaboration			
Institutionalism			
Effects of public-private collaboration			
Achievement of goals			
Collaborating with stakeholders			
Insulation			
Affordability			
Sustainable heat techniques			
Network reliability			
Technical matching opportunities			

Social matching opportunities			
Important notions			
Important quotes			
General notes			
Summary per case			

Table 3: Characteristics of public heat networks A,B and C. (Author, 2024)

Private District Heating

Two private district heating cases have been used for this research. An overview of the characteristics of the cases based on the output of the interviews can be seen in table 4.

Municipality D

Description

The district heating network under discussion, established in the 1980s, initially utilised 4GDH technology and was powered by waste incineration. This network, first managed by the municipality, aimed to provide affordable and efficient heating solutions to local residents. One of the primary goals was to connect neighbourhoods with the lowest social costs first, emphasising the importance of affordability and social equity in its rollout. However, despite its early promise, the network struggled with profitability and operational efficiency under municipal management. Consequently, the municipality sold the network to private entities, leading to a fully privatised system. This transition aimed to enhance the network's operational efficiency and sustainability by leveraging private sector expertise and investment.

PPP

After the municipality sold the network due to its struggles with profitability and entrepreneurial challenges, it transitioned to a completely private ownership model. This shift marked a significant change in the network's management structure, with the municipality stepping back from direct operation to a more oversight-oriented role. Periodic meetings between the municipality and the heating company facilitate ongoing collaboration, although the relationship has faced challenges, particularly concerning regulatory developments. For instance, the heating company partook as a key member of a consortium that researched regional heat network options. However, it decided to exit due to uncertainties relating to the new collective heat law. This has caused delays in the project, highlighting the complexities and dependencies.

Municipal Goals

The HTV has been formulated in cooperation with a consultancy company that has mainly done calculations on which decoupling of neighbourhoods from the natural gas would lead to the least social costs in municipality D. Citizens and other stakeholders, such as housing corporations, were also incorporated in the process, which, according to municipality D, has led to the fact that for citizens it did not feel like a burden to live in an area heated by district heating. The HTV prioritises connecting neighbourhoods with the lowest social costs first. Affordability remains a critical theme, with efforts to maintain costs within reach for all residents. Although the agenda includes potential synergies with other municipal activities such as road maintenance and neighbourhood green spaces,

these opportunities have not yet been fully realised. There are plans to integrate these possibilities in the future.

Municipality E

Description

The district heating network of municipality E is heated by the waste heat of a factory and operates using fifth-generation district heating (5GDH) technology. The network utilises various sustainable sources, including asphalt heat collectors. The concept for this heating network was initiated by an installation company, aiming to make the grid appealing to private individuals and companies. Municipality E has another larger, public, heat network within its borders. The HTV was drafted in collaboration with both heat companies and a private consultancy firm.

PPP

Up till now, the municipality has been a mediator by linking housing corporations with the heating company to ensure that both could work together in an efficient and cost-effective way. Individual installations were initially envisaged, but through municipal efforts, a central installation was established leading to better efficiency. Although the limited role of the municipality in creating the heating company, it has been crucial to organise in this way with said stakeholders. Nevertheless, the vision of the heating company tends to stay too technical and neglects the social components of the transition. This emphasises the importance of an approach that integrates technical solutions with community engagement, to ensure that not only the heating network meets environmental goals but it aligns social and environmental objectives.

Municipal Goals

This PPP has had a mixed effect on municipal objectives. At the same time, cost reduction and synergy among stakeholders have been possible to some degree through the mediating role of the municipality. Nevertheless, lack of municipal leadership has hindered the overall goal setting regarding sustainable heating and social issues as well. The heating company, despite its potential, has not actively contributed to the social transition required for broader acceptance and integration of the heating network. The municipality's insufficient involvement has led to setbacks and slower progress toward the goals outlined in the heat transition vision (HTV). Given these challenges, effective collaboration and more forward-thinking municipal leadership are needed. This will also greatly enhance the development and long-term viability of our network by making it more human, alongside focusing more on sociological challenges along with technological solutions. Ensuring the heating network remains attractive for residents means keeping it affordable and adopting more renewable sources, such as asphalt heat collectors or geothermal heat.

(Dis)similarities

Municipality D and Municipality E are similar in the fact that the private organisation drives innovation and efficiency in their district heating networks. For instance, the heating network used to be operated by Municipality D, however it was privatised which resulted in professionalism and investment that improved system performance and improved sustainable heating. This change allowed for other technologies to be implemented that were deemed more sustainable and technically superior over its initial base technology of using waste incineration plants on the network. In municipality E, an installation company was needed to get a heating network off the ground using asphalt heat collectors as an innovative way of solutions. This innovation helped make the grid more attractive for consumers and companies, but also contributed to municipal plans by increasing the share of

sustainable sources. In both municipalities, private sector involvement has been critical to improve technology adoption and operational efficiency aligning with the municipalities' sustainability goals.

While these are all positive consequences, both cases show that private organisations also have an adverse influence on the realisation of greater municipal goals. In Municipality D, the privatisation of the district heating network has led to challenges in maintaining public steering, resulting in a limited ability for the municipality to directly have an influence on the steering of the project. This has made it difficult to ensure affordability and address social costs. Similarly, in Municipality E, the municipality's limited role and lack of leadership in the heating network's creation have resulted in setbacks and slower progress toward achieving the goals outlined in the heat transition vision (HTV). This technical mindset in private organisations can also mean that social transformation, which is necessary to make the heating network more accessible and integrated, gets left behind. The two municipalities have had trouble matching the private sector's operating objectives with their municipal social and community aims, showing a challenge of these PPPs.

Private	**Municipality D**	**Municipality E**
Generation of District Heating		
Special Goals		
Form of public-private collaboration		
Institutionalism		
Effects of public-private collaboration		
Achievement of goals		
Collaborating with stakeholders		
Insulation		
Affordability		
Sustainable heat techniques		
Network reliability		
Technical matching opportunities		
Social matching opportunities		
Important notions		
Important quotes		
General notes		
Summary per case		

Table 4: Characteristics of private heat networks D and E. (Author, 2024)

50/50 District Heating

One intermediate form of public private collaboration was included in this research. An overview of its characteristics based on the output of the interview can be seen in table 5.

Municipality F

Description

The district heating network in question utilises 4GDH technology and is powered by incineration heat. This system is designed to provide efficient and sustainable heating to approximately 30,000 homes. One of the primary goals of this heat network is to address social costs, prioritising equitable investment to ensure equal opportunities for all residents. The network is strategically implemented in areas where there is a significant renovation task, aligning infrastructure upgrades with the deployment of sustainable heating solutions. By integrating these efforts, the network aims to enhance both the energy efficiency and overall quality of living in targeted neighbourhoods.

PPP

Since 2021, the municipality has actively participated in the management of the district heating network through a shareholder agreement with a private energy company, in which it is established that both parties are 50% shareholders. This form of 50/50 public-private collaboration emphasises clear communication and mutual understanding of goals between the partners. The agreement outlines mechanisms for conflict resolution, ensuring that any disagreements are managed effectively. The municipality's involvement is part of a broader institutional framework aimed at achieving sustainable objectives, such as the heat transition. By maintaining its stake in the network, the municipality retains influence over the transition away from natural gas, capitalising on opportunities to drive sustainable outcomes.

Municipal goals

Municipality F prioritises social costs significantly higher than other goals, demonstrating a commitment to “unequal investing for equal opportunities”. This approach ensures that vulnerable neighbourhoods receive the necessary support to connect to the district heating network, which is aligned with ongoing renovation tasks. The municipality actively supports residents in these areas to facilitate their transition to the heating network, addressing affordability and social equity. Neighbourhoods selected for the district heating network are chosen based on planned renovation works, ensuring a strategic alignment that maximises the impact of the heating system.

Despite these efforts, the ACM mechanism has become less effective, it is suggested that the heating company has increased prices, affecting affordability. Zero emissions are still the target and to enhance this it is proposed to incorporate waste heat from a new data centre into the network. The choice of neighbourhoods for the heat network will be guided by other renewal opportunities, together with considerations regarding their potential to host a future heat network.

General outcomes

Municipality F, which has used a 50/50 PPP model, experienced it generally well and managed to balance the desires coming from residents with efficiency needs on behalf of private companies. This has fostered transparent communication and target setting between the municipality on one hand, private energy company on another to direct both parties towards shared goals. Shared ownership ensures the municipality maintains control over the effect of its district heating network, bracing it

with wider institutional goals like moving away from natural gas and delivering sustainable energy services. Furthermore, the agreement signed contains conflict resolution mechanisms which can be used to control and reduce disputes thereby ensuring uninterrupted operation and continuous progress. The 50/50 model also offers an opportunity for the phased roll out of upgrading existing infrastructure to be aligned with implementation of sustainable heating solutions, leading to improved energy efficiency and quality of living in the specific neighbourhoods.

These benefits aside, the model for 50/50 PPP in Municipality F has also brought some downside aspects related to affordability and social costs. An important problem is the increase in heating costs, which makes the measures taken by the Authority for Consumers and Markets (ACM) useless. This has hit the ambition of affordable district heating especially for vulnerable neighbourhoods. Furthermore, the city still holds control on the heating network via its shareholding, but the municipality has limited its involvement which in turn limited the mitigation of social issues. This includes improvement of insulation and synchronisation of proposed improvements to infrastructure with the roll-out of heat networks. As a result, the broader social and community-oriented goals have not been fully met, indicating a need for more proactive municipal involvement and better integration of social considerations into the technical and operational aspects of the heating network.

Public-Private 50%/50%	**Municipality F**
Generation of District Heating	
Special Goals	
Form of public-private collaboration	
Institutionalism	
Effects of public-private collaboration	
Achievement of goals	
Collaborating with stakeholders	
Insulation	
Affordability	
Sustainable heat techniques	
Network reliability	
Technical matching opportunities	
Social matching opportunities	
Important notions	
Important quotes	

Table 5: Characteristics of 50/50 district heating case F. (Author, 2024)

Heating company remarks

Next to the municipalities that have been interviewed, three extra interviews were conducted with heat companies to get an insight in their perspectives as well. These interviewees consisted of two people

concerned with public heat networks and one interviewee concerned with a 50/50 model network. Their input was similar to the input of the municipal servants, but with lesser knowledge about the (politics behind the) municipal goals. Something that was stressed by the public heat companies is the fact that the communication between municipality and heat company can be so intense that responsibilities fade, which reduces operational efficiency in some instances.

Comparative Analysis

Operational Efficiency
The private majority model in Municipalities D and E has shown greater operational efficiency and investment in sustainable technology, thanks to substantial private sector participation. This is consistent with a view on institutional theory, in which private parties bring different operational norms and efficiencies relating to their profit motives (Scott 2004). The public majority model in Municipality A, B and C has been progressive with sustainability but also resulted in operational difficulties because of conflicts between shareholders. Municipality F offers a middle ground, balancing efficiency with public oversight. It does however still encounter issues regarding the alignment of profitability and social goals.

Municipal Goal Alignment
The public majority model in Municipality A, B and C are closely aligned with municipal goals in terms of sustainability and social costs due to a solid level of control exercised by the public influenced through collaborative governance. Municipalities D and E (Private majority model): This public-private division of responsibilities is efficient, but it tends to struggle on municipal goals in the field of affordability or considering social costs. Although the 50/50 model applied by Municipality F takes a balanced approach, its efficiency in delivering municipal objectives is mixed and integration of social considerations and proactive engagement requires improvement.

Stakeholder Collaboration
The 50/50 model provides the strongest stakeholder collaboration with both public and private actors working together, consistent with principles of collaborative governance (Emerson et al., 2011). Municipality F benefited from clear communication and shared goals. In municipalities A, B and C, the public majority model sees collaboration among stakeholders except for when they do not due to internal issues. For municipalities D and E, the private majority model has a reduced level of collaboration as municipalities have limited control to tackle emerging regulatory changes as well as social objectives.

Social and Community Impact
The more complicated public majority model of municipality A, B and C focuses on social costs as well as affordability but operational inefficiencies are some of the challenges. This reflects the views of institutional theory in terms of both normative and regulative pressures which shape organisational behaviour. Municipality D and E have demonstrated that a private majority could bring substantial efficiency but might not integrate the costs of society or be as affordable. The elements of the 50/50 model of municipality F attempts to balance energy efficiency and living, but struggles concerning rising costs and social engagement.

Summary
When comparing these three models we see clear advantages and disadvantages of each approach. The public majority model further solidifies alignment with municipal goals but has operational

challenges, whereas the private majority model is seeing efficiency but struggles with social costs and municipal alignment. The balanced 50/50 model has clear agreements about collaboration, however the absence of stakeholder collaboration and proactive engagement of the municipality leaves much to be desired.

Conclusion

In this concluding chapter, answers to the research questions will be provided. First, the sub-research questions are answered, after which the main research question is provided an answer to.

The definitions of 4th and 5th generation district heating systems highlight significant advancements in energy efficiency, sustainability, and technological integration compared to previous generations. These networks offer the possibility to adhere to the policy requirements for creating more sustainable energy infrastructure.

The Dutch government aims to reduce greenhouse gas emissions by transitioning to sustainable energy sources and enhancing energy efficiency, in line with international agreements such as the Paris Agreement. District heating is crucial in integrating renewable energy, reducing reliance on fossil fuels, and lowering emissions. The government envisions widespread adoption of 4GDH and 5GDH systems to achieve CO2 reductions. The country is divided into 30 RES regions, each developing tailored strategies involving diverse stakeholders to produce renewable energy locally. These strategies guide municipal policy, ensuring coordinated efforts towards national energy objectives. It was found that municipalities create HTVs based on the RES, addressing collaboration, insulation, affordability, sustainable heat techniques, network reliability, technical and social matching opportunities.

Based on academic literature and frameworks by Elsman (2024) and Sanders et al. (2016), three forms of public-private collaboration are identified:

- Public majority interest district heating: More than 50% of shareholders are public entities.
- Private majority interest district heating: More than 50% of shareholders are private entities.
- 50/50 interest district heating: Public and private entities each own 50% of the stakes.

All cases have their own experiences and path dependent heating outcomes. The goals of each municipality can be captured in the seven goals mentioned before. However, all cases have specific goals that are valued more. Therefore, the way in which these goals were approached differed per municipality. As demonstrated in the results, there are similarities between the cases within a subgroup of their form of collaboration. These differences are highlighted in the next paragraph. The achievement of goals per municipality can be seen in the tables presented in the chapter ‘Results’.

Answering the main question: What is the influence of different forms of public-private collaboration in the implementation of 4th&5th generation district heating on achieving Dutch municipal district heating goals?

Every form of collaboration has different outputs. In the public majority model, municipalities retain substantial control over district heating networks. This control facilitates alignment with municipal goals in terms of sustainability and social costs, ensuring that the heating transition prioritises affordability and social costs. However, a municipality that is only a small shareholder in a public majority interest heat network, is less able to take control and profit from the positive side effects of a public heating network compared to a larger shareholder. The influence of this model on municipal goal achievement is marked by strong alignment with public policy objectives but may face challenges in terms of equality between municipalities.

The private majority model leverages private sector expertise and investment to enhance the operational efficiency of district heating networks. This approach can lead to more effective management and quicker implementation of sustainable technologies. However, reduced municipal influence can lead to conflicts over regulatory changes and challenges in ensuring that social objectives are adequately met. This model is characterised by improved efficiency and technological advancement, but potentially at the cost of comprehensive social and societal considerations.

The 50/50 public-private collaboration model offers a balanced approach that combines the strengths of both sectors. Shared ownership fosters robust conflict resolution mechanisms and aligns goals through collaborative governance. This model can effectively balance the need for operational efficiency with the pursuit of sustainability and social objectives. However, it requires robust communication and coordination to address affordability and social issues comprehensively. This model achieves a balance between efficiency and social costs, provided that effective communication and strategic alignment are maintained.

In conclusion, the form of public-private collaboration significantly shapes the success of district heating implementations in Dutch municipalities. Each model presents advantages and challenges, but a common thread is clear: the most effective goal achievement arises from models that balance efficiency and innovation with strong public oversight and a focus on social equity.

Discussion

This thesis provides an understanding of how different forms of public-private collaboration influence the implementation of 4th and 5th generation district heating systems in achieving Dutch municipal district heating goals. By comparing several cases through a qualitative comparative case study, this research contributes to the existing field of knowledge using the frameworks of Elsman (2024) and Sanders et al. (2016). This study extends beyond the previously studied scope by examining how various collaboration models, public majority, private majority, and 50/50 partnerships, affect the success of district heating projects in terms of achievement of municipal goals, related to sustainability, affordability, and social equity.

Methodology

An important step for the data collection process was creating an understanding of public-private collaboration in implementing 4th and 5th generation district heating systems across various Dutch municipalities. Additionally, the governance structures and collaboration models within the energy sector were studied extensively before conducting semi-structured interviews. This preparatory phase included reviewing relevant literature and policy documents to understand the nuances of each collaboration model. The understanding from this data collection process produced input for the interview guide and enabled a more focused choice of interviewees. This preparation increased the validity of the data collected during the semi-structured interviews, ensuring that the findings accurately reflect the dynamics of public-private collaborations in district heating projects. Next to that, although outside of the scope of this research, extra interviews have been conducted with heating company representatives in order to include another perspective on the collaboration between the public and private sectors and decrease the chance of overemphasis on certain aspects of district heating.

However, focusing primarily on key stakeholders such as municipal officials and representatives from private heating companies, the study might not capture all perspectives. The exclusion of other important perspectives, such as residents, independent experts, and environmental groups, can lead to a narrower understanding of the impact of forms of collaboration. This limitati on may result in an incomplete picture of the challenges and successes, particularly concerning social and community level impacts. Additionally, the relatively small sample size inherent in qualitative research restricts the generalizability of the findings. As a consequence, while the insights gained provide valuable depth, they might not fully represent the broader complexities and diverse stakeholder views necessary for a holistic evaluation of public-private collaboration in district heating projects. To address this, future research could benefit from a broader scope, including a wider range of perspectives.

Furthermore, this research has been conducted in a period of insecurity for private district heating companies. New legislation that has been on the way for some time has deterred the position of the private sector. This means that in a context in which this factor of insecurity is a lesser issue, results could be affected if this study was conducted again. The outcomes of the research are time dependent.

Relation to theory

The results of this study show similarities with the theoretical framework. The operational efficiency that is demonstrated by the private majority interest models is one of the characteristics of institutional theory. Private entities bring operational norms and efficiencies, more than the municipality has, which shape the behaviour and structure (Scott, 2001), relating to collaborative governance.

Furthermore, the results show that private majority interest models perform well on efficiency and sustainable technologies, just as Hodge & Greve (2007) have seen. However, they mention that the effectiveness of sustainability initiatives is fostered by this process, while it is seen in certain cases that the private district heating company does not want to contribute to expand district heating, whereas public majority district heating companies feel a deep-rooted urge to increase sustainability and therefore expand their networks. This relates to the ideas of Jooste et al. (2011) concerning long-term commitment to sustainability goals, in which the adaptability of PPPs to new developments is questioned.

Another advantage highlighted in the literature is access to private capital, as noted by the EIB (2020). However, this study did not identify this advantage. The primary cost concerns discussed were social costs, leading some municipalities to hesitate in expanding their networks not due to financial constraints in creating viable heat networks, but because of high social costs and affordability issues. Addressing this challenge would require additional investment to lower prices, but such investment may not be attractive to private companies due to its lack of immediate returns.

Collaborative governance and institutional theory are both observed in the findings. Collaborative governance emphasises the importance of multi-stakeholder engagement and shared decision-making. This can be seen in for example the public majority interest model that is characterised by high levels of communication between heating companies and municipalities that achieve social goals as well during the implementation of district heating networks. This model shows how effective collaboration between two entities can lead to more sustainable and social heating solutions. Institutional theory can also be recognised in the findings. Public majority models, guided by institutional norms of public accountability and social welfare, excel in aligning with municipal sustainability goals but may lack operational ability. On the other side, private-majority models cause innovation and efficiency due to their market-oriented institutional pressures but often struggle with prioritising social norms. These theories underscore the complex interplay between governance structures and institutional norms in shaping the success of district heating initiatives.

The frameworks of Elsman (2024) and Sanders et al. (2016) were instrumental in the establishment of the three main forms of collaboration. Concerning the framework of Sanders et al. (2016), the complexity of the network regime was in all cases high. The private majority cases can be sorted in the ‘private’ subsection. The public cases, however, just like the 50/50 model case, must be sorted in the ‘hybrid’ subgroup as the heat companies are detached from municipalities. The infrastructure is therefore not direct property of the municipalities, which is a condition for the ‘public’ subgroup. In the case of the Elsman (2024) framework, the functional collaboration (left upper in his framework) can be found in the course of events of the private majority interest heat companies. These heat companies were efficient and enhanced sustainability in order to be attractive to customers. Entrepreneurial collaboration (right upper in his framework) can be seen in the public majority cases, but especially in the 50/50 model as it was evident that both parties were innovating their way of collaboration: the municipality, because sustainability goals were getting more attention, and the private company because the regulations (Wcw), institutional framework, were changing.

Practical implications and advice

What has emerged from this research is that all different forms of collaboration have its advantages and disadvantages. In the case of a public majority heat network, communication between heating companies and the municipalities is very tight-knit, which makes it easier to discuss all issues that are affected by implementing a heat network such as social and spatial issues. Heating companies owned

by public parties seem to make an effort of not only providing heat, but also addressing these mentioned issues individually, without the direct help of the municipalities. Private heating networks, on the other hand, have seen efficiency and quick expansion. After this expansion there was room for improving sources and their sustainability to make the networks more attractive for expansion. However, the municipalities explained that they could not have the influence on the policy of the heating company that they wanted. Companies do not collaborate when exploring new options due to insecurity of new legislation and synergy of combining themes was difficult because of planning and communication that was not very tight knit. The 50/50 model depends on a strong agreement on conflict resolution. The municipality has its share to intervene when it is necessary, but the market forces are leading.

Depending on the individual goals of the municipality, one model may be chosen above the other. However, as stated in the conclusion, when considering the main goals in the HTVs of municipalities, it appeared that the public majority interest model achieved municipal goals in the best way.

As has been discussed in this thesis, the Dutch government is in the process of installing the new law on collective heat supply. This law will fundamentally change the forms of collaboration in district heating. Private parties will have a smaller role and public majority interest will be the new standard. However, this research has seen that a public majority interest model has some potential disadvantages. The most important disadvantage being the fact that not all municipalities benefit from a public majority interest model. A public majority interest can be established by one or a few large shareholders, but municipalities with smaller budgets can only afford a small share. A smaller share means unequal decision making within the heating company and potentially causes a lesser benefit of the advantages or even disadvantages of public district heating networks. Therefore, in order to achieve municipal heating goals in the best way, the advice to the Dutch government would be to indeed focus on public district heating networks. However, due to a potentially widening inequality between municipalities through the current intended regulations, it is advised to add the condition to the new law that in case a network covers several municipalities, every municipality must have an equal share in the heating company.

References

5GDHC. (2024). Different generations of DHC. Retrieved from https://5gdhc.eu/different-generations-of-dhc

Abugabbara, M., et al. (2021) 'The Evolution of District Heating and Cooling Networks', Energy, 235, p. 120520. doi: 10.1016/j.energy.2021.120520.

Agrawal, A., & Lemos, M. C. (2007). A greener revolution in the making?: Environmental governance in the 21st century. Environment: Science and Policy for Sustainable Development, 49(5), 36-45.

Almagtome, A. H. (2020) 'An empirical analysis on the influence of factors affecting the quality of auditing using a financial reporting approach: An empirical study in Iraq', International Journal of Mathematical, Engineering and Management Sciences, 5(6), pp. 1039-1050. doi: 10.33889/IJMEMS.2020.5.6.082.

Ansell, C., & Gash, A. (2008). Collaborative Governance in Theory and Practice. Journal of Public Administration Research and Theory, 18(4), 543-571. doi:10.1093/jopart/mum032

Batory, A., & Svensson, S. (2019). The fuzzy concept of collaborative governance: A systematic review of the state of the art. Central European Journal of Public Policy, 13(2), 28-39.

Battilana, J., Leca, B., & Boxenbaum, E. (2009). How actors change institutions: Towards a theory of institutional entrepreneurship. The Academy of Management Annals, 3(1), 65-107.

Bowen, G. (2009). Document analysis as a qualitative research method. Qualitative Research Journal, 9(2), 27-40.

Bryson, J. M., Crosby, B. C., & Stone, M. M. (2006). The Design and Implementation of Cross-Sector Collaborations: Propositions from the Literature. Public Administration Review, 66(s1), 44-55. doi:10.1111/j.1540-6210.2006.00665.x

Clifford, N., Cope, M., Gillespie, T., & French, S. (Eds.). (2016). Key methods in geography. Sage. Danish Energy Agency. (2017). Copenhagen's district heating. Retrieved from Danish Energy Agency.

DiMaggio, P. J., & Powell, W. W. (1983). The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. American Sociological Review, 48(2), 147-160.

Economische Zaken en Klimaat (2016). Energierapport transitie naar duurzaam.

EIB. (2020). The role of PPPs in sustainable infrastructure. European Investment Bank.

Elsman, R. (2024) Organisatiemodellen en samenwerkingsvormen onder de WCW.

Emerson, K., Nabatchi, T., & Balogh, S. (2011). An integrative framework for collaborative governance. Journal of Public Administration Research and Theory, 22(1), 1-29. doi:10.1093/jopart/mur011

European Commission (2024) 5th Generation District Heating and Cooling. Available at: https://5gdhc.eu/ (Accessed: 20 March 2024).

Fabozzi, S., De Luca, G., Vanoli, L.. (2022) 'Fourth generation district heating and cooling', in Sioshansi, F. P. (ed.) Energy, Buildings and the Grid. 1st ed. Elsevier, pp. 63-76. doi: 10.1016/B978-0-12-820625-6.00003-7.

Gavriilidis, K. (2021) Measuring Climate Policy Uncertainty. http://dx.doi.org/10.2139/ssrn.3847388

Grimsey, D., & Lewis, M. K. (2004). Public Private Partnerships: The Worldwide Revolution in Infrastructure Provision and Project Finance. Edward Elgar Publishing.

Hastie, J., Sutrisna, M., & Egbu, C. (2017). Modelling knowledge integration process in early contractor involvement procurement at tender stage - a western Australian case study. Construction Innovation, 17(4), 429-456.

Hennink, M., Hutter, I., & Bailey, A. (2020). Qualitative Research Methods. Sage.

Hodge, G. A., & Greve, C. (2007). PPPs: An International Performance Review. Public Administration Review, 67(3), 545-558.

Jooste, S. F., Levitt, R. E., & Scott, W. R. (2011). Beyond 'One Size Fits All': How Local Conditions Shape PPP-enabling Field Development. Engineering Project Organization Journal, 1(1), 11-25.

Klimaatakkoord. (2019). Klimaatakkoord.

Longhurst, R. (2016). Semi-structured Interviews and Focus Groups. In Clifford, N., Cope, M., Gillespie, T. & French, S. (Ed.), Key Methods in Geography (pp. 143-156). Sage.

Lund, H., Werner, S., Wiltshire, R., Svendsen, S., Thorsen, J.E., Hvelpund, F., Mathiesen, B. (2014) '4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems', Energy, 68, pp. 187-197. doi: 10.1016/j.energy.2014.02.089.

Lund, H. (2021). Different generations of district heating and cooling. doi:10.1016/j.energy.2021.120520

NPLW (2024) Strategieuitvoering: Verhaal Lokale Warmtetransitie. Available at: https://www.nplw.nl/strategieuitvoering/verhaal-lokale-warmtetransitie/default.aspx (Accessed: 2 April 2024).

Nederlandse Vereniging Duurzame Energie. (2024). Warmtenetten in vergelijking met andere warmteoplossingen. Policy document.

Netbeheer Nederland. (2024). Retrieved from https://www.netbeheernederland.nl/sites/default/files/Net_NL_nummer_34_47.pdf

Netherlands Enterprise Agency (RVO) (2024) Verduurzaming Warmtevoorziening: Warmtenetten. Available at: https://www.rvo.nl/onderwerpen/verduurzaming-warmtevoorziening/warmtenetten (Accessed: 19 March 2024).

O'Leary, R., Bingham, L. B., & Gerard, C. (2006) 'Special issue on collaborative public management', Public Administration Review, 66, pp. 1-170.

Onwuegbuzie, A. J., & Leech, N. L. (2010). Generalization practices in qualitative research: A mixed methods case study. Quality & Quantity, 44(5), 881-892.

Ostrom, E. (1990) Governing the commons: The evolution of institutions for collective action. Cambridge: Cambridge University Press.

PBL Netherlands Environmental Assessment Agency. (2023). Sizeable global emission gap in 2050 remains for net-zero pledges. Retrieved from https://www.pbl.nl/en/latest/news/sizeable-global-emission-gap-in-2050-remains-for-net-zero-pledges

Provan, K. G., & Kenis, P. (2008) 'Modes of Network Governance: Structure, Management, and Effectiveness', Journal of Public Administration Research and Theory, 18(2), pp. 229-252.

Pryke, S., Badi, S., Almadhoob, H., Soundararaj, B., & Addyman, S. (2018). Self-organizing networks in complex infrastructure projects. Project Management Journal, 49(2), 18-41.

Rafique, M. M., & Rehman, S. (2023) 'Techno-economic and environmental evaluation of wind energy systems in Saudi Arabia', Energy, 277, p. 128561. doi: 10.1016/j.energy.2023.128561.

Rijkeboer, M. (2022) Fostering innovation in the Dutch construction industry: A comparative qualitative case study of four Dutch circular construction projects.

Rijksoverheid. (2023, November 23). Wetsvoorstel collectieve warmte voor betaalbare en duurzame warmtelevering aan burgers en bedrijven. Retrieved from https://www.rijksoverheid.nl/actueel/nieuws/2023/11/23/wetsvoorstel-collectieve-warmte-voor-betaalbare-en-duurzame-warmtelevering-aan-burgers-en-bedrijven

Rijksoverheid. (2024). Plan kabinet: Meer huizen en gebouwen aansluiten op collectieve warmte. Retrieved from https://www.rijksoverheid.nl/onderwerpen/energie-thuis/plan-kabinet-meer-huizen-en-gebouwen-aansluiten-op-collectieve-warmte

RVO. (2022). Transitievisie warmte en wijkuitvoeringsplan. Retrieved from https://www.rvo.nl/onderwerpen/aardgasvrij/transitievisie-warmte-en-wijkuitvoeringsplan

Sanders, M., Brunnekreef, A., Heldeweg, M. (2016). Sturing van warmtenetten naar een typologie van governance structuren. Retrieved from

https://research.utwente.nl/en/publications/sturing-van-warmtenetten-naar-een-typologie-van-governance-struct

Sanders, M., Brunnekreef, A., Heldeweg, M. (2017). Publiek-private samenwerking bij warmtenetten. Retrieved from https://www.researchgate.net/publication/321853647_Publiek-private_samenwerking_bij_warmtenetten

Schomaker, R. (2020) Institutional quality and private sector participation: theory and empirical findings. Available at: https://hdl.handle.net/10419/217731 (Accessed: 30 March 2024).

Scott, W. R. (2001). Institutions and Organizations. Sage Publications.

Scott, W. R. (2004). Institutional Theory: Contributing to a Theoretical Research Program. In K. G. Smith & M. A. Hitt (Eds.), Great Minds in Management: The Process of Theory Development (pp. 460-484). Oxford University Press.

Siemiatycki, M. (2010). Delivering transportation infrastructure through PPPs: Planning concerns. Journal of the American Planning Association, 76(1), 43-58.

Simons, H. (2009). Evolution and concept of case study research. In Case Study Research in Practice (pp. 12-28). Sage.

Gong, Y., Ma, G., Jiang, Y., Wang, L.. (2023) 'Research progress on the fifth-generation district heating system based on heat pump technology', Journal of Building Engineering, 62, p. 106533. doi: 10.1016/j.jobe.2023.106533.

Verhees, G. (2013). Publiek-private samenwerking: adaptieve planning in theorie en praktijk.

Volkskrant. (2023). Vattenfall trekt stekker uit nieuwe Amsterdamse warmtenetten. Retrieved from https://www.volkskrant.nl/nieuws-achtergrond/vattenfall-trekt-stekker-uit-nieuwe-amsterdamse-warmtenetten

Yin, R. K. (2009). How to do better case studies. In Bickman, L., & Rog, D. J. (Eds.), The SAGE Handbook of Applied Social Research Methods (pp. 254-282). Sage. [Original source: https://studycrumb.com/alphabetizer]

Appendices

Appendix 1:
Coding guide

Code	Strategy used	Description	Code	Summary
Generation of District Heating	Deductive	Sustainability of the specific heat network, relating to a generation of District Heating		
Special Goals	Inductive	Important goals for municipality in the Heat Transition Vision		
Form of public-private collaboration	Deductive	The structure of collaboration between municipality and heating company		
Institutionalism	Deductive	Influence of (in)formal rules on organisation of collaboration. Experience or knowledge present in current civil service.		
Effects of public-private collaboration	Deductive	Notions with regards to collaboration		
Achievement of goals	Deductive	**The gap between expected and experienced output**		
		Collaborating with stakeholders		
		Insulation		
		Affordability		
		Sustainable heat techniques		
		Network reliability		
		Technical matching opportunities		
		Social matching opportunities		
Important		Personal general notions of		

notions		the interviewee		
Important quotes	Inductive	Quotes that could be used in the results		

General notes

Appendix 2:
Intake and progress form

Name:	Sjoerd Duim
Student-number:	s3581896
(optional) phone number:	+31 6 29887995
Master study:	EIP
How much time expected to spend on thesis research per week?	30
Meeting 1: Date:	9-1-24
Status of work:	Discussing research question. Exchanging ideas on the topic of district heating and existing literature.
Meeting 2: Date:	16-1-24
Status of work:	Discussing new ideas on research question after first days of internship at Arcadis.
Meeting 3: Date:	6-2-24
Status of work:	Discussing feedback on research proposal. Methodology and theory could be expanded a little more. Practicalities are clear.
Meeting 4: Date:	25-3-24
Status of work:	New planning was made because of personal circumstances and delay of several weeks. Decided on a new planning and talked about concepts and theoretical framework.
Meeting 5: Date:	11-4-24
Status of work:	Went through interviewguide and ethical underpinnings and privacy of interviewees. Theoretical framework and methodology have to be refined.
Meeting 6: Date:	23-5-24
Status of work:	Interviews completed, transcribing and writing up results have started. Discussions about coding and research ethics.
Meeting 7: Date:	24-6-24

Status of work:	Almost finished. Some discussions about the last feedback. Conceptual framework needed some last editing.

Appendix 3:
Interview guide

Thesis Msc Environmental & Infrastructure Planning
District Heating: Influence of PPP on municipal goal achievement
Sjoerd Duim
Rijksuniversiteit Groningen

Beste deelnemer,

Mijn naam is Sjoerd Duim, ik doe de master Environmental & Infrastructure Planning aan de Rijksuniversiteit Groningen en daarnaast doe ik een afstudeerstage bij Arcadis. Momenteel ben ik bezig met mijn masterscriptie over de invloed van publiek-private samenwerking (pps) op het behalen van gemeentelijke doelen met betrekking tot warmtenetten. Het doel van mijn onderzoek is om inzicht te krijgen in de rol van pps bij de ontwikkeling, implementatie en exploitatie van warmtenetten, evenals de uitdagingen, succesfactoren en mogelijke verbeterpunten die hierbij komen kijken. Met de nieuwe warmtewet in het vooruitzicht is het van belang om te weten welke vormen van samenwerking de meest duurzame oplossingen bieden en welke verhoudingen tussen de overheid en de markt van belang zijn om te behouden of juist aan te passen. Dit onderzoek zal hier duidelijkheid in brengen.

Tijdens dit interview zullen we ingaan op hoe de samenwerking tussen de gemeente en private partijen is verlopen, hoe de verhoudingen zijn vastgelegd en wie welke verantwoordelijkheden droeg in het implementatie- en exploitatieproces. Daarnaast zal ik aan de hand van de Transitievisie Warmte/Warmtevisie en het Wijkuitvoeringsplan de doelstellingen van uw gemeente doornemen en nagaan op welke manier private partijen betrokken zijn geweest en welke invloed dit heeft gehad op het behalen van deze doelstellingen.

Voordat we beginnen met het interview, zou ik u toestemming willen vragen voor het opnemen van dit interview. Na afloop zal ik een transcript sturen en hoor ik graag binnen 5 werkdagen na ontvangst of u akkoord bent met het transcript. De data zal alleen door mij en alleen voor dit onderzoek worden gebruikt. Daarnaast mag u dit interview op elk moment stoppen. Als u een vraag of meerdere vragen niet wilt beantwoorden, mag dat, ook zonder reden te vermelden.

Omdat de data van dit interview traceerbaar is, zal ik u benaderen in het geval ik een quote of andere traceerbare informatie wil gebruiken in de rapportage.

Introductie

1. **Hoe bent u op de positie terechtgekomen waar u nu zit?**
    a. *Wat is uw studieachtergrond?*
    b. *Wat is uw ervaring in het vakgebied?*

2. **Wat is uw positie binnen de organisatie waarbinnen u werkt?**
    a. *Welke werkzaamheden voert u uit?*
    b. *Waar is uw afdeling op dit moment veel mee bezig?*

3. **Op welke manier bent u betrokken bij warmtenetten?**
    a. *Wat zijn uw werkzaamheden met betrekking tot warmtenetten?*

Transitievisie warmte

4. **Hoe is de Warmtevisie opgesteld?**
    a. *Door wie?*
    b. *Aan de hand waarvan?*
5. **Was er al kennis/ervaring met warmtenetten binnen de gemeente?**
    a. *Is er extern kennis en/of advies gevraagd?*
6. **Wat zijn de belangrijkste elementen in de Warmtevisie van uw gemeente?**
    a. *De belangrijkste elementen bestaan uit:*
        i. *Samenwerken met alle betrokkenen*
        ii. *Energiebesparing en isolatie*
        iii. *Betaalbaarheid*
        iv. *Warmtetechnieken zo duurzaam mogelijk*
        v. *Betrouwbaarheid van het net*
        vi. *Technische koppelkansen*
        vii. *Sociale koppelkansen*
7. **Is er een Wijkuitvoeringsplan opgesteld?**
    a. *Wat zijn de belangrijkste punten uit dit plan?*

Warmtenet

8. **Kunt u een beschrijving geven van het warmtenet in kwestie?**
    a. *In welke wijk ligt het net?*
    b. *Hoe ziet de bebouwing er uit in de desbetreffende wijk?*
    c. *Wanneer begon het initiatief?*
    d. *Welke partij nam het initiatief?*
    e. *Welke gemeentelijke afdelingen waren betrokken?*
    f. *Hoeveel aansluitingen waren er beoogd?*
    g. *Hoeveel aansluitingen zijn er inmiddels?*

Publiek private samenwerking

9. **Welke rol heeft de gemeente ingenomen?**
    a. *Vergunningverlener/concessieverlener/eigenaar?*
    b. *Welke onderdelen heeft de gemeente gefinancierd?*
10. **In welke mate is er sprake van publiek-private samenwerking?**
    a. *Welke partijen zijn betrokken geweest in het proces vanaf de initiatieffase tot aan de exploitatiefase?*
        i. *Waarom zijn er partijen afgehaakt/aangehaakt gedurende het proces?*
    b. *Is er sprake van een warmtebedrijf?*
11. **Wie is/zijn eigenaar van het fysieke net?**
        i. *Zijn er aandelen van de gemeente?*
            1. *Wat is het aandeel van de gemeente?*
        ii. *Is hier op enige andere wijze een publiek belang?*
        iii. *Wat waren de afwegingen van de gemeente bij het besluit over eigenaarschap?*
12. **Wie is de warmteleverancier?**
        i. *Zijn er aandelen van de gemeente?*
            1. *Wat is het aandeel van de gemeente?*

ii. *Is hier op enige andere wijze een publiek belang?*
iii. *Wat waren de afwegingen van de gemeente bij het besluit over eigenaarschap?*

13. **Hoe is de publiek-private samenwerking verlopen?**
    a. *Wat is uw algemene gevoel bij het verloop van de samenwerking?*
        i. *Verschilt dit gevoel per fase van het proces?*
    b. *Zijn er botsingen geweest tussen de samenwerkende partijen?*
        i. *Wat was de oorzaak van deze botsingen?*

Behaalde doelen

14. **In welke mate zijn de vooropgestelde doelen uit de Warmtevisie en het Wijkuitvoeringsplan behaald?**
    a. *Op het gebied van:*
        i. *Samenwerken met alle betrokkenen*
        ii. *Energiebesparing en isolatie*
        iii. *Betaalbaarheid*
        iv. *Warmtetechnieken zo duurzaam mogelijk*
        v. *Betrouwbaarheid van het net*
        vi. *Technische koppelkansen*
        vii. *Sociale koppelkansen*
15. **Heeft u het idee dat de vorm van samenwerking invloed heeft gehad op de doelen opgesteld in de Warmtevisie of het Wijkuitvoeringsplan?**
        i. *In welke mate een positieve invloed?*
        ii. *In welke mate een negatieve invloed?*

Ik wil u hartelijk danken voor uw deelname aan dit interview. Ik zal u het transcript via het bij mij bekende mailadres doen toekomen ter beoordeling van de juistheid. Graag ontvang ik binnen 5 dagen bevestiging.

Dit onderzoek zal afgerond zijn tegen het einde van juni. Na beoordeling zal ik het volledige rapport met u delen.

Appendix 4:
Participant information

Beste deelnemer,

Via dit document wil ik u graag informatie geven over het onderzoek waaraan u zult deelnemen. Na een algemene schets heb ik informatie opgenomen over uw rechten als deelnemer. Ik verzoek u vriendelijk om dit te ondertekenen en terug te sturen. Mijn contactgegevens staan hieronder vermeld; aarzel niet om contact met mij op te nemen als u vragen heeft.

Onderzoek
Momenteel ben ik bezig met mijn masterscriptie over de invloed van publiek-private samenwerking (pps) op het behalen van gemeentelijke doelen met betrekking tot warmtenetten. Het doel van mijn onderzoek is om inzicht te krijgen in de rol van pps bij de ontwikkeling, implementatie en exploitatie van warmtenetten, evenals de uitdagingen, succesfactoren en mogelijke verbeterpunten die hierbij komen kijken. Met de nieuwe warmtewet in het vooruitzicht is het van belang om te weten welke vormen van samenwerking de meest duurzame oplossingen bieden en welke verhoudingen tussen de overheid en de markt van belang zijn om te behouden of juist aan te passen. Dit onderzoek zal hier duidelijkheid in brengen.

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Deelnemersinformatie
Allereerst wil ik u bedanken voor uw deelname aan dit onderzoeksproject. Ik ben een onderzoeksmasterstudent aan de Universiteit van Groningen en dit onderzoek vindt plaats als onderdeel van het curriculum van mijn master. Via dit document wil ik u informeren over uw rechten als deelnemer:

- Deelname is altijd vrijwillig.
- U heeft het recht om vragen niet te beantwoorden, het interview op elk moment te beëindigen of vragen te stellen aan de onderzoeker wanneer u maar wilt.
- Het interview wordt opgenomen.
- Citaten uit dit interview worden u toegestuurd ter bevestiging van het gebruik ervan, indien u dat wenst.
- Persoonlijke (identificeerbare) informatie blijft vertrouwelijk; het onderzoek vermeldt slechts uw functie en organisatie.
- De informatie die u verstrekt tijdens het interview zal worden gebruikt voor het onderzoek. Het uiteindelijke resultaat van het onderzoek zal een paper zijn. Deze paper kan worden gepubliceerd op de juiste (academische) kanalen op internet, of worden gebruikt voor artikelen, boeken en/of presentaties binnen academische settingen. Alle gegevens worden geanonimiseerd in het uiteindelijke paper.
- De informatie die wordt verzameld via de interviews kan anoniem worden opgeslagen tot vijf jaar na voltooiing van het onderzoek. Daarna worden alle gegevens permanent verwijderd.

Om er zeker van te zijn dat u uw rechten begrijpt, vraag ik u het volgende te bevestigen:

- Ik heb het informatieblad voor dit onderzoeksproject gelezen en begrepen.
- Ik ben bereid deel te nemen aan dit onderzoek en ik heb het recht om het interview op elk moment te stoppen en om vragen te weigeren.
- Ik begrijp dat mijn deelname aan dit onderzoek geanonimiseerd zal zijn.

- Ik begrijp dat deze gegevens ook kunnen worden gebruikt in artikelen, boeken (hoofdstukken), gepubliceerde en ongepubliceerde werken en presentaties.
- Ik begrijp dat het interview wordt opgenomen en dat de persoonlijke informatie geanonimiseerd zal worden.
- Ik begrijp dat alle informatie die ik verstrek (anoniem) tot vijf jaar na voltooiing van het onderzoek kan worden opgeslagen en daarna zal worden verwijderd.

Gelieve 'Ja' of 'Nee' aan te kruisen voor het volgende:
Ik wil de resultaten van het interview ontvangen ter bevestiging van het gebruik van citaten (Ja / Nee).

“Ik ga akkoord om deel te nemen aan dit interview en ik bevestig dat ik een kopie van het informatie- en toestemmingsformulier heb ontvangen."

Handtekening van de deelnemer/Datum: _____

"Ik ga akkoord met de voorwaarden in het informatieblad en ik zal tijdens mijn onderzoek geen deelnemers schaden."

Handtekening van de onderzoeker/Datum: _____

Vul alstublieft de onderstaande informatie in als u een kopie van de interviewnotities wenst, waarbij u ook het recht heeft om ons het recht te weigeren delen van uw interview te gebruiken.

Adres:

Telefoonnummer:

E-mail:

Nogmaals bedankt voor uw tijd en deelname aan ons onderzoek. Als u vragen of zorgen heeft, aarzel dan niet om contact met mij op te nemen.

Met vriendelijke groet,

Sjoerd Duim

Contactgegevens: