Between Sustainability and Affordability:

Housing Corporations and the Future of District Heating in Amsterdam

An Empirical Analysis of the Capacity of Amsterdam Housing Corporations to Adopt a Proactive Role in the Heating Transition.

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Abstract

This master's thesis explores the capacity of Dutch housing corporations to take on a proactive role in advancing district heating (DH) developments within existing urban areas, amid the Netherlands' national goal of achieving a 49% reduction in CO_2 emissions by 2030. DH networks, particularly fourth-generation systems, are positioned as a key component of the sustainable heating transition (Onencan et al., 2024). However, recent developments, such as the financial withdrawal of private energy companies, mounting cost pressures, and regulatory uncertainties linked to the proposed Collective Heat Act (Wcw), have severely challenged progress. Housing corporations, which own nearly 29% of the national housing stock, are uniquely positioned to facilitate large-scale connections, yet many have withdrawn from DH initiatives due to escalating costs and concerns about affordability.

This study employs a qualitative case study of Amsterdam's housing corporations, combining semi-structured expert interviews with secondary document analysis. Using a capacity-based framework adapted from Kuzemko & Britton (2020), it categorises barriers into six dimensions: responsibility, authority, finance, personnel, knowledge, and energy materialities. The findings reveal that rising costs, market volatility, and a strong dependence on both energy providers and tenant approval result in financial constraints, limited strategic autonomy, and social resistance, all of which significantly hinder housing corporations' ability to participate in DH developments. Notably, tenant consent requirements and concerns over tariff transparency and long-term affordability critically undermine housing corporations' willingness to engage.

To address these barriers, the study identifies potential solutions, including the anticipated effects of new legislation such as the Wcw and the Municipal Instruments for Heating Transition Act (Wgiw), which may strengthen affordability considerations and reduce housing corporations' dependency on other stakeholders. However, it also becomes evident that these legislative measures alone are insufficient. Structural financial compensation, coupled with stronger policy coordination and clearer guidance from various governmental levels, is necessary to revitalise DH development. Political will from public authorities is therefore critical. These solutions are essential not only to re-enable housing corporation involvement but also to ensure that DH development aligns with both environmental goals and social justice. Their implementation carries significant implications for public-private cooperation, requiring institutional reforms and redefined stakeholder roles within the energy governance landscape.

The research contributes to scientific debates on stakeholder roles in urban energy governance, highlighting the underexplored but pivotal role of housing corporations. It identifies a structural mismatch between environmental ambitions and housing corporations' social mandates. The findings offer actionable insights for policymakers and energy providers to co-develop enabling conditions, regulatory clarity, and tenant engagement strategies, that could restore housing corporations' confidence and re-engage them as essential actors in a just and effective heating transition.

Key concepts: district heating, housing corporations, energy transition, urban governance, stakeholder capacity, affordability

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1. Introduction

Across the Netherlands, a thorough heating transition is underway, driven by national policies outlined in the Climate Agreement (Dutch: *Klimaatakkoord*) (Rijksoverheid, 2019). This transition plays a role in achieving the ambitious goal of reducing CO_2 emissions by 49% by 2030 compared to the 1990 levels and the ambition to make approximately 1.5 million buildings gas-free by 2030 (Rijksoverheid, 2019; VNG, 2024a). Heat is an integral part of the broader energy transition, and various solutions are being explored to achieve a sustainable future. One prominent approach, particularly in urban areas, is the implementation of district heating (DH) systems. This method is seen as one of the most efficient ways to transition away from natural gas dependency in urban areas, as Auvinen et al. (2024) state. The Dutch government has set an ambitious target of connecting 2.6 million households to DH networks by 2050, underscoring its commitment to expanding this solution as a cornerstone of the national heat strategy (Ministry of Economic Affairs and Climate, 2022).

However, the development of the DH systems in the Netherlands is becoming increasingly unattractive, particularly for private companies, which currently dominate the construction and operation of these networks. According to Netbeheer Nederland (2019), nearly 90% of all Dutch heating networks are privately owned, with 80% of connections managed by the three largest energy companies (Martínez et al., 2022; Netbeheer Nederland, 2019). Rising installation and operational costs, declining heat demand, labour shortages and greater financial risks have intensified the pressure on these companies. Increased financial risks also stem from uncertainty surrounding the upcoming Collective Heat Act (Dutch: *Wet collectieve warmte*; Wcw). This legislation will eventually require private heating companies to transfer a majority stake in their heating networks to public entities. As a result, financial incentives for private companies to invest in new infrastructure are diminishing, raising concerns about whether they will be able to recover their substantial investment. Consequently, many have halted the development of DH networks in existing areas (Labohm, 2024).

To offset these rising costs, energy companies are shifting the financial burden onto consumers and homeowners, not only through higher connection fees but also through increased monthly fixed charges (Dutch: *vastrecht*) (Opheikens, 2024; Keete, 2024; NOS, 2024a). In Utrecht, homeowners face connection fees of €1,500 to €2,000 for switching from gas to DH systems, while in cities like Rotterdam and Amsterdam, private energy companies have sharply increased both connection prices and fixed charges due to higher contractor, labour, and material costs (Huisman, 2024; Opheikens, 2024; Keete, 2024).

As a result, housing corporations have begun to withdraw from connecting existing homes to newly developed DH networks (NOS, 2024b). These corporations face mounting financial burdens, as they are responsible for paying the connection fees for their properties. These one-time costs fall to property owners and form part of the 'unprofitable top' of such projects. Although subsidies are available from governments to offset these expenses, corporations argue that the funding is still insufficient to cover all associated costs (Hoving, 2023). Van Suylekom (2024) reports that corporations are needing to pay nearly double the subsidy amount, especially when factoring in additional expenses for insulation and property maintenance.

The increase in monthly fixed fees for DH networks by private heating companies has caused frustration among various housing corporations, which are responsible for ensuring affordable living in their properties (Van Zoelen, 2024). These tariff increases burden their tenants, who are already struggling to make ends meet due to limited financial resources (Hoving, 2023; NOS, 2024a). As a result, the housing corporations in Amsterdam announced they would no longer connect their properties to DH systems after energy provider Vattenfall implemented a 30% price increase in the monthly fixed price for DH connecting households (De Koning, 2024; NOS, 2024b). This hike led to serious higher monthly costs for their tenants compared to gas heating, forcing the corporations to prioritise tenant affordability over environmental goals. As a result, housing corporations across the city find themselves unable to guarantee the affordability of DH connections for their tenants and have begun halting further involvement (Opheikens, 2024).

The growing divide between housing corporations and private energy companies poses a challenge to the Dutch heating transition (Koster, 2024; NOS, 2024a). Housing corporations are key players in this transition, owning 28.7% of all Dutch homes as of 2024 (CBS, 2024; Onencan, Ou & De Koning, 2024). Their large-scale property portfolios position them to drive the country's climate goals, like the requirement for all social rental homes to be CO_2-neutral by 2050 (Rijksoverheid, 2019). To meet this target, housing corporations must focus on reducing heat demand through insulation and connecting homes to potential sustainable heating sources like DH networks. Because of the large-scale ownership of housing complexes, they can implement these changes across entire neighbourhoods simultaneously, making their efforts far more impactful than individual homeowners (Koster, 2024; Van Zoelen, 2024). They can, therefore, lead the charge toward the national goal of removing 1.5 million homes from the gas grids by 2030 (Rijksoverheid, 2019).

Despite their critical role, the academic literature on stakeholders in this context is limited, according to Ma et al. (2020). While some studies focus on end-users and their perceptions (Onencan et al., 2024) or on policymakers as leaders and facilitators in these developments (D'Oca, Hong & Langevin, 2018), research on property owners, like housing corporations, remains scarce, despite their decisive role in the energy transition.

Given the pivotal role of housing corporations and the existing knowledge gap, it is relevant to investigate, identify and determine the extent to which housing corporations can contribute to the development of DH networks, as well as the factors that hinder them from assuming this role. While various sources highlight some barriers (Keete, 2024; NOS, 2024b), it is essential to establish a comprehensive understanding of these challenges, given that climate agreements impose strict deadlines and housing corporations play a major role in achieving these ambitions (Firan, 2020). Additionally, it is important to examine what housing corporations require to partially overcome these barriers. Identifying their capabilities and shortcomings will enable the development of solutions. These solutions, in turn, can help stakeholders resume progress and accelerate the energy transition. The urgency of this issue is further underscored by the fact that climate change and its consequences will not wait. Therefore, this research aims to identify how housing corporations can adopt a proactive role in advancing DH developments in existing areas, in light of their recent withdrawal from such initiatives. It investigates the barriers preventing their involvement and the conditions necessary for their re-engagement and meaningful contribution to these projects. This forms the central objective of the study.

Given the apparent lack of knowledge about the role of this specific actor, and the absence of the desired research findings, this study appears to address what Miles (2017) terms a 'knowledge gap'. Alternatively, in the terminology of Müller-Bloch & Kranz (2015), this constitutes a 'knowledge void gap'.

This apparent knowledge gap may be resolved by answering the following research question:

How can housing corporations take on a proactive role in advancing district heating[1] network developments in existing areas?

The central research question is to be answered based on the sequence of the following sub-questions:

1. How can the role of housing corporations in the district heating developments in existing areas be characterised?
2. What factors shape this role of housing corporations in the district heating developments in existing areas?
3. What conditions must be met for housing corporations to adopt a proactive role in district heating developments in existing areas?

1.1 Societal relevance

This research contributes to the growing body of knowledge on the stagnation of DH developments, a trend that risks undermining the progress of the broader energy transition and jeopardising national and international climate targets. By highlighting the urgency of this issue, the study reinforces the need to identify and implement effective solutions to prevent further delays.

Given the pivotal role of housing corporations in the heating transition, a deeper understanding of their motivations, constraints, and decision-making processes is essential. Such insight can enable stakeholders to better anticipate and respond to the needs of housing corporations during the planning and execution of DH projects, and can support the development of more effective and targeted collaboration strategies among stakeholders (Opheikens, 2024). Strengthening these partnerships may not only accelerate DH implementation but also enhance the sustainability of residential areas and ensure equitable access to renewable heating for tenants.

In light of the forthcoming Collective Heat Act (Dutch: *Wet collectieve warmte*; Wcw), this study may offer insights for policymakers. Recognising housing corporations as key actors, often referred to as the 'starting engine' of DH development, requires a nuanced understanding of the conditions under which they can participate proactively. The findings of this research may help inform policy design and adjustments, particularly in relation to affordability, risk distribution, and regulatory certainty, thereby strengthening the alignment between legislative frameworks and the operational realities of housing corporations.

Finally, the study offers relevant guidance for heating companies, whether publicly owned, privately operated, or joint ventures, by elucidating the perceived barriers and conditions under which housing corporations are willing to engage in DH initiatives. These insights can support more adaptive and responsive strategies that foster trust and co-investment, ultimately facilitating a more effective and just heating transition.

1.2 Scientific relevance

This study strengthens the ongoing debate on why the development of DH networks is challenging (Onencan et al., 2024; Yoon, Ma & Rhodes, 2015). It also provides answers to these barriers and contributes to the discussion on which strategies are most suitable for addressing the difficulties associated with DH development (Ma et al., 2020; Köhler et al., 2024). Moreover, it enhances the

[1] district heating will be noticed as DH

understanding of stakeholder capacities and, in doing so, contributes to the scientific community by shedding light on the roles and perspectives of underrepresented stakeholders.

The involvement of stakeholders in DH development and the broader energy transition has been identified by Herreras Martinez et al. (2023) as a critical gap in the literature. They emphasise the necessity of further research to gain a more comprehensive understanding of the perspectives of diverse stakeholders in energy transitions. Similarly, Ma et al. (2020) underscore this point, highlighting a significant lack of literature on stakeholders' participation in DH developments, despite their pivotal role in addressing energy challenges. Colmenar-Santos et al. (2015) address the unequal attention given to various types of barriers. While they note that market failures are well-documented and understood, and that the institutional and financial barriers of stakeholders, despite their "particular relevance to the implementation of energy-efficient technologies" (p. 406), have received considerably less attention and lack adequate empirical support. By addressing the need to explore the role of stakeholders, like housing corporations, and the existence and impact of their encountered barriers, this study contributes to this broader understanding and aims to bridge the evident gaps in existing academic discourse.

Theory specifically addressing housing corporations appears to be scarce. Most studies on stakeholders in DH networks tend to focus on local governments, consumers, or homeowners with commercial motives (Onencan et al., 2024; Devenish & Lockwood, 2024; Upham, Oltra & Boso, 2015; Reda et al., 2021). Organisations primarily engaged in managing and developing social housing, such as housing corporations in the Netherlands, have a distinctive character (Steinhoff, 2024). As this model can be considered unique, it may explain the limited attention given to these stakeholders in DH related literature. This research contributes to broadening the focus on this stakeholder group.

2. Literature Review

This section establishes the theoretical foundation for this research. It begins by exploring the definition and various generations of DH, providing insight into the distinct characteristics of each generation and the extent to which these differences influence the current heating transition. Subsequently, the general role of urban energy governance in the heating transition will be examined, outlining the governance dynamics and the division of roles among the actors involved in this process.

Following this, the conditions crucial for the successful rollout of DH networks and the potential role of housing corporations as a central actor in this process will be examined. To analyse this role, the study adopts a single analytical framework developed by Kuzemko & Britton (2020), which serves as the core methodological foundation. Finally, the conceptual model underpinning this study will be presented, drawing directly from this framework. Together, these components establish the theoretical basis for the research.

2.1 Multi-generational District Heating

DH is a centralised system where heat is generated at a central facility, such as a combined heat and power plant, peak load boiler, or waste incinerator and distributed to multiple buildings through a network of insulated pipes (Yoon et al., 2015; Bush, Bale & Taylor, 2016). These pipes transport hot water or steam to connected buildings, providing heat for space and water heating (Ma et al., 2020). By eliminating the need for individual boilers or heaters in each building, DH efficiently supplies heat from a single source to a variety of users, such as homes, offices and public buildings.

DH systems have evolved over multiple generations, each differing in size, complexity and flexibility (Levihn, 2017). The first generation (1880–1930) utilised steam-based distribution, while the second generation (1930–1980) introduced hot water networks with temperatures exceeding 100°C. The third generation (1980–2020) marked a shift to lower temperatures (below 100°C) and the use of pre-insulated pipes, increasing efficiency and reliability (Lund et al., 2014). However, these generations still relied heavily on fossil fuels and suffered from significant heat losses (Sayegh et al., 2017; Jangsten et al., 2017).

Europe is now primarily deploying fourth-generation district heating (4GDH) systems, designed to phase out fossil fuel dependency and facilitate the integration of multiple renewable and excess heat sources (Lund et al., 2014; Werner, 2017). 4GDH enables efficient thermal storage and operates at significantly lower supply temperatures (around 50°C) with return temperatures as low as 20°C, reducing heat losses and improving system efficiency (Brange et al., 2017; Bush et al., 2016). The economic feasibility of 4GDH is further enhanced by pre-insulated flexible piping, which minimises heat loss by up to 75% (Li & Wang, 2014). This generation provides greater flexibility and efficiency (Buffa et al., 2019), making 4GDH a sustainable solution for heat provision and playing an important role in the energy transition by enabling the integration of geothermal, industrial waste heat, and biomass as heat sources (Onencan et al., 2024; Ma et al., 2020). However, when considering the recent substantial increase in cooling demand, which is projected to nearly triple between 2006 and 2050 (Publications Office of the European Union, 2011), 4GDH proves to be less optimal. In 4GDH, the piping infrastructure is incapable of simultaneously supplying both heating and cooling to buildings (Buffa et al., 2019).

Although fifth-generation district heating and cooling (5GDHC) networks are emerging, they remain in the early stages of development, with several pilot projects currently in operation across Europe (Buffa et al., 2019). 5GDHC systems aim to eliminate nearly all thermal losses by maintaining a distribution temperature close to ambient ground levels and leveraging quasi-infinite indigenous heat sources (Buffa et al., 2019). Moreover, 5GDHC is capable of operating in either heating or cooling mode independently of the network temperature, while also enabling bi-directional and decentralised energy flows; features that provide added value compared to 4GDH. Additionally, another key advantage of 5GDHC lies in its shift from a production-centric to a consumer-centric approach. Traditional DH systems rely on a production-oriented model, where the grid manager is responsible for maintaining adequate differential pressure and supply temperature at each substation. In contrast, future DH systems that incorporate distributed and active substations could transition towards a consumer-centric paradigm (Frederiksen & Werner, 2013). Despite these promising advantages, Buffa et al. (2019) highlight that 5GDHC still requires further research and standardisation before widespread adoption becomes feasible. As Buffa et al. (2019) emphasise, no technical standards or guidelines are currently available, and there remains a lack of knowledge regarding the operational optimisation and control of 5GDHC. Although 5GDHC is gaining traction in certain countries, most DH networks in Europe still range from first- to fourth-generation systems (Munćan et al., 2024). An overview of the generations of DH networks is provided in the following table (see Table 1).

DH networks, particularly third-, fourth- and fifth-generation systems, have significant potential for integrating sustainable energy sources and can thus play a crucial role in the heating transition (Onencan et al., 2024). The heating transition aims to minimise greenhouse gas emissions associated with heat generation and distribution to mitigate climate change (Bogdanov et al., 2021). According to Wissner (2014), DH networks, when connected to sustainable sources, can contribute to reducing CO_2 emissions. Consequently, they are often regarded as an environmentally friendly form of heat supply, as supported by multiple authors (Ma et al., 2020; Jie et al., 2012; Udomsri et al., 2012). Given that approximately 50% of the EU's energy consumption is allocated to heating and cooling, DH systems can contribute significantly to meeting climate and energy targets (Lygnerud et al., 2019). Moreover, they have substantial growth potential. Persson et al. (2014) estimate that 81% of the EU's heat demand is located in regions where industrial activities generate excess heat (Bush et al., 2016). In the Netherlands, DH networks are considered the most economical method for supplying approximately 60–70% of the national demand for low-temperature heat (Vitéz & Lavrijssen, 2020). Furthermore, a study by Battisti, Cozzini & Macii (2016) finds that integrating renewable heat sources into DH systems is among the most cost-effective methods for reducing carbon emissions. As a result, DH networks can make an important contribution to reducing greenhouse gas emissions and thus play a major role in heating transitions.

Table 1: overview of DH generations' characteristics

DH generation	Period of best availability technology	Function	Heat Carrier	Piping	Heat Production
1GDH	1880-1930	Heating only	Steam	In situ insulated steel pipes	Coal steam boilers and some combined heat and power (CHP) plants
2GDH	1930-1980	Heating only	Pressurized hot water >100 °C	In situ insulated steel pipes	Coal and oil-based CHP and some heat-only boilers
3GDH	1980-onwards	Heating only	Pressurized hot water <100 °C	Pre-insulated steel pipes	Large-scale CHP, distributed CHP, biomass and waste, or fossil fuel boilers
4GDH	2014-onwards	Heating only	Low-temperature water 50-70 °C	Pre-insulated flexible (possibly twin) pipes	Renewable and excess heat sources in addition to conventional
5GDHC	2016-onwards	Heating and cooling (bi-directional)	Ambient-temperature water/brine 10-40 °C	Pre-insulated or uninsulated flexible pipes	Low-grade heat sources e.g. local urban waste heat and renewable sources

Source: adapted from Jodeiri, Goldsworthy, Buffa & Cozzini, 2022

2.2 Governing the Heating Transition

To effectively implement and expand DH networks, it is essential to examine how their development takes shape in practice. How are DH systems ultimately established, and what forms of governance are required to ensure their contribution to the broader heating transition? Furthermore, what role does urban governance play in steering these developments? Several scholars have investigated the role of governance in energy transitions. This section reviews the state of the art and explores how urban governance is manifested within the context of the heating transition, as well as how the heating transition itself is governed in practice.

For a general definition of the abstract term 'governance', Bulkeley (2012) adopts the definition by Ruggie (2004), who notes that "governance, at whatever level of social organization it may take place, refers to conducting the public's business—to the constellation of authoritative rules, institutions, and practices by means of which any collectively manages its affairs" (p. 504). Andonova, Betsill & Bulkeley (2009) further elaborate on this and state that governance is defined by the public nature of its goals. It is concerned with conducting the public's business. This does not mean that only public actors are involved, but rather that governance seeks to achieve some form of public good.

This concept appears applicable to the energy transition. Cheung & Oßenbrügge (2020) define the energy transition as "…a political approach to transforming the system that responds explicitly to energy-related goals within the climate change imperative" (p. 2). By referring to energy-related goals within the climate change imperative, they emphasise the pursuit of societal (public) objectives. The authors further add: "In the urban context, this transformation involves negotiations and coordination among multiple actors, as well as their inter-actor relations, in steering energy provision and consumption" (p. 2). This implies that multiple actors are engaged in the process of the energy transition, and that, according to these authors, the transition is fundamentally a process of negotiation and coordination between these stakeholders.

These observations correspond with what Bulkeley & Kern (2006) regard as an additional characteristic of the term governance. They argue that: "governance implies a focus on governing mechanisms which do not rest on recourse to the authority and sanctions of government. Governance […] encompasses forms of governing associated with the state, coordination and co-operation among social and political actors, as well as self-governing mechanisms." (p. 2240). Taken together, these assertions suggest that this multi-actor definition of governance is likely embedded within the structure and functioning of energy transitions. This is confirmed by Morlet & Keirstead (2013), who state that in Europe, "…governance processes are used to ensure the provision of public goods and to address market failures. For urban energy systems, this encompasses the provision of basic energy services and market interventions to address environmental issues like climate change or local air pollution." (p. 853).

Hawkey & Webb (2014) observed that, for decades in Europe, energy services were predominantly provided by the state or in close association with the state. Yet Monstadt (2007) noted that this arrangement has been subject to change, as he argued that the organisation of energy systems in regional monopolies is no longer considered indispensable. "As a consequence of the poor performance of public monopolies—their lack of productive efficiency, their failure to identify consumer demands, and their inertia in socio-technological innovation, the European Commission has been initiating the competitive restructuring of the energy market" (p. 327). This shift led to a wave of liberalisation and privatisation of local and regional energy markets in Europe. Hawkey, Webb & Winskel (2013) align with this view, noting that financial pressures, coupled with political difficulties in adopting market-based tariffs, have driven the privatisation of many energy companies (Ericsson, 2009; Rutherford, 2008). The wave of liberalisation and privatisation across Europe has led governments in the Global North to relinquish authority over energy provision to predominantly private companies (Monstadt & Coutard, 2019).

To retain some measure of influence over the energy transition, public policy has become increasingly reliant on the mobilisation of private capital (Monstadt, 2007). According to Hawkey & Webb (2014), the liberalised energy sector prioritises market competition and seeks short-term cost efficiencies: "Social obligations are limited and policies are oriented to profitable returns on private capital" (p. 1230). This approach, driven by market contracts, price signals and temporary support schemes, appears to have undermined the capacity to develop large-scale systems capable of achieving substantial long-term cost and carbon savings.

The emergence of new governing practices, as Coaffee & Healey (2003) argue, further complicates this landscape. They suggest that it can no longer be assumed that policy-making occurs within stable institutional contexts. Instead, a fragmented and multilayered governance environment has emerged, shaped by the complex interplay between different levels of authority and their interrelations (Bulkeley & Kern, 2006). Monstadt (2007) confirms this by stating that the more shifts take place toward an integrated approach across multiple policy domains and territorial scales, involving diverse private actors, institutional challenges in policy-making are likely to emerge. Cheung & Oßenbrügge (2020) further highlight the increasing role of urban non-state actors in the energy transition, which, according to them, may further complicate the governance landscape. Contemporary transition governance, they argue, is shaped by both state and non-state actors, with governance outcomes determined by varying degrees of consensus-building and conflict among stakeholders. As a result, governments are "…less and less able to claim to regulate all the relevant economic and social relationships in the energy sector within their territories." (Monstadt, 2007, p. 335).

In light of these developments, public authorities aiming to achieve climate and public service objectives must explore alternative governance approaches. This involves a shift toward shaping private infrastructure provision through cooperative, contractual and market-oriented mechanisms. Governments are thus required to rely more on persuasion, negotiation, and coalition-building; leading rather than commanding (Bulkeley & Kern, 2006).

However, the processes of privatisation and liberalisation do not necessarily equate to deregulation or a retreat of public responsibilities. Numerous scholars suggest that these transformations frequently necessitate the reform of state institutions and, in some cases, an expansion of governmental activities (Vringer, De Vries & Visser, 2021; Monstadt, 2007). What has changed are the main tasks of urban and regional policy and the way in which public responsibilities for energy supply are exercised (Monstadt, 2007, p. 340). According to Hoppe & Miedema (2020), these developments have prompted a shift from centrally organised governance that can be referred to as 'network governance'. This governance mode consists of multiple interdependent actors, none of whom is formally subordinate to the others. Instead, governance is facilitated through inter-organisational coordination, enabling a more flexible response to complex societal challenges, including the heating transition.

Yet, these evolving governance arrangements also impose constraints. Governments cannot compel actors to commit to investments in heating transition projects, as participation is largely voluntary (Herreras Martínez et al., 2022). Consequently, successful governance relies on the willingness of multiple stakeholders to collaborate, where non-collaboration or non-compliance with strategic plans can hardly be sanctioned (Monstadt, Pilo & Van Gils, 2025). Hoppe & Miedema (2020) further emphasise that the effectiveness of such governance structures hinges on the extent to which actors trust one another and engage in strategic behaviour to achieve common objectives. This issue is exacerbated by the generally low public acceptance of the heating transition, primarily due to high costs and uncertainties regarding future pricing and cost distribution (Monstadt et al., 2025). These financial and regulatory uncertainties make it difficult to secure actor commitment to energy transition initiatives (Späth & Rohracher, 2015).

The development of DH networks presents distinct governance challenges compared to other energy transitions, primarily due to their strong dependence on local contextual factors and local actor involvement (Hawkey, Webb & Winskel, 2013). Decarbonising heating systems requires much greater direct involvement and political consent of local stakeholders and spatial coordination than electricity transitions (Devenish & Lockwood, 2024). This necessity arises from the inherent characteristics of heating transitions, which must be tailored to local factors, including the energy efficiency of the building stock, building density, the availability of local heat sources, physical conditions of storing and transporting thermal energy, institutional conditions and local energy network configurations (Monstadt et al., 2025; Hawkey et al., 2015; Wade et al., 2022). The governance of urban energy transitions, including DH development, is thus deeply embedded in local institutional and actor-specific configurations.

The involvement of a broad array of stakeholders, and the high level of interdependency among them, combined with their reliance on the local context, introduces substantial governance risks. Since municipal governments lack the authority to enforce mandatory participation in DH projects in several European countries (Martínez et al., 2022; Bulkeley, 2010), the heating transition in these areas largely depends on voluntary cooperation. This reliance on actor willingness makes the transition process particularly vulnerable. The energy transition, therefore, hinges on a fragile balance of motivations, where even minor shifts in commitment can have disproportionate effects on progress (Yoon et al., 2015). This precarious situation may, in turn, foster hesitation and distrust among actors, further reducing their willingness to invest or collaborate. Additionally, given the substantial financial commitments required (such as the high initial costs of DH infrastructure), stakeholders carefully weigh risks before engaging, leaving the transition vulnerable to stagnation (Selvakkumaran, Axelsson & Svensson, 2021).

2.3 Positive Network Externalities

These substantial financial commitments represent a crucial component in the development of DH systems and account for a considerable proportion of the total supply cost. Due to the relatively high initial investments required for DH infrastructure, it is important to consider the principle of positive network externalities, which fundamentally affects the overall feasibility of DH projects. This principle holds that the value of a DH system for each connected user increases as more households and businesses join the network (Karhu et al., 2024). In the context of DH, this principle manifests through three key, interconnected factors: heat density, heat demand and connection rate (Wissner, 2014; Reidhav & Werner, 2008). Consequently, the feasibility of DH, particularly in terms of covering the high initial investments, is closely linked to uncertainties surrounding these factors (Fallahnejad et al., 2018).

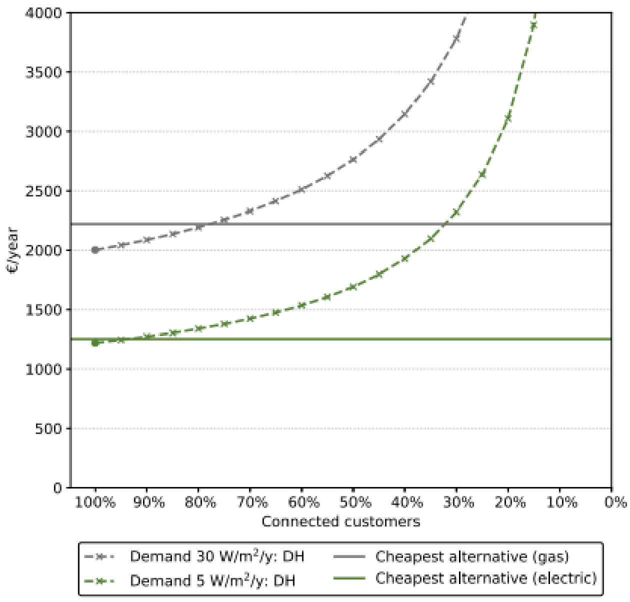
Beyond merely recovering the initial investments, DH must remain competitive with both sustainable individual heating systems (such as heat pumps) and continued reliance on natural gas. To drive the heating transition and ensure consumer adoption, DH must offer clear cost advantages. As Lygnerud (2018) notes, this requires DH pricing to be compelling in comparison to alternatives. Reidhav & Werner (2008) state that "the combination of the connection fee and the level of the price model must be competitive compared to other heating options" (p. 876). However, this competitive pressure, coupled with the high initial investments required, imposes significant constraints on the overall feasibility of DH projects (Reidhav & Werner, 2008).

Gudmundsson, Thorsen & Zhang (2013) challenge the common assumption that DH requires high capital investments. They argue that "it is a common misunderstanding that district heating is an investment expensive technology" (p. 107). In fact, they argue that DH systems may have lower total investment costs compared to decentralised alternatives, though these costs are often borne by a single entity rather than distributed among individual users. This centralisation of investment creates financing challenges, especially in the absence of clear governmental support. Their research demonstrates that DH production costs can be lower than decentralised systems, particularly in areas with high heat density (Gudmundsson et al., 2013).

Reidhav & Werner (2008) affirm the relationship between heat density and competitiveness, stating: "District heating is competitive [...] when the district heat is delivered to areas with high heat densities" (p. 867). They further explain that "profitable district heating presupposes a favourable combination of certain factors. The boundaries of two such factors have been identified [...]: linear heat density and annual use of district heat/house" (p. 876). Hansen, Gudmundsson & Detlefsen (2019) also find that the feasibility of DH depends on the heated square meter per land area and the annual heat demand per square meter, both of which influence network distribution costs. In high-density areas, heat losses and distribution costs can be significantly reduced, improving DH's competitive position. Hendricks et al. (2016) warn, however, that "without a sufficient heat density, [areas] cannot cover the relatively high capital costs associated with the distribution network" (p. 568). This underscores the importance of heat demand and density in determining the cost-efficiency and viability of DH systems.

Nonetheless, when assessing these factors, it is crucial to acknowledge, as Hansen et al. (2019) note, that feasibility studies often assume that DH systems will meet the full heat demand of an area and that all households will connect to the system. In practice, this is rarely achieved. Thus, the actual connection rate must be carefully evaluated (Fallahnejad et al., 2018). Yoon et al. (2015) further stress the significance of connection rates, noting that: "few users opting out already could cause relatively large-scale rises in supply cost within any DH network. Such rises would be borne only by the users in the same supply network. This could in theory lead to a chain reaction of customers' opting out as a result" (p. 80). As Hansen et al. (2019) explain, lower connection rates reduce the system's competitiveness, as fewer customers must shoulder the system's fixed costs and heat losses. Their Danish case study (Figure 1) illustrates how DH competitiveness is directly affected by varying levels of heat demand and connection rates.

Figure 1: Yearly heating cost for a heat demand of 30 W/m²/year and 5 W/m²/year. The percentage of connected customers to the district heating system is varied and compared to the cheapest individual alternative for the heat demand variation. The heating cost of district heating is represented by the dot/x's (dashed lines), while the cheapest individual alternatives is represented by the solid lines. In the figure, the dot/x's should only be compared to the solid lines of the same colour.



Source: Hansen et al. (2019)

Thus, achieving a minimum connection rate is essential for DH project success (Wissner, 2014; Hansen et al., 2019). The interplay of heat density, heat demand, and connection rate forms the basis of positive network externalities. These factors influence affordability and feasibility for both developers and end users (like housing corporations) by ensuring that upfront investments can be recouped (Hendricks et al., 2016; Wissner, 2014). Moreover, they help strengthen the market position of DH, attracting additional connections and creating a positive feedback loop that reduces costs further (Reidhav & Werner, 2008; Fallahnejad et al., 2018).

However, the feasibility of DH is also affected by broader sustainability measures that impact heat demand. Reidhav & Werner (2008) highlight that the introduction of energy conservation measures can affect the cost-efficiency of DH. While these measures are beneficial for building occupants, they challenge the competitiveness of DH. This is because such measures reduce the heat demand of buildings, which in turn lowers the volume of heat sold and limits the extent to which fixed DH system costs can be distributed among users. This undermines affordability (Hansen et al., 2019).

Nonetheless, Reidhav & Werner (2008) also refute the notion that reduced heat demand necessarily undermines DH's competitiveness. They argue that DH can still remain competitive by diversifying its applications within residential buildings, for example by supplying heat for domestic hot water, cooling, or other uses that currently rely on electricity. In addition, Hansen et al. (2019) stress that despite the implementation of energy conservation measures, DH can continue to contribute to ensuring the sustainability of future energy systems.

Also, connection rates, heat demand and heat density are not the sole determinants of DH's cost-efficiency. Hansen et al. (2019) underline that numerous other factors also influence the success of DH and must be considered accordingly. These include labour costs, soil composition, regulations, source availability, financial conditions and weather. According to the authors, these elements equally shape the overall cost-effectiveness of DH systems.

The literature thus convincingly demonstrates that the success of DH projects depends on activating positive network externalities. At the heart of this challenge lies a collective action problem: while investment costs are centralised, the benefits are diffuse. Coordinated efforts are needed to ensure a sufficiently high connection rate (Gudmundsson et al., 2013; Yoon et al., 2015). Although the literature implicitly points to the need for large coordinating actors, there remains a knowledge gap concerning the specific roles and strategic contributions of housing corporations in this process.

2.4 The Role of Housing Corporations in the Heating Transition

The focus on housing corporations as potential large-scale actors is particularly relevant given the crucial role of the entire housing sector in addressing climate challenges. In the European context, the new Green Deal and the ambition to achieve climate neutrality by 2050, with a corresponding reduction in carbon emissions (Lambrechts et al., 2021), place a particular focus on this sector. McManus, Gaterell & Coates (2010) note that, as of 2010, a quarter of total UK emissions stemmed from the energy required to heat, light and operate homes; thus, targeting the housing sector is key to mitigating emissions. Energy efficiency is therefore "at the heart of the European Union's strategy to become a smart, sustainable and inclusive economy that is resource-efficient" (Kumbaroğlu & Madlener, 2012). The EU remains on course to meet half of its target of reducing energy consumption by 20% through efficiency improvements. As nearly 40% of Europe's final energy consumption in 2012 occurred in buildings, the EU's plans recognise that the greatest potential for energy savings lies in this sector and focus on increasing building energy efficiency (p. 327). As discussed in Section 2.1, DH can contribute meaningfully to this objective.

In line with these ambitions for the housing sector, and recognising the importance of positive network externalities to maximise both heat demand and connection rates, housing corporations represent a particularly promising type of organisation that can support DH development (Tigchelaar et al., 2019). "This type of organisation, also referred to as social housing associations or social housing societies, can be described as: 'privately owned, nonprofit organisations executing a public task'." (Lambrechts et al., 2021, p. 1). Housing corporations are primarily tasked with fulfilling an important social and societal role by providing affordable and good-quality housing for vulnerable citizens. Increasingly, however, they are also expected to address environmental challenges by promoting energy efficiency and sustainability in the housing sector (Lambrechts et al., 2021). These organisations hold a significant share of the sector's real estate: in 2014, the 45 national and regional federations within CECODHAS Housing Europe were responsible for managing over 27 million social housing units, accounting for approximately 12% of dwellings in EU member states (Meehan & Bryde, 2014). Upgrading buildings on this scale would substantially contribute to global and regional CO_2 reduction (Lambrechts et al., 2021). Moreover, these large property holders could make DH development financially viable by enabling the simultaneous connection of a large number of buildings, generating sufficient heat demand to facilitate the rollout of DH networks and support the broader energy transition (Tigchelaar et al., 2019). Housing corporations can therefore be key actors in efforts to foster positive network externalities for DH networks and the wider heating transition.

In addition, the implementation of DH can help reduce fuel poverty among vulnerable citizens. According to Bush et al. (2016), "District heating was seen as a solution for improving the living conditions of residents in social housing as well as meeting regulatory requirements for social housing standards. This was seen as a way to reduce the costs of heating and maintenance for residents…" (p. 87). Such outcomes would directly support housing corporations in fulfilling their social mandate to provide affordable housing, particularly given that, for example, in the Netherlands in 2023, around 70% of households experiencing energy poverty were living in social housing (Van Ooij et al., 2023). According to McManus et al. (2010), reducing fuel poverty is therefore considered one of the primary objectives of social housing.

However, the literature also indicates that investments in heating transition or energy efficiency measures are not always progressing swiftly. Lambrechts et al. (2021) suggest that delays in such investments by Dutch housing corporations may stem in part from a split-incentive problem: "a phenomenon whereby the landlord pays for home improvements that benefit the tenant, in terms of reduced energy costs. This has discouraged landlords from investing because they did not benefit personally" (p. 5). This creates a so-called 'investor/user dilemma'. Schleich & Gruber (2008) similarly identify this as a major barrier to energy efficiency in the UK and Ireland, "…not only in private households, but also in commercial as well as in most private and some public services sectors" (p. 461).

Furthermore, as previously discussed, DH networks require relatively high initial investments, a challenge that applies equally to housing corporations due to potentially high connection fees (Yoon et al., 2015). Although such corporations in the Netherlands and the UK are leading efforts to achieve sustainability goals in the housing sector, often ahead of the private sector, they operate under restricted financial means (McManus et al., 2010; Lambrechts et al., 2021). In many cases, housing corporations are not permitted to pass on investment costs through rent increases, as their core mission is to preserve housing affordability and prevent any rise in basic living expenses for tenants, particularly when such increases could place additional financial strain on vulnerable households (McManus et al., 2010; Rijpstra & Blum, 2022). These financial constraints directly affect the capacity of housing corporations to invest in sustainable energy infrastructure and shape the role they are able to play in the heating transition (Roos & Manussen, 2011).

When DH networks are powered by sustainable sources, the supplied temperature tends to be lower than with fossil fuel systems (Schmidt et al., 2017). This may necessitate retrofitting buildings to ensure sufficient heating. Poorly insulated dwellings may require significant renovations to perform effectively under low-temperature DH systems (Ziemele et al., 2018). Wang et al. (2009) recommend measures such as underfloor heating and improved insulation to enhance thermal efficiency, but these upgrades involve high costs. Therefore, housing corporations must not only fund connection fees but also invest in energy-efficiency improvements, further potentially straining their financial capacity (Ma et al., 2020).

Moreover, housing corporations must ensure that their sustainability efforts do not compromise their other core social responsibilities, namely, maintaining and providing affordable housing (McManus et al., 2010). As Oyebanji, Liyanage & Akintoye (2017) observe: "it requires economic means to provide social service or actualise not-for-profit motive in making it available to beneficiaries and putting environmental protection into consideration while taking social housing development decisions" (p. 217). Balancing these social obligations financially is a recognised challenge. De Jong (2019) likewise found that housing corporations view the affordability, availability and sustainability of housing as their three core responsibilities. However, the study emphasises that the first two are generally prioritised, while sustainability is not always treated as a top priority. Consequently, substantial energy renovations should not lead to higher living costs for tenants (Economidou, 2014). For many housing corporations, the assurance that sustainability measures will not increase tenants' living costs is a precondition for undertaking such renovations (Swan, Ruddock & Smith, 2013). Given the high initial investments required for DH networks and the restricted financial resources of housing corporations, it is therefore crucial to examine how corporations can achieve sustainability objectives without undermining housing affordability and availability (De Jong, 2019, p. 21). It is possible that, due to limited financial means or unforeseen cost overruns, housing corporations may ultimately be unable to fulfil their sustainability commitments and may be prevented from adopting a proactive role in the heating transition.

In addition to balancing their core responsibilities, housing corporations also act as representatives of their tenants, who are often drawn from lower socio-economic groups. These corporations are responsible for ensuring that tenants have access to affordable and comfortable housing (Bush et al., 2016). In this capacity, they are also tasked with protecting tenants from unexpected price fluctuations arising from exploitation, discrimination and dynamic inefficiency, which can occur in DH networks (Wissner, 2014). DH systems are typically isolated entities without mutual interconnectivity. Consequently, each DH supplier maintains exclusive control over the distribution and sale of heat within their network, effectively binding housing corporations (and their tenants) to a single provider (Stennikov & Penkovskii, 2020). These vertically integrated systems lock consumers into long-term contracts, eliminating the ability to switch suppliers or opt for alternative heat sources (Onencan et al., 2024; Wissner, 2014; Lavrijssen & Huygen, 2013). As a result, DH networks function as natural monopolies (Vitéz & Lavrijssen, 2020), leaving tenants dependent on a single supplier for their heating needs. This dependency increases tenants' vulnerability to unexpected tariff changes. This means that housing corporations themselves will have little to no influence over the affordability of heat once connected to a DH network. Therefore, when deciding whether to connect to DH systems, they must carefully weigh their role in these heat network developments against the potential loss of control over housing affordability.

In addition, tenants also may experience reduced control over their heating costs, as DH pricing structures typically include a base cost that is only loosely tied to actual heat consumption (Wissner, 2014). This limits potential cost savings even when tenants lower their heat usage. For consumers with low usage, such pricing schemes are often perceived as unfair, since fixed charges may exceed the variable costs associated with actual consumption. This can foster a perception among tenants that they are worse off with DH compared to other heating alternatives (Onencan et al., 2024).

Also, the lack of transparency in DH pricing also intensifies tenant uncertainty, further damaging DH perceptions (Li et al., 2015; Song et al., 2017). Martínez et al. (2022) emphasise that private DH providers often withhold detailed information about revenue models and infrastructure costs. Consequently, there is limited clarity about the investment burden and tariff structures that housing corporations and end-users face. Köhler et al. (2024) define price transparency as the complete and accurate disclosure of market prices. Nevertheless, consumer protection bodies have frequently criticised the DH sector for its opacity. The same authors further emphasise that improving price transparency is essential for building trust and increasing acceptance. Enhanced transparency would not only counteract unjustified assumptions but also facilitate better decision-making among housing corporations and consumers.

These inherent characteristics of DH systems may contribute to negative perceptions among tenants, posing challenges for housing corporations seeking tenant support for DH developments. Such support can be important, and somewhat necessary. In the Netherlands, tenants hold a legal right to consent to renovation projects and similar investments (Jansma, Gosselt & de Jong, 2020). Without an attractive offer from housing corporations, tenants may exercise this right to block various changes to their housing. Such dynamics can significantly limit the role of housing corporations in facilitating DH developments (Roos & Manussen, 2011).

These unjustified, mostly negative, assumptions and perceptions can also lead to social unrest. Kuipers (2018) observes that this unrest can manifest as formal objections to permitting procedures, causing delays and unforeseen costs. Given the complexity of DH implementation, resistance from residents can significantly hinder progress.

Moreover, these negative perceptions may also originate from a lack of trust in the functioning of DH systems. For instance, residents often worry that DH systems may not adequately heat their homes (Van Lidth de Jeude & Midden, 2014). A general mistrust in DH technology persists (Volkova et al., 2018), with many fearing it offers lower comfort levels than gas. Upham & Jones (2012) note that citizens prioritise supply certainty, and perceived reliability risks can trigger resistance. This concern may amplify by the lower operating temperatures of DH systems compared to gas. Onencan et al. (2024) warn that newer DH generations are expected to operate at even lower temperatures, raising doubts about heating adequacy, especially in poorly insulated homes.

These authors further argue that such resistance and negative perceptions is partly due to tenant knowledge gaps. Many residents are unfamiliar with how DH systems function, leading to misconceptions about their efficiency and reliability. Onencan et al. (2024) state that "…for further support, actors need to engage in interventions aimed at enhancing tenant knowledge and understanding of the specifics of the district heating network in their neighbourhood" (p. 828). This aligns with the findings of Qazi et al. (2019), who highlight the crucial role of education and individual risk attitudes in shaping openness to new technologies. Without sufficient information, tenants may perceive DH as an inferior alternative to gas, further deepening resistance. Housing corporations and municipalities have an important role to play in addressing these knowledge gaps. By actively informing tenants about the benefits and functionality of DH, these institutions can help mitigate scepticism and foster social acceptance (Köhler et al., 2024).

In addition to a certain degree of dependence on tenant support, the success of housing corporations in DH developments also hinges on collaboration with other key stakeholders. Local governments play a decisive role, as they establish local energy policies and determine the direction of the heating transition (Yoon et al., 2015). Housing corporations must align themselves with these municipal strategies or risk encountering structural barriers to implementation. Moreover, they are dependent on energy providers, who control and develop the majority of DH networks (Lavrijssen & Vitéz, 2021). This mutual dependence reflects what Hoppe & Miedema (2020) describe as 'network governance' (see Section 2.2), in which multiple interdependent actors jointly shape complex policy domains. Housing corporations therefore operate within a network of interconnected stakeholders, each of whom influences the trajectory and outcomes of the heating transition. If even one of these actors withdraws or refuses to cooperate in the rollout of DH systems, it may significantly undermine the role that housing corporations are able to play in this transition. This is underscored by Köhler et al. (2024), who note: "The transformation and expansion of DH require the support of various stakeholders, whose active involvement and acceptance are critical" (p. 1).

Thus, while involving housing corporations in DH projects offers opportunities to achieve large-scale connections and aggregate heat demand, thereby enhancing the financial viability of DH networks, the mentioned factors may considerably diminish their potential role (Roos & Manussen, 2011).

Despite their apparent role in the energy transition, and although a handful of scholars have acknowledged their contribution, the overall body of research remains disproportionately limited considering the scale of their involvement. Ma et al. (2020) previously highlighted the scarcity of literature concerning stakeholder roles in the rollout of 4GDH, and this observation appears equally applicable to housing corporations. This highlights both the importance and the relevance of this research topic. A clear knowledge gap remains. To address this gap, and to better understand the actual contribution that housing corporations can make to the development of DH, it is essential to examine how the role of actors within the heating transition can be analysed. The following section will explore this issue in greater depth.

2.5 The Capacity Approach: determining the Role of Actors in the Heating Transition

An important question within the context of the energy transition is how actors, such as housing corporations, can pursue sustainable energy or take on a proactive role in advancing DH developments. A key interest lies in whether a scientific, systematic framework exists to assess both the extent to which actors can participate in such transitions and the factors that influence their ability to do so.

Kuzemko & Britton (2020) propose an approach for determining the role of actors in the heating transition; one that emphasises the notion of capacity. Their 'capacity approach' centres on the idea that 'capacity' is a key concept in scholarship on city climate change governance and urban sustainability transitions (p. 1). They argue that capacity fundamentally determines the ability of local actors to pursue sustainable energy objectives; that is, to take on a proactive role in developments such as DH. According to the authors, capacity "…is, essentially, about having access to, and using, the various resources and skills available, whilst recognising that they may change over time" (p. 2).

The emphasis on actor capacity aligns closely with the observations made by Webb, Hawkey & Tingey (2016), who argue that numerous analyses identify a lack of capacity as a major constraint on sustainable action, and a key reason why actual outcomes often fall short of stated ambitions. These authors highlight the need to examine the types and levels of resources and capabilities available to actors in order to assess whether, and how, they can assume a more active role in the heating transition. Such an assessment helps to identify the specific conditions that either enable or constrain actors in adopting a proactive stance in sustainability transitions.

In their article, Kuzemko & Britton (2020) identify six interrelated types of capacity for analysing the sustainable energy capabilities of local governments. These include responsibility, political authority, financial resources, personnel, knowledge, and energy materialities (see Table 2 for detailed interpretations). By defining these six dimensions, the framework offers a nuanced analytical lens to assess the extent to which, and the ways in which, local governments can engage as active participants in the energy transition, despite various contextual constraints. Furthermore, it helps illuminate both the strengths and limitations of these actors, as well as their potential for progress within sustainable energy transitions.

Although the framework defines capacity at a general actor level, its application in Kuzemko & Britton (2020)'s original study is primarily focused on local governments. Their aim is to assess the capacity of these institutions to engage with sustainable energy policy, particularly in relation to their roles within public policy. However, housing corporations, given their legally defined social mandate and their important role in the built environment, may likewise be considered actors operating within the scope of societal policy. These organisations are responsible for making complex decisions and undertaking actions aimed at achieving societal objectives, such as the provision of affordable and sustainable housing (Lambrechts et al., 2021, p. 1; Ministry of Housing & Spatial Planning, 2024). In this regard, they may satisfy the conceptual foundations laid out by Kuzemko & Britton (2020) for analysing actor capacity.

Moreover, the authors themselves indicate that their framework is not confined to the context of local governments. They explicitly suggest that their typology may be relevant "in exploring the capacity of other actors, and actor networks, involved in sustainable energy governance" (Kuzemko & Britton, 2020; p. 8). Earlier in their article, they further reinforce this broader applicability, stating: "Whilst all our cases relate to the English context, our conceptual framework has broader relevance" (p. 7). These remarks support the legitimacy of extending the framework to other actor types, such as housing corporations, particularly those operating in hybrid governance contexts.

Nonetheless, a direct application of the model to housing corporations is limited due to its government-specific terminology. Consequently, an operationalisation of the framework is required in order to adapt its core concepts to the particular context of housing corporations. This operationalisation will be elaborated upon in the following methodology chapter.

Table 2: The six types of capacity relevant to local governments regarding sustainable energy transitions

Capacity	**Description**
Responsibility	Statutory duties; defined administrative authority; often assigned by central government and/or national constitution.
Political authority	Policy discretion; ability to make policy decisions in relation to the locality, rather than contributing to national policy.
Finance	Financial resources; local tax raising abilities; capital assigned from the centre; land.
Personnel	Personal capital; number and quality of staff capable of making and implementing sustainable energy policies.
Knowledge	Experience; access to specific forms of knowledge; sustainable learning and innovation.
Energy materialities	Proximity to energy resources; low carbon energy assets; local infrastructure.

Source: Kuzemko & Britton (2020)

2.6 Conceptual Model

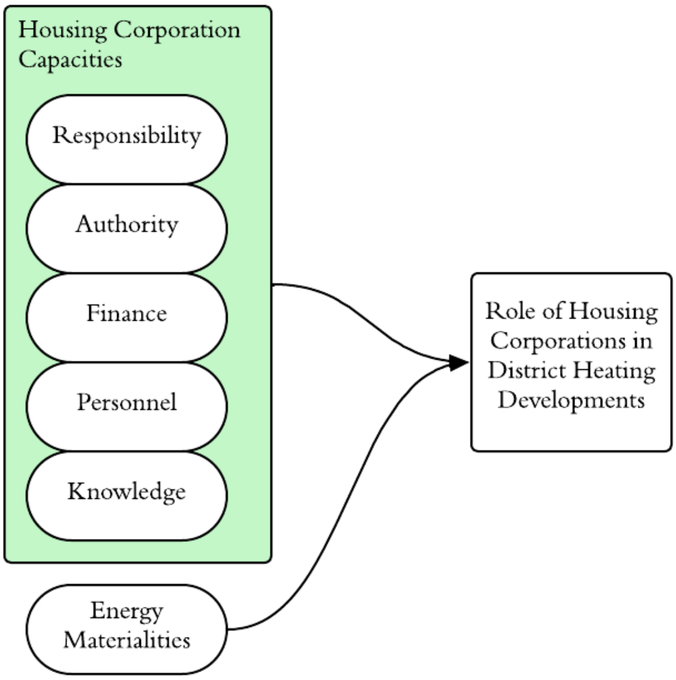
The preceding sections have demonstrated that the successful development of DH networks requires a complex governance model (see Section 2.2), in which overcoming a collective action problem related to network externalities is central (see Section 2.3). The literature implicitly points to the crucial role of large, coordinating actors (such as housing corporations) in addressing this challenge (see Section 2.4). However, in order to understand whether and how housing corporations can effectively fulfil this role within such a complex environment, it is necessary to analyse what resources and capabilities they actually possess (see Section 2.5).

Several factors already identified in the literature have been shown to influence the way homeowners such as housing corporations operate. An analysis of their capacities therefore offers a suitable and in-depth perspective. A capacity-based approach, as proposed by Kuzemko & Britton (2020), enables a systematic investigation of the internal forces and resources that either empower or constrain a housing corporation's ability to act proactively within a web of external dependencies.

Although the reviewed literature does not explicitly address all the capacity types defined by Kuzemko & Britton (2020), particularly the capacities regarding 'personnel' and 'knowledge', these capacities remain essential for a comprehensive analysis. The need for knowledge capacity stems from the technological complexity of DH systems and the importance of accumulated learning in the governance of sustainable energy policies (Kuzemko & Britton, 2020). Likewise, personnel capacity is critical for managing intensive stakeholder engagement and tenant participation processes, as identified in Section 2.4, where the quality and expertise of personnel can have a significant impact (Kuzemko & Britton, 2020). Therefore, incorporating all capacity types into the analysis is essential to fully grasp the model's applicability.

Accordingly, this study adopts a synthesised analytical framework that combines the contextual insights derived from the literature with the categorical structure offered by Kuzemko & Britton (2020). The resulting conceptual model, which serves as a guiding framework for the remainder of this research, is presented below (see Figure 2).

Figure 2: Conceptual Model: Overview of the Relationships Under Analysis



Source: Adapted from Kuzemko & Britton (2020)

3. Methodology

3.1 Operationalisation

In the present study, the analytical framework developed by Kuzemko & Britton (2020) was applied to housing corporations; quasi-public actors operating at the intersection of social responsibility and market-based housing provision. While originally intended for assessing the institutional capacities of local governments, the framework was adapted here to explore the role of housing corporations in the energy transition.

To ensure analytical validity and prevent 'conceptual stretching' (Sartori, 1970), a systematic operationalisation of the six capacities defined in the original model was carried out. The abstract core functions of each capacity were retained, but government-specific terminology and examples were replaced with broader, neutral concepts. This adjustment preserved the conceptual integrity of the framework while making it applicable to other organisational forms. The results of this process are presented in Table 3. These definitions were employed in this research to subsequently determine the potential role of housing corporations in the heating transition.

Table 3: The six types of capacity for local governments and societal actors, relevant to sustainable energy transitions

Capacity	Description (for local governments), according to Kuzemko & Britton (2020)	Generalised Description (for societal actors); adapted from Kuzemko & Britton (2020)
Responsibility	Statutory duties; defined administrative authority; often assigned by central government and/or national constitution.	The formal mandate or tasks assigned to the actor through laws and regulations or by a governing body. This defines the actor's operational scope and obligations in achieving specific societal goals.
Political / Strategic authority	Policy discretion; ability to make policy decisions in relation to the locality, rather than contributing to national policy.	The degree of strategic autonomy the actor possesses. The ability to make independent strategic choices and formulate policies for its own domain, rather than directly contributing to national strategy.
Finance	Financial resources; local tax raising abilities; capital assigned from the centre; land.	The financial resources available to the actor, including its ability to generate revenue, attract investment, and secure subsidies or funding.
Personnel	Personal capital; number and quality of staff capable of making and implementing sustainable energy policies.	The personal capacity of the actor. The quantity and quality of personnel possessing the skills and expertise required to develop and implement sustainable energy strategies and projects.
Knowledge	Experience; access to specific forms of knowledge; sustainable learning and innovation.	Experience; access to specific forms of knowledge; sustainable learning and innovation
Energy materialities	Proximity to energy resources; low carbon energy assets; local infrastructure.	Proximity to energy resources; low carbon energy assets; local infrastructure

Source: Adapted from Kuzemko & Britton (2020)

3.2 Case selection

To examine how housing corporations can adopt a proactive role in DH developments, this study employed a case study approach within a clearly defined context. The selection process followed a set of narrowing criteria designed to ensure both relevance to the research question and feasibility within the research timeframe.

First, the study focused on Dutch housing corporations, as these organisations play a significant role in national energy transition efforts (Lambrechts et al., 2021). Among these, preference was given to corporations that had previously expressed an explicit willingness to engage in DH initiatives, as evidenced by their support of the 'Startmotor Framework' in 2020 (Dutch: *Startmotorkader* ; VNG, 2020).

Second, to minimise policy variation and ensure a more consistent analytical context, the selection was limited to housing corporations operating within a single municipal boundary. In addition, municipalities with multiple active housing corporations were prioritised to allow for cross-organisational comparisons and avoid over-reliance on data from a limited number of actors.

Based on these criteria, the city of Amsterdam was selected as the most suitable case. The city not only met all of the above conditions but also presented a particularly relevant context: its housing corporations had been vocal in publicly distancing themselves from DH developments in recent years. This was formally expressed through their joint platform, the Amsterdam Federation of Housing Corporations (AFWC) (Van Zoelen, 2024). The case's manageable geographical scope also facilitated the collection of in-depth and reliable data within the available research timeframe.

3.3 Data collection

According to Colmenar-Santos et al. (2015), a particular approach to identifying and understanding influencing factors in the field of energy efficiency has gained increasing acceptance among researchers. This approach involves conducting interviews or administering surveys with experts. In this methodology, experts served as key informants, providing researchers with crucial insights to identify, classify and discuss current situations, thereby facilitating the creation of a complete and realistic understanding of specific issues. Since its introduction, conducting interviews had become a widely used research approach in similar contexts. Lygnerud, Fransson & Klugman (2024) corroborated this in their study, which investigated the factors experienced by stakeholders in implementing the use of waste heat. They identified in-depth interviews with experienced stakeholders as the most effective method for acquiring new, context-specific information.

Based on these considerations, this study adopted this method to develop a comprehensive understanding of the role of housing corporations as the selected stakeholder, in the DH developments. Consequently, this study primarily employed a qualitative research methodology. This approach was further supported by Shackleton et al. (2021), who argued that interviews were an appropriate method for generating data and insights into the 'individual dimension', including behaviour and perceptions of individuals and organisations. The interviews took the form of key informant in-depth interviews. According to Shackleton et al. (2021), key informant interviews were used to purposively collect qualitative data from individuals who possessed specific relevance to, or held valuable knowledge for, the study. The interviews were semi-structured to allow for both guided inquiry and flexibility in exploring emergent themes (Bryman, 2016; Legard, Keegan & Ward, 2003). The semi-structured format also allowed the analytical framework of Kuzemko & Britton (2020) to be applied as both a guiding structure and an interview guide. This ensured that all interviewees were asked the same core questions, allowing for the comparison of their responses (see Appendix 1 for the complete interview guide).

Interviewees were drawn from the six major housing corporations in Amsterdam (see Appendix 2). Only corporations serving a broad demographic cross-section were included; those catering exclusively to niche groups (e.g., student or elderly housing) were excluded, as their specialised focus might have limited the generalisability of their perspectives on DH developments. Additional stakeholders were interviewed to triangulate perspectives and validate housing corporations' responses (Olsen, 2004). These included representatives from the municipality of Amsterdam, the energy provider Vattenfall, the Amsterdam Federation of Housing Corporations (AFWC), and a tenants' association affiliated with one of the corporations (see Appendix 2 for a total overview of the interviewees).

In total, ten interviews were conducted. Data collection continued until theoretical saturation was reached, that is, until additional interviews yielded no new insights (Saunders et al., 2018). To mitigate the subjectivity inherent in interview-based research (Shackleton et al., 2021), interview data were cross-validated with secondary sources, including academic literature and a document analysis, focusing on governmental reports, policy documents and council briefings. The relevant data generated through the interviews served to either reinforce or challenge the existing literature, thereby helping to identify inaccuracies and gaps within existing theoretical frameworks. This methodological approach was further supported by Bryman (2016), who noted that such interviews could help to explain or contextualise data obtained from other sources.

3.4 Data analysis

The interview data were analysed using the thematic text analysis method. This method involved identifying themes (also referred to as patterns) within the dataset (Preiser et al., 2021). Themes were identified through a coding process inspired by the approach used in the research of Selvakkumaran et al. (2021). In this process, arguments (whether in the form of situational descriptions, barriers, or proposed solutions) were manually extracted into a spreadsheet. These arguments were categorised according to the analytical model (see Figure 2 & Table 2) and systematically arranged. This structure allowed for the identification of recurring situations and patterns, thereby revealing how the capacities of housing corporations influenced their role in DH developments. The frequency with which an argument was mentioned in the interviews helped determine its significance. To support this analysis, the software NVivo 15 and Microsoft Excel were used. The analytical approach applied in this study combined inductive and deductive methods (Mayring, 2004). This allowed the analytical framework of Kuzemko & Britton (2020), which pre-identified specific themes, to be used deductively, while also permitting an inductive approach to remain open to new insights. In doing so, the framework and existing literature were enriched with context-specific empirical contributions.

3.5 Ethical considerations

Participants were approached through the researchers' personal contacts. After respondents had given their consent, their contact information was shared with the researcher. Respondents were provided in advance with background information about the study and the anticipated interview guide (see Appendix 1). The interviews were conducted and recorded via Microsoft Teams, for which explicit consent was obtained in advance. Respondents were informed that the recordings would be used solely to optimise the transcription process, and that the resulting transcripts would be used exclusively for the analyses within this study. Subsequently, both the recordings and the transcripts were securely deleted and were not used for any other purpose.

To protect confidentiality, participants' responses were anonymised. Instead of personal identifiers, organisational pseudonyms were used in reporting. For example, the representative of the housing corporation Stadgenoot is referred to as 'Stadgenoot's representative' in the results.

This ethical approach enabled participants to share their views freely and without concern, contributing to the richness and reliability of the data collected.

4. Results: District Heating and the Role of Housing Corporations

This section outlines the current context and situation of DH governance in the Netherlands. Providing this background is crucial to understanding the present state of DH developments within which this research is situated, as well as the key drivers that have led to this study. It explains how, and what types of, DH systems are being deployed in the Dutch energy transition, what role DH currently plays in the transition, how this is being shaped by current and emerging government regulations, and what role such regulations play in the development of DH systems.

Subsequently, the role of housing corporations in the Dutch heating transition is addressed. The section elaborates on why and how the role of these corporations has been shaped in a particular way, with a specific focus on institutional contexts unique to the Netherlands.

Finally, attention is directed to the case study that forms the core of this research: the Amsterdam region. This part illustrates the state of DH developments within these geographical boundaries. It outlines the ambitions of various stakeholders operating in this region and explains how these ambitions are being translated into practice, along with the consequences and challenges that arise in the process.

4.1 District Heating Development in the Netherlands

In alignment with various international climate agreements, such as the Paris Agreement and the European Green Deal (UNFCCC, n.d.; European Commission, n.d.), the Netherlands has enacted national legislation and agreements to accelerate its energy transition. Prominent among these are the Climate Act and the Climate Agreement (CBS, n.d.), through which the country aims to achieve specific climate targets. These include a reduction of greenhouse gas emissions by 95% by 2050 compared to 1990 levels, with an intermediate goal of 49% reduction by 2030 (Raad van State, n.d.;

Rijksoverheid, 2019). A central component of this strategy is the energy transition, defined by the Dutch Central Bureau of Statistics as the shift from fossil fuels to renewable energy sources (CBS, n.d.). Within this broader transformation, the heating transition plays a pivotal role (Energievoorelkaar, n.d.), emphasising the need to reduce CO_2 emissions and generate heat from renewable sources. As stipulated in the Climate Agreement, by 2050, approximately 7 million homes and 1 million buildings must be disconnected from the natural gas grid. The first milestone entails the sustainable retrofitting of 1.5 million existing dwellings by 2030 (Energievoorelkaar, n.d.).

Despite these targets, the transition to sustainable heating in the Netherlands remains a significant challenge, as much of the existing building stock is still reliant on natural gas (Vringer et al., 2021). DH has emerged as a key strategy to replace natural gas in urban areas (Onencan et al., 2024; Vringer et al., 2021), especially in densely populated regions. New construction projects are no longer allowed to connect to the gas grid (Martínez et al., 2022), and the Dutch government has set a goal to double the number of DH connections to one million by 2030, up from roughly 515,000 in 2023 (Algemene Rekenkamer, 2025a; 2025b, p. 7).

Currently, about 90% of major DH networks are operated by private companies, with Vattenfall, Eneco, and Ennatuurlijk dominating the market (Algemene Rekenkamer, 2025b; NOS, 2022). To support the integration of renewable energy sources, major DH providers are increasingly investing in fourth-generation DH systems (4GDH) (Landman, 2024; Ennatuurlijk, 2023). As such, the Dutch heating transition is progressively centred on the deployment of 4GDH technologies.

Implementation of the heating transition follows a municipality-led model (VNG, 2025). Municipalities are tasked with identifying neighbourhoods to be disconnected from the gas grid and selecting suitable sustainable alternatives. This must be formalised in a municipal Heat Plan (Dutch: *Warmteprogramma*; formerly known as Heating Transition Visions; *Transitievisie Warmte*). The legal foundation for this responsibility is laid out in the Municipal Instruments for Heating Transition Act (Dutch: *Wet gemeentelijke instrumenten warmtetransitie*, Wgiw), which grants municipalities the authority to designate transition areas and to phase out natural gas delivery. However, this must be done while ensuring affordability and sufficient public participation (VNG, 2024b).

In addition to the Wgiw, the forthcoming Collective Heat Act (Dutch: Wet collectieve warmte, Wcw) is expected to significantly reshape the governance and regulation of DH systems. The Wcw will replace the current gas-indexed price cap with a cost-based tariff model, requiring consumers to pay only for the efficient costs incurred by heat providers (Martínez et al., 2022; Wiebes, 2019). Moreover, the Wcw mandates that at least 50% of DH infrastructure be publicly owned, to ensure democratic accountability and reduce monopolistic risks (Stichting Warmtenetwerk, 2022a; VNG, 2024c).

Whereas the Wgiw governs municipal planning processes, the Wcw defines the market structure and operational conditions for DH systems developed through those processes (VNG, 2024b; VNG, 2024c).

Nonetheless, as Akerboom & Huygen (2021) emphasise, considerable uncertainty remains regarding the timing and final form of the Collective Heat Act. As of early 2025, the legislation is still under development, leaving key stakeholders, including housing corporations, without clarity on its practical implications. Although certain ambitions have been made public, the detailed regulatory framework is still undefined (Herreras Martinez et al., 2023). This regulatory uncertainty hinders decision-making and planning across the sector, as actors remain unclear about the future shape of the DH landscape (Akerboom & Huygen, 2021).

4.2 The Role of Housing Corporations in the Dutch Heating Transition

Housing corporations are an important stakeholder in urban energy governance, particularly in the Netherlands. Onencan et al. (2024) explicitly acknowledge this role of the social housing sector in the Dutch DH development, noting that 75% of the three million rental homes in the Netherlands fall under social housing. This segment constitutes 28.7% of the total housing stock (CBS, 2024), amounting to approximately 2.2 million buildings. In terms of absolute size, the Dutch social housing sector is the third largest in Europe, following the United Kingdom and France (Lambrechts et al., 2021), while in proportion to the total housing market, it is the largest in Europe (Bal et al., 2021). Due to its scale, Bal et al. (2021) argue that the decarbonisation of the existing housing stock cannot be achieved without integrating social housing into sustainability efforts.

In the Netherlands, social housing is primarily owned and managed by housing corporations. These organisations have a clearly defined statutory mandate outlined in the Housing Act (Dutch: *Woningwet*) (Rijksoverheid, n.d.). According to this legislation and its subsequent regulations, housing corporations are tasked with providing affordable and good-quality housing for low-income groups and other vulnerable populations. Their core responsibilities include constructing, renting and maintaining dwellings at affordable rates, without a profit-maximisation objective (Aedes, n.d.). As legal owners of a significant portion of the housing stock, they are responsible for deciding whether their properties are connected to DH networks (De Koning et al., 2020). As such, housing corporations hold considerable decision-making power and have a direct influence on investments toward energy and climate goals within their portfolios. Other stakeholders, including municipalities, therefore depend on the willingness of housing corporations to participate in joint energy strategies.

Given their extensive property portfolios, it is in the interest of national and local governments to involve these corporations in the energy transition and persuade them of the benefits of DH networks. Tigchelaar et al. (2019) indicate that areas with a high concentration of social housing are often prioritised in DH feasibility studies, as housing corporations control a substantial number of potential connections. Whether or not these properties are integrated into a DH network significantly impacts the positive network externalities, and thus the viability of business cases for DH developments (see Section 2.3; Reidhav & Werner, 2008). Consequently, areas with a high proportion of corporately owned housing are frequently considered an effective starting point for DH rollout and are explicitly included in municipal Heating Transition Visions (Dutch: *Transitievisie Warmte*) (Municipality of Amsterdam, 2020). This underscores the pivotal role housing corporations play in the broader heating transition.

Beyond their direct involvement in DH decision-making, housing corporations also fulfil a broader environmental role in the Netherlands. As Lambrechts et al. (2021) note, these organisations are tasked with providing affordable, high-quality housing for vulnerable citizens *and* contribute to sustainability objectives. This includes improving energy efficiency, utilising low-carbon building materials and supporting circular economy initiatives. These ambitions have been formalised in the National Performance Agreements (Dutch: *Nationale Prestatieafspraken*): a cooperative framework between housing corporations, municipalities, central government and tenant organisations (Ministry of Housing & Spatial Planning, 2022). Within this framework, housing corporations have committed to ensuring that the entire social housing stock is carbon-neutral by 2050. More specifically, they are tasked with disconnecting 450,000 existing homes from the gas grid by 2030 and future-proofing another 675,000 rental homes through insulation. Corporations themselves are responsible for selecting which dwellings will be insulated. In practice, a portion of the 450,000 homes scheduled for gas disconnection will also undergo insulation measures, thereby preparing them for DH integration or other low-carbon alternatives. This insulation agenda, especially the focus on reducing heat demand, also aligns with earlier commitments to phase out homes with poor energy ratings (E, F, and G energy labels) (Ministry of Housing & Spatial Planning, 2024). These national agreements reduce the likelihood of project failure due to reluctant parties. Municipalities can no longer develop transition plans without input from housing corporations, and corporations cannot opt out of these municipal strategies. This shared responsibility fosters collaborative governance and mitigates interdependency conflicts (Ministry of Housing & Spatial Planning, 2024; Yoon et al., 2015).

In addition, the 'Startmotor Framework' (Dutch: *Startmotorkader*) was established in 2020 as an agreement between heat providers and housing corporations to accelerate the decarbonisation of 100,000 rental housing, primarily through the connection to DH networks (Aedes, 2020). This agreement is supported by a government subsidy scheme (Hier, 2023), which is designed to ensure that tenants do not face higher energy costs as a result of the transition; specifically, that they will not pay more than they currently do for their gas bills (Boesveld, 2020). The framework thus not only confirms the pivotal role of housing corporations in the development of DH in the Netherlands, but also formally acknowledges them as the 'starting engine' (Dutch: *startmotor*) of this national transition.

However, despite these frameworks, housing corporations are often slow in realising sustainability goals. Lambrechts et al. (2021) attribute this inertia to the aging nature of the housing stock: over a third of social housing units in the Netherlands were built before 1980. These buildings typically suffer from outdated insulation and inefficient heating systems. Bal et al. (2021) similarly note that social housing is often poorly insulated, resulting in excessive heat loss and high energy consumption. This aging infrastructure poses major technical and financial challenges, potentially delaying the heating transition. Yet, as Kammen & Sunter (2016) argue, this inefficiency also presents a major opportunity: retrofitting such dwellings could result in substantial energy savings and reductions in carbon emissions.

As noted in Section 2.4, tenant consent rights can severely hinder the ability of housing corporations to carry out sustainability upgrades, including DH integration (Jansma et al., 2020). These consent rights are particularly salient in the Netherlands when implementing major changes such as DH connections. As the end-users of DH, Dutch tenants can influence DH developments through legal and participatory channels. Dutch civil law (Article 7:220, Paragraph 2 of the Civil Code) stipulates that tenants must receive a 'reasonable' proposal during renovation projects (Aedes, n.d.). According to the law, at least 70% of tenants in buildings with a minimum of ten units must voluntarily approve the proposal for it to be considered 'reasonable'. This gives tenants a strong influence, making their approval a vital component in DH decision-making. As such, tenant attitudes are a major consideration for housing corporations (Onencan et al., 2024). Corporations must invest in fostering support among tenants, often via tenant committees, which are formally recognised entities that represent tenant interests. However, gaining approval from these committees can be particularly challenging (Roos & Manussen, 2011).

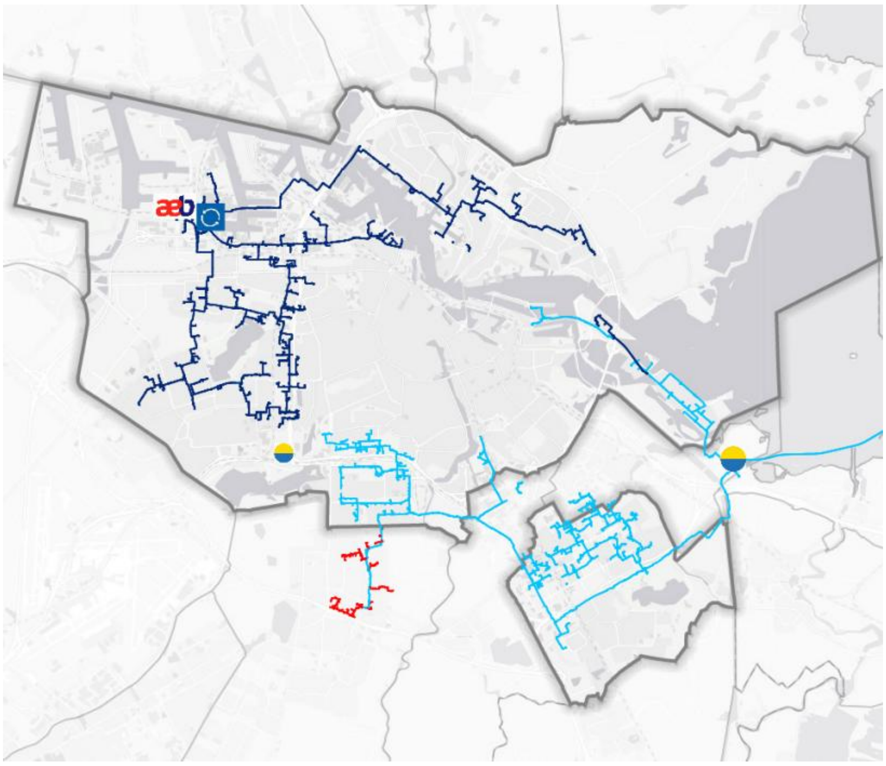
Roos & Manussen (2011) also note that not reaching the 70% threshold does not automatically block a project. If approval falls short, corporations may bring the case before a judge, who can determine whether the proposal is still reasonable. However, pursuing legal routes is often viewed as undesirable due to the negative impact it may have on tenant relations, and because it can delay project timelines. In response, the National Performance Agreements propose legal amendments to simplify this approval process (Ministry of Housing & Spatial Planning, 2022). These include clearer definitions of what constitutes a 'reasonable' proposal and provisions allowing non-responding tenants to be excluded from vote counts. These new measures are only valid under specific conditions (Ekkel, 2024), but aim to reduce the bottleneck effect posed by tenant resistance.

In summary, the large-scale housing portfolios, formalised agreements and strategic imperatives position housing corporations as central actors in the heating transition within the built environment. However, the everyday reality is shaped by the persistent challenges of ageing building stock and complex tenant relations.

4.3 District Heating Development in Amsterdam

For an up-to-date overview of the current state of DH in the municipality of Amsterdam, Figure 3, reproduced from the Heat Transition Vision, has been included. This map shows two major DH networks distributed across the municipality: Vattenfall covering the southeastern districts (light blue) and Westpoort Warmte in the northwestern districts (dark blue). Westpoort Warmte is a joint venture between Vattenfall and the municipality of Amsterdam, with each party owning 50% (Westpoort Warmte, n.d.).

Figure 3: Existing district heating networks in the Municipality of Amsterdam

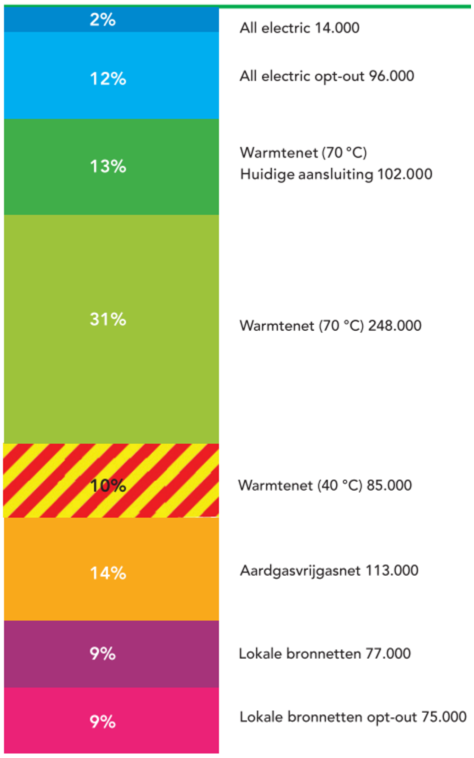


Source: Municipality of Amsterdam (2020)

As of 2025, approximately 85% of Amsterdam's housing stock is still heated by natural gas (Municipality of Amsterdam, n.d.). To meet climate targets, the city and region must reduce CO_2 emissions, switch to clean heat sources and lower overall energy use. The municipal council has set a goal of achieving a 55% reduction in CO_2 emissions by 2030 compared to 1990 levels (Municipality of Amsterdam, 2020). Furthermore, Amsterdam aims to be fully free of natural gas by 2040, ten years ahead of national targets, and to become climate-neutral by 2050. Therefore, the municipality adopted its initial Heat Transition Vision (Dutch: *Transitievisie Warmte*; now referred to as: Heat Plan) in 2020 (Municipality of Amsterdam, n.d.). This document outlines the first steps toward phasing out natural gas in existing buildings, identifying, together with stakeholders, which sustainable alternatives to gas are best suited to different neighbourhoods and dwellings. It also acknowledges the need for comprehensive insulation across Amsterdam to reduce heat demand and enable the transition to clean energy sources (Municipality of Amsterdam, 2020).

The ambitions for DH are substantial. The Heat Transition Vision (now: Heat Plan) targets the transition of just over half (54%) of Amsterdam's homes to DH networks by 2040, approximately 435,000 dwellings (see Figure 4; Municipality of Amsterdam, 2020). Of these, 110,000 homes are expected to be connected by 2030 (Van Zoelen & Wagemakers, 2025). This decision is based on a calculation of the lowest societal cost, with the municipality underscoring that affordability of gas alternatives constitutes a fundamental criterion. According to the Vision, DH delivers greater short-term CO_2 savings than all-electric solutions and offers the lowest long-term risk of continued dependency on fossil fuels (Municipality of Amsterdam, 2020).

Figure 4: Graphical overview of the distribution of heat supply options in the municipality of Amsterdam in dwelling equivalents by 2040, including the projected new housing developments. (Warmtenet = District Heating)



Source: Municipality of Amsterdam (2020)

4.4 The Role of Housing Corporations in Amsterdam's Heating Transition

Housing corporations are vital to achieving these ambitions. Their extensive property holdings, primarily in multi-unit dwellings, make them essential partners in enabling sufficient scale for collective heating solutions (Municipality of Amsterdam, 2020). As of 2024, Amsterdam's housing corporations owned nearly 40% of the city's housing stock; about 192,000 homes (NUL20, 2025). In order to achieve the necessary density and scale to make the infrastructure feasible (Hansen et al., 2019), the housing corporations are particularly well positioned to provide this scale. They often own multiple residential complexes within the same neighbourhood. As a result, areas with a high concentration of social housing and uniform housing typologies are given high priority in the rollout of new DH networks (Municipality of Amsterdam, 2020).

Amsterdam's housing corporations have expressed their support for the city's energy transition through strategic policy documents. Under the 2007 Housing Corporation Governance Code (Dutch: *Governancecode Woningcorporaties*; Aedes, 2025), these organisations are required to define their strategic objectives in light of their social mandate. Most corporations have therefore articulated their ambitions and action plans.

In Appendix 3, a table summarises the energy transition ambitions of the Amsterdam housing corporations, based on their strategic documents, websites and interviews. All corporations share the common goal of making their housing stock independent from natural gas by 2050, in line with the National Performance Agreements (Ministry of Housing & Spatial Planning, 2022). A key condition in this transition is ensuring affordability for tenants. Most corporations prioritise reducing energy demand and preparing homes to be gas-free, primarily through insulation, before selecting an alternative heating source. They regard DH as the most suitable solution for part of their housing stock and therefore do not exclude its use; however, this is contingent on meeting certain key conditions (see Appendix 3).

4.5 'Warm Amsterdam'

Driven by a shared ambition to accelerate the energy transition, an initial partnership was formed between Vattenfall and several housing corporations in Amsterdam (Warm Amsterdam Steering Group, 2024). The collaboration followed a specific rationale: a DH network already existed in Amsterdam, operated by Vattenfall and Westpoort Warmte; housing corporations owned substantial property portfolios and had insight into the condition and energy profile of their buildings. By working together, both parties were able to reduce uncertainties during project implementation, thereby contributing to the expansion of DH. Later, the Municipality of Amsterdam joined the initiative, motivated by its climate goals and the critical role of public subsidies. This collaboration was formalised in 2021 under the name 'Warm Amsterdam' (Municipality of Amsterdam, 2024).

The project's core ambition was to accelerate the energy transition. This could only be achieved, according to the founding partners, through joint ambitions, mutual understanding of each other's interests and adequate financing (AFWC, n.d.). The initiative was guided by key principles: affordability for tenants, a transparent business case among partners, and an area-based approach involving key stakeholders (Municipality of Amsterdam, 2024). These values formed the foundation of 'Warm Amsterdam'. Specific targets were also set: 110,000 homes connected to the DH network within 15 years, including 10,000 by 2027 (Warm Amsterdam Steering Group, 2024). Homes within 200 meters of an existing network were prioritised for early connection (Stichting Warmtenetwerk, 2022b).

However, by 2024, the partnership began to show signs of strain. Although the Municipality of Amsterdam had agreed with Vattenfall in 2021 that the company would remain within the lowest 25% of heat suppliers nationwide in terms of pricing (Schukkink, 2025), the company nevertheless raised its fixed tariffs by 30% that year (Stadszaken, 2025; De Koning, 2024; NOS, 2024b). Shortly thereafter, Vattenfall decided to cease the development of large-scale DH networks for existing buildings, citing unfavourable market conditions. These included declining heat demand due to energy efficiency measures, sharply rising operational costs driven by inflation, and, most notably, the anticipated implementation of the Collective Heat Act (Vattenfall, 2024; Tiekstra, 2024). These developments have increased financial uncertainty for private DH providers. Vattenfall further explained that it no longer sees a viable path to offering competitive DH tariffs to customers transitioning from gas in existing buildings without putting its own financial stability at risk (Vattenfall, 2024). This decision has significant implications for the development of DH in Amsterdam, including the 'Warm Amsterdam' project (Stichting Warmtenetwerk, 2022a). These implications will be further explored in the next section.

5. Discussion: The Capacities of Housing Corporations

This section draws on the interview findings to address the central research questions. The focus lies specifically on the role of Amsterdam's housing corporations in the development of DH systems, not the ideal or intended role discussed earlier, but the role they are currently able to play as of 2025. The analysis identifies both the barriers that prevent these corporations from taking on a more proactive role, as well as the potential solutions discussed with respondents. In particular, the interviews explore how housing corporations might reclaim a more active position in the energy transition and what conditions would need to be met to make this possible.

The analytical framework developed by Kuzemko & Britton (2020) serves as the guiding structure for this section. Its key components are outlined in Table 3 and form the structure of the results section.

5.1 Responsibility

According to Table 3, the concept of responsibility relates to the formal mandate assigned to actors through legislation and regulation enacted by governmental bodies. As outlined in Section 4.2, Dutch housing corporations are tasked with providing affordable housing and contributing to sustainability objectives, as formalised in the National Performance Agreements (Ministry of Housing & Spatial Planning, 2022). Although these agreements address topics such as new construction, affordability, and liveability, they also contain commitments concerning the sustainability of the housing stock. The 2024 version of the Performance Agreements emphasises that housing corporations, in collaboration with governmental bodies, must find solutions to ensure their housing stock is disconnected from natural gas by 2050 (Ministry of Housing & Spatial Planning, 2024).

Although sustainability is highly prioritised, the National Performance Agreements stipulate that housing costs for tenants must remain stable, ensuring that sustainability efforts do not result in increased financial burdens (Ministry of Housing & Spatial Planning, 2024). Initially, a viable business case supported this condition, preserving affordability for both tenants and corporations while even allowing for a modest profit margin for Vattenfall (Policy Advisor for Sustainability, AFWC, interviewed on May 13, 2025). However, a fixed-tariff increase at the end of 2023 made the business case financially unfeasible, with the added costs falling on housing corporations and tenants. According to the AFWC representative (interviewed May 13, 2025), this tariff increase disrupted the economic viability of DH connections. Rochdale's respondent noted that while the variable cost per gigajoule is regulated by the Dutch Authority for Consumers and Markets (Dutch: *Autoriteit Consument en Markt*; ACM), energy companies retain the ability to manipulate the fixed component, which made DH systems unaffordable for tenants (interviewed May 22, 2025). Stadgenoot's respondent confirmed that the unexpected tariff increase dramatically altered the financial outlook (interviewed May 22, 2025), and Ymere's respondent stated that housing corporations had not been informed of the 30% rise in fixed tariffs, a figure that far exceeded the year's 10% inflation rate (interviewed May 21, 2025).

As a result, the affordability of housing came into direct conflict with the sustainability objectives of housing corporations. With affordability no longer guaranteed, a conflict between these dual responsibilities emerged in the 'Warm Amsterdam' initiative. The respondent from housing corporation Alliantie (interviewed June 3, 2025) identified the tension between sustainability and affordability as a central obstacle. Lieven de Key's representative (interviewed June 4, 2025) confirmed this dynamic, and the representative from HYA described the burden of balancing these responsibilities as "immense" (interviewed May 15, 2025).

This conflict is recognised in academic literature. Bush et al. (2016) highlight that the goals of availability, affordability, and sustainability often clash in practice. Onencan et al. (2024) point out that housing corporations frequently express concerns about potential increases in energy costs for tenants when connecting to DH systems, a concern that is substantiated by Upham & Jones (2012), who notes that tenants often feel financially disadvantaged post-connection due to higher heating expenses. Other studies confirm this trend (Van Aalderen et al., 2021).

Nevertheless, multiple respondents asserted that affordable housing remains their core mission. While the energy transition is acknowledged as important, it should not override this primary responsibility. According to the respondent from Stadgenoot, "Moving away from gas is for the planet, not primarily for tenants or ourselves. We have many other, more urgent priorities" (Senior Policy Advisor for Sustainability, interviewed on May 22, 2025). The AFWC respondent added: "Housing corporations have agreed to make their housing stock gas-free and reduce CO_2 emissions, but they are also responsible for offering affordable housing. If the conditions for sustainability do not ensure tenants will not face increased costs, corporations cannot force them off gas. Affordability of heat must be guaranteed to gain support." (Policy Advisor for Existing Buildings and Sustainability, interviewed on May 13, 2025). The respondent concluded that the current prioritisation of affordability outweighs their sustainability mandates. This view is affirmed by the Eigen Haard representative: "Affordability of our properties is paramount, even above the energy transition" (Senior Advisor for Corporate and Portfolio Strategy, interviewed on May 28, 2025). This aligns with McManus et al. (2010), who argue that sustainability efforts should not compromise the other core social responsibilities of housing corporations.

Affordability became a decisive factor in the 'Warm Amsterdam' project. The municipal official admitted this condition could not be met (interviewed on May 15, 2025), and Vattenfall's representative identified unaffordable tenant pricing as the main reason for corporations' withdrawal (interviewed May 23, 2025). While there had originally been a viable business case ensuring affordability for tenants and corporations, the fixed-rate tariff hike at the end of 2023 rendered it financially unviable, according to the AFWC representative (interviewed on May 13, 2025). This ultimately compelled housing corporations to vocally withdraw from collaborative DH efforts, as long as affordability for tenants could not be guaranteed.

Vattenfall's representative stated that connecting existing buildings at scale had become financially unattractive due to high investment costs, which would inevitably raise district heating (DH) expenses for end users (interviewed on May 13, 2025). The municipal representative voiced concerns that the city's most vulnerable residents could ultimately bear the financial burden of the energy transition (interviewed on May 15, 2025). Although Bush et al. (2016) previously framed DH as a strategy to lower heating and maintenance costs and to combat fuel poverty—arguing that UK governments often view the reduction of fuel poverty as a key incentive for DH development—this rationale does not appear to apply in the Amsterdam context, where rising fixed tariffs have undermined affordability. As such, the findings of this study present a strong contradiction to the notion that DH systems inherently lead to cost reductions.

Although housing corporations had promised tenants DH prices comparable to gas (the 'no-more-than-otherwise' principle; Dutch: *Niet Meer Dan Anders*, or NMDA; Chairperson, HYA, interviewed on May 15, 2025), this pledge proved unsustainable when fixed tariffs increased. Corporations had agreed to temporarily compensate for cost differences in fixed charges between gas tariffs and DH tariffs for a period of 5 to 10 years, but these compensations were fixed and did not apply to already connected homes. Once the fixed tariffs rose, the financial burden on corporations made the NMDA principle unworkable (Chairperson, HYA, interviewed on May 15, 2025).

Vattenfall's representative responded by stating that in the 'Warm Amsterdam' agreements (developed as an outcome of the *Startmotorkader* introduced in Section 4.2), housing corporations had committed to covering the landlord's share of the fixed tariff (interviewed on May 13, 2025). However, these agreements were based on early 2023 tariff levels. When tariffs rose in 2024, the compensation owed by corporations became significantly higher than anticipated. Unprepared for this change, they refused to pay the additional compensation. With municipalities and energy companies also unwilling to shoulder the cost, the project was cancelled. The Vattenfall respondent cited this lack of clarity around financial arrangements under shifting market conditions as a decisive factor (interviewed on May 13, 2025).

Additionally, tenants are unable to change energy providers, resulting in dependence on monopolistic suppliers; an issue Stadgenoot's respondent (interviewed on May 22, 2025) identified as a significant disadvantage, which is likewise corroborated in academic literature (Onencan et al., 2024; Wissner, 2014; Lavrijssen & Huygen, 2013). Unlike gas contracts, DH contracts cannot be fixed; they are updated biannually based on current gas prices under the NMDA principle. This volatility, stemming from the close link between DH tariffs and fluctuating gas prices, means that DH users may experience frequent and unpredictable cost changes. While gas customers often benefit from multi-year fixed contracts that shield them from short-term market swings, DH users are typically exposed to semi-annual tariff adjustments (Manager of Business Management, Vattenfall, interviewed on May 13, 2025). Consequently, tenants connected to DH systems face greater financial uncertainty, particularly when gas prices spike, which can result in DH clients paying more than gas users with fixed contracts (Onencan et al., 2024).

This situation further underscores how the monopolistic structure of the DH market, combined with the long-term lock-in to a single energy provider, creates a considerable level of dependence on that provider to offer affordable tariffs (Strategy & Portfolio Manager, Lieven de Key, interviewed on June 4, 2025). Consequently, housing corporations are unable to guarantee affordable living costs for their tenants, as they lack any direct influence over energy pricing. This lack of control undermines their capacity to ensure stable and equitable housing expenses.

Current laws and regulations do not adequately protect tenants from this monopoly power, according to the HYA representative (May 15, 2025). The ACM-regulated tariffs offer insufficient security. Housing corporations also lack direct influence over tariff setting, undermining their ability to guarantee affordability. This lack of regulatory framework for both fixed and variable tariffs allows commercial providers to raise prices unchecked, stalling DH developments (Rochdale's respondent, Coordinator of Programming and Quality, interviewed on May 22, 2025). Corporations should be able to rely on national legislation and ACM tariffs to ensure affordability, according to Lieven de Key's respondent (Strategy & Portfolio Manager, interviewed on June 4, 2025).

The Alliantie's respondent stated that corporations could no longer justify DH connections to tenants or offer acceptable proposals due to price uncertainty (interviewed on June 3, 2025). Corporations feel a duty of care and believe tenants need protection against financial risks. Ymere's representative affirmed that corporations must safeguard tenant interests (interviewed on May 21, 2025). This aligns with Wissner (2014), who asserts that housing corporations must protect tenants from price fluctuations, exploitation, discrimination and inefficiencies in DH networks.

Stadgenoot's participant emphasised that while housing corporations play a crucial role in DH development, they will not do so at any cost (interviewed on May 22, 2025). According to the municipal representative, financial security and affordability are critical preconditions (Programme Manager for Heating in Existing Buildings, interviewed on May 15, 2025). The abrupt increase in fixed tariffs created uncertainty about the future cost trajectory and the monopolies tenants would face after the compensation period. As the respondent noted, "For vulnerable tenants, even a monthly increase of €10–20 can be significant, let alone the larger financial risks we are now facing." This led Lieven de Key to deem it irresponsible to expose tenants to such uncertainties (Lieven de Key's respondent, Strategy & Portfolio Manager, interviewed on June 4, 2025).

Lavrijssen & Vitez (2021) note that long-term cost implications for tenants remain uncertain, raising concerns about how vulnerable groups will be protected during the heating transition. Without guarantees of affordable and stable tariffs, DH is not an attractive option (Rochdale's respondent, Coordinator of Programming and Quality, May 22, 2025). Projects are postponed until tenant financial security can be ensured (AFWC's respondent, Policy Advisor for Existing Buildings and Sustainability, interviewed on May 13, 2025). This tension results in a wait-and-see approach among corporations, as HYA's representative notes: "Almost all corporations in the Randstad have decided to no longer lead and are awaiting clearer conditions" (Chairperson, interviewed on May 15, 2025).

Nevertheless, Rochdale's representative emphasises that housing corporations remain engaged (interviewed on May 22, 2025). They continue to participate in discussions with public actors, conduct feasibility studies, and prepare buildings for future DH connections, even if they remain temporarily gas-fuelled. The municipal representative states that corporations still aim to meet their sustainability targets by prioritising building insulation (interviewed on May 15, 2025). Eigen Haard chose to focus on insulation "because we have 100% control over it. The property side is sacred to us, the transition side far less so" (Senior Advisor for Corporate and Portfolio Strategy, interviewed on May 28, 2025). Corporations are committed to phasing out poorly insulated buildings, as agreed in the National Performance Agreements (Ministry of Housing & Spatial Planning, 2024). They also aim to reduce heat demand, thereby improving indoor comfort (HYA's Chairman, interviewed on May 15, 2025).

Stadgenoot's respondent considers insulation a core responsibility, more so than DH connections, since no other party can perform this task (interview May 22, 2025). HYA's representative affirms that insulation can demonstrably lower tenant energy bills, helping to reduce energy poverty, which HYA regards as "one of the greatest issues in social housing." (Chairman, interviewed May 15, 2025; Van Ooij et al., 2023). Lieven de Key's transition strategy similarly focuses first on insulation, postponing DH connections. They recognise this may weaken Vattenfall's business case, as reduced heat consumption undermines the return on DH investments (Strategy & Portfolio Manager, interviewed on June 4, 2025). This aligns with the argument made in Section 2.3.

Nevertheless, corporations are technically preparing for future DH connections. Eigen Haard installs dummy pipes during renovations, and Rochdale is upgrading radiators for medium-temperature networks, simplifying future connections (Eigen Haard's respondent interviewed on May 28, 2025; Rochdale's respondent interviewed on May 22, 2025). These adjustments make future DH connections technically easier, according to Stadgenoot's respondent (interviewed on May 22, 2025). Housing corporations thus indicate that their role in direct DH connections is largely on hold, but they view this as a temporary situation. According to the Alliantie respondent, corporations are not opposed to DH systems; rather, they still consider them the most viable solution and continue to see potential in their future use (interviewed on June 3, 2025).

In conclusion, the responsibilities of housing corporations can clearly obstruct one another. The increase in fixed tariffs highlights this: the goal of phasing out gas and adopting DH compromises the affordability of housing. This presents a critical bottleneck in DH developments, compelling corporations to prioritise affordability. Yet, corporations continue to fulfil their sustainability responsibilities where they retain full control, notably through insulation and internal system upgrades. However, DH connections will only occur when responsibilities are no longer at odds and affordability for tenants can be guaranteed.

5.2 Authority

Table 3 defines strategic authority as the ability to make independent strategic choices and formulate policies within one's own domain. Housing corporations maintain full autonomy over decisions concerning their property portfolios, including the decision to connect their buildings to a DH network (De Koning et al., 2020). As property managers, they hold the authority to determine how their assets are heated. Ma, Billanes & Kjærgaard (2017) also highlight that, in rental housing, it is the landlords who decide on DH connections, not the tenants. This view is corroborated by the respondent from the Municipality of Amsterdam, who stated that the owner ultimately determines the heating system (Programme Manager for Heating in Existing Buildings, interviewed May 15, 2025). While municipalities can influence preconditions and may, in extreme cases, decide to phase out gas in a neighbourhood, the property owner retains the final say. As such, housing corporations are free to choose the type of heating system to be installed in their complexes.

The respondent from Lieven de Key confirms this authority, noting that housing corporations indeed have a say in DH developments concerning their own property (interviewed on June 4, 2025). The corporation exercised this autonomy when it decided to withdraw from certain collaborations, judging that the energy provider's offer was not sufficiently beneficial for their tenants. They felt empowered to say 'no'. Vattenfall's representative also acknowledges this: "Housing corporations have significant authority over DH developments for their own properties, as evidenced by their decision to withdraw from partnerships." (Manager of Business Management, interviewed on May 13, 2025). The Ymere respondent adds that although housing corporations may sign letters of intent with municipalities and energy providers, these are not legally binding, but rather moral commitments. Withdrawal, such as in the Warm Amsterdam case, carries no legal consequences. No one can require housing corporations to adopt a specific approach (Senior Advisor for Strategy and Policy, Ymere, interviewed on May 21, 2025).

Despite this internal authority, corporations remain highly dependent on energy companies and government actors in DH developments, according to Rochdale. Corporations are not permitted to act as energy suppliers themselves (Acantus case; Rijpstra & Blum, 2022). According to the Alliantie respondent, this means they are bound to the tariffs and terms set by energy companies, without having influence over affordability (interviewed on June 3, 2025). Consequently, they depend on energy companies to offer commercially attractive and affordable proposals, which is now uncertain due to external factors, such as the forthcoming Collective Heat Act (Wcw) and Vattenfall's financial status (Eigen Haard's respondent, interviewed on May 28, 2025).

This aligns with Onencan et al. (2024), who state that if energy companies lack sufficient financial incentives, such as in the case of declining profitability of DH projects, they may withdraw. In these scenarios, housing corporations cannot proceed with DH connections. Their participation is conditional on the attractiveness and affordability of energy companies' offers, both for themselves and their tenants.

While corporations do not seek to become energy providers (Rochdale's Coordinator of Programming and Quality, interviewed on May 22, 2025), they desire greater control over pricing and terms. The recent unilateral increase in fixed tariffs by Vattenfall illustrates that corporations lack bargaining power over commercial entities. Vattenfall's representative confirmed that housing corporations are dependent on the offers provided by energy companies (interviewed on May 13, 2025). If a connection fee is too high, corporations will opt out and pursue alternative solutions. This reflects a functional dependency, where the financial terms set by energy companies are decisive for housing corporation involvement. Rochdale describes this dependency as critical, significantly limiting their proactive role (interviewed on May 22, 2025). Lavrijssen & Vitéz (2021) affirm that this dynamic undermines housing corporations' authority, as they must relinquish part of their decision-making power to a single energy provider over long periods.

Housing corporations are also reliant on governmental actors, such as the Municipality of Amsterdam (Eigen Haard's Senior Advisor for Corporate and Portfolio Strategy, interviewed on May 28, 2025). Municipalities designate neighbourhoods for DH development and define heating transition policies through Heat Plans. This is consistent with Patil, Ajah & Herder (2006), who note that governments essentially decide whether, how, and when DH networks are implemented in specific locations. Housing corporations can only connect to DH networks if the policy allows for it.

The Rochdale respondent stresses that without stronger leadership from municipalities, DH developments stagnate (interviewed on May 22, 2025). Corporations benefit from governments that act as partners, safeguarding affordability and supply security. The Stadgenoot participant confirms the municipality's influence, noting that primary DH agreements are negotiated with them (Senior Policy Advisor for Sustainability, interviewed on May 22, 2025). The municipality also issued key subsidies necessary for DH progress. According to AFWC's respondent: "The actions available to housing corporations are heavily influenced and constrained by government policy and the conditions imposed by energy providers. This leaves corporations 'trapped'." (Policy Advisor, interviewed on May 13, 2025).

Lieven de Key's representative remarked that interdependencies contributed to the decision to withdraw from collaborations (interviewed on June 4, 2025). The complexity arose from conflicting interests across parties, despite each having logical standpoints. For example, while corporations focus on building-level renovations and insulation prior to DH connections, Vattenfall prefers switching entire neighbourhoods simultaneously to maximise return on investment, without waiting for housing corporations' insulation timelines (Vattenfall's Manager of Business Management, interviewed on May 13, 2025). Municipalities, in contrast, adopt a neighbourhood-based view in their Heat Plans. These misaligned approaches created continuous negotiations. Ymere's respondent described this as a difficult aspect of the project, stating that the continuous need to compromise worsened their position. After the tariff increase, a month of negotiations followed, but with insufficient progress. To avoid protracted discussions, corporations exited the project. The fragile business case collapsed (Senior Advisor for Strategy and Policy, Ymere, interviewed on May 21, 2025).

This domino effect, starting with Vattenfall's tariff adjustment, led Lieven de Key to stop persuading tenants to connect, citing the lack of a credible narrative (Strategy & Portfolio Manager, Lieven de Key, interviewed on June 4, 2025). Respondents also confirmed housing corporations' dependency on tenants, as noted in Section 2.4. The Alliantie's respondent emphasised that tenant consent is crucial, if not decisive: "Without 70% tenant approval, corporations can do nothing" (interviewed on June 3, 2025). This severely limits corporate authority. Eigen Haard's representative stated: "If tenants say 'no', the energy transition collapses" (interviewed on May 28, 2025). Without a favourable and affordable offer, corporations cannot obtain tenant approval. According to the respondent from Alliantie, if DH costs exceed gas, there is no case to present. HYA's representative added that tenants view the right to consent as a protective tool and actively use it when dissatisfied (interviewed on June 3, 2025). This supports Devenish & Lockwood (2024), who argue that poor engagement can trigger pushback, suggesting that housing corporations risk encountering opposition if they do not take tenants' concerns seriously.

Lieven de Key's respondent elaborated that when corporations themselves are unconvinced by the offer, they do not initiate discussions with tenants, citing their duty of care (Strategy & Portfolio Manager, Lieven de Key, interviewed on June 4, 2025). The controversy surrounding tariff hikes, tenant scepticism of DH systems, and distrust of Vattenfall meant the necessary tenant support was no longer feasible. Corporations lost confidence.

The Stadgenoot respondent explained that tenants perceived no improvement compared to gas, often experiencing worse conditions (interviewed on May 22, 2025). While DH's sustainability benefits appeal to some tenants, most tenants prioritise different concerns. Rochdale's participant argued that tenants primarily seek the cheapest energy option and are not focused on sustainability, often distrusting Vattenfall (interviewed on May 22, 2025). Ymere's respondent added that tenants fear coercion and lack of alternatives, worsened by media reports and monopoly anxieties (interviewed on May 21, 2025). This aligns with literature stating that DH's monopolistic nature leads to negative tenant perceptions (Wissner, 2014; Lavrijssen & Huygen, 2013). Tenants feel excluded from technical decisions and question their influence.

A major concern for both tenants and corporations is the opaque pricing structure. According to HYA's chairman, "It is highly diffuse, with each supplier defining its own structure," making it difficult for tenants to understand or predict costs (interviewed on May 15, 2025). This prevents corporations from guaranteeing DH will not become more expensive than gas. This argument is consistent with Li et al. (2015) and Song et al. (2017), who note that the lack of transparency in DH pricing also intensifies tenant uncertainty, further damaging DH perceptions. HYA's chairman further reported that tenants hold negative views of DH, citing a Ymere survey in Amsterdam showing 80-90% negative responses (interviewed on May 15, 2025). Negative experiences from other neighbourhoods contributed to poor public perception. Distrust in energy providers and in housing corporations themselves further eroded support. According to Onencan et al. (2024), over 50% of tenants lack trust in housing corporations.

Due to this fragile trust, corporations risked failing to meet the 70% tenant approval threshold, undermining their commitments to energy companies. Stadgenoot's respondent explained that corporations had accepted the risk of achieving this threshold so that energy providers could incorporate it into their business cases (interviewed on May 22, 2025). Failure to secure 70% approval resulted in penalties. According to the Lieven de Key representative, corporations were required to financially compensate energy companies for buildings that did not connect due to insufficient tenant support (interviewed on June 4, 2025). This 'volume risk', as noted by Stadgenoot's respondent, arises because energy providers require connection guarantees to secure DH viability (interviewed on May 22, 2025). This links to the discussion in Section 2.3 regarding the role of connection rates in determining the feasibility of DH (Fallahnejad et al., 2018).

Lieven de Key's Strategy & Portfolio Manager described the resulting conflict: "On one hand, we had to protect tenants; on the other, we had to persuade them to connect, to avoid penalties" (interviewed on June 4, 2025). This meant corporations only committed when sufficient tenant consent seemed likely, delaying grid construction and increasing costs. This risk was exacerbated by the Warm

Amsterdam strategy, which involved mass connections across multiple owners. If one owner failed to gain 70% support, it affected tariffs for others, increasing complexity.

Initial requests for tenant consent encompassed both insulation measures and DH connections simultaneously, as confirmed by the Stadgenoot respondent, which created further risks (Senior Policy Advisor for Sustainability, interviewed on May 22, 2025). Negative publicity surrounding DH endangered insulation efforts. While separating the two could protect insulation goals, it would weaken DH support. Tenants are more likely to approve DH if insulation is included. However, insulation cannot be delayed for DH feasibility, creating a dilemma: early insulation removes a key incentive for later DH support (Strategy & Portfolio Manager, Lieven de Key, June 4, 2025).

In conclusion, the authority of housing corporations in DH development is significantly shaped by their dependence on other actors. Although they retain final control over their property, the behaviour of energy companies, governments and tenants determines whether they can make credible offers and pursue DH as a viable option. This interdependence confirms the mutual dependency discussed in Section 2.2, supporting Hoppe & Miedema's (2020) assertion of a 'network governance' dynamic.

5.3 Finance

In terms of financial capacity and its influence on the role housing corporations can play in DH developments, respondents provided a consistent response. According to Rochdale's respondent, financial resources are often the determining factor for the success of DH projects (interviewed on May 22, 2025). "Money is central," stated Stadgenoot's Senior Policy Advisor for Sustainability (interview on May 22, 2025). Housing corporations operate within strict financial constraints. For Stadgenoot, the principle is that the cost of connecting to a DH network must not exceed the cost of installing a new gas boiler and its maintenance. The amount of the connection fee (Dutch: *Bijdrage Aansluitkosten*; BAK) directly influences whether housing corporations accept a DH connection. This confirms findings by Roos & Manussen (2011), who identify the BAK as a key determinant in corporations' participation in DH developments.

The Alliantie's representative adds that corporations are legally bound by the Dutch Housing Authority's (Dutch: *Autoriteit Wonen*) regulations to not invest more than the cost of a gas boiler system (interviewed on June 3, 2025). This is not merely an internal guideline, but a legal limit that restricts financial flexibility. If investments surpass the equivalent of a boiler system, housing corporations may be excluded from participating in DH projects altogether.

Moreover, according to the respondents from Stadgenoot and the AFWC, housing corporations are not permitted to pass investment costs on to tenants via rent increases (interviewed on May 22, 2025; May 13, 2025). As discussed in Section 2.4 and supported by McManus et al. (2020) and Rijpstra & Blum (2022), social housing providers are obligated to maintain affordable housing. Under the National Performance Agreements, Dutch corporations have committed to ensure that sustainability investments, including DH, are rent-neutral (Ministry of Housing & Spatial Planning, 2024). Thus, all required investments must be covered through internal funds, either rental income or loans. The AFWC representative notes that corporations currently lack sufficient investment capacity to meet all their sustainability targets (interviewed on May 13, 2025). Lieven de Key's respondent also indicates that limited financial resources heavily influence internal decision-making (interviewed on June 4, 2025). The participant from Rochdale concurs, stating that investment limitations force difficult prioritisation decisions (interviewed on May 22, 2025). Stadgenoot's respondent explains, "There is only one budget pot from which all obligations, construction, maintenance, affordability, and sustainability, must be financed” (Senior Policy Advisor for Sustainability, interviewed on May 22, 2025).

Within the framework of affordability, agreements under the *Startmotor* scheme (see Section 4.2) required housing corporations to cover the landlord’s portion of fixed DH tariffs to ensure rent neutrality for tenants. However, the total BAK and tariff compensation must remain below the equivalent cost of a gas boiler (Boesveld, 2020).

Ymere’s respondent stresses that the business case must be viable for the corporation and not come at the expense of tenants or the corporation’s financial health (interviewed on May 21, 2025). In addition to ensuring tenant affordability, DH must also be affordable for corporations themselves. The respondent from the Alliantie describes this balance using a triangle model, which it employs to evaluate heat supply solutions based on three criteria: the investment required from the corporation, the affordability for the tenant, and the degree of sustainability achieved (interviewed on June 3, 2025). Ymere’s respondent argues that the goal of achieving ‘lowest societal cost’, a collaborative concept between municipalities, corporations, and energy companies, fails when housing corporation contributions become too high (Senior Advisor for Strategy and Policy, interviewed on May 21, 2025). If costs escalate, corporations reach their financial limits. According to Ymere’s respondent, financial feasibility directly impacts their proactive role: if the business case is unviable, cooperation ends. This supports findings by Roos & Manussen (2011), who report that connection fees can represent a critical obstacle for housing corporations during the decision-making process.

In the case of ‘Warm Amsterdam’, costs escalated for Vattenfall, according to AFWC’s respondent (interviewed on May 13, 2025). These increases were attributed to infrastructure maintenance, staff shortages, and inflation, which were identified by Eigen Haard’s respondent as external causes (interviewed on May 28, 2025). As compensation to tenants became costlier than expected, corporations were unprepared for the rising financial burden and, unable to pass these on to tenants, lacked the capacity to absorb them. HYA’s representative reports that this financial pressure was the primary reason for corporate withdrawal from the project (interview on May 15, 2025). Ymere’s Senior Advisor for Strategy and Policy confirms: “The fragility of the business case and lack of financial resolution were decisive in our withdrawal” (interview on May 21, 2025).

Vattenfall’s respondent noted that the BAK and housing corporation contributions formed the ‘residual item’ to bridge the funding gap (interviewed on May 13, 2025). In effect, housing corporations were expected to make the DH scheme viable. According to the Ymere representative, repeated cost escalations increased the unprofitable portion of the project, straining corporations’ financial limits (interviewed on May 21, 2025). When the corporate contribution or tenant costs grew too high, Ymere’s respondent concluded that the lowest societal cost target could not be met and exited the collaboration.

The Eigen Haard representative characterised ‘Warm Amsterdam’ as exceptionally vulnerable and complex, unable to withstand cost shocks (interviewed on May 28, 2025). The respondent emphasise that much is expected of housing corporations, yet they remain poorly understood. Despite assumptions of what are perceived, based on market value assessments, as vast capital reserves, housing corporations rent at significantly below market rates and operate with thin margins. While committed to their public mandate, they cannot bear the full financial burden of DH schemes. “The funds we invest come from rent,” noted Eigen Haard’s Senior Advisor for Portfolio Strategy. “Those rents are not particularly high, so it must also be viable for us” (interviewed on May 28, 2025).

Lieven de Key's respondent emphasised that housing corporations should not be responsible for developing, funding, or ensuring the profitability of DH projects (interviewed on June 4, 2025). They oppose carrying the volume risk (see Section 5.2), seeing their role as preparing buildings for connection, not as co-investors sharing usage risk. The Stadgenoot representative echoed this: it is unreasonable for corporations to compensate tenants to cover unprofitable portions of DH (interviewed on May 22, 2025). "Our responsibility is affordable housing, not affordable heat tariffs," the respondent stated. While they contribute to low energy use through measures like insulation, they are not energy suppliers.

According to DH literature, higher heat demand spreads infrastructure costs across more consumers, improving DH cost-competitiveness (Hansen et al., 2019; Guelpa & Verda, 2021; see Section 2.3). Wissner (2014) and Ma et al. (2017) stress the importance of critical mass for economic viability. Theoretically, this positive network externality should reduce BAK and required compensations, making DH more feasible. However, the respondents from the AFWC, the Municipality of Amsterdam, Rochdale and Vattenfall note that 'Warm Amsterdam' aimed for scale to unlock such advantages, but that the scale itself became a liability (interviewed on respectively May 13, 2025; May 15, 2025; May 22, 2025; May 13, 2025). AFWC and Vattenfall's respondents cite high investment costs due to the project's vast scope, with new infrastructure proving too expensive relative to potential benefits; challenging the theory that higher demand lowers per-user costs (Yoon et al., 2015).

Several corporations also cited volume risk as a compounding problem. The scale made actors mutually dependent, heightening this risk. Eigen Haard's representative labelled the project 'megalomaniacal' (interviewed on May 28, 2025).

The Lieven de Key respondent introduced a new perspective, arguing that BAK is only a small portion of total costs (Strategy & Portfolio Manager, interviewed on June 4, 2025). "Construction costs to prepare homes and the additional expenses needed for tenant engagement are far greater than the BAK." Rochdale's respondent partially agrees (interviewed on May 22, 2025), noting that while BAKs are not the main barrier, they are a one-time investment that may be cheaper in the long run than repeated investments in alternatives like heat pumps. This aligns with Yoon et al. (2015), who observe that DH reduces maintenance needs and long-term costs.

Moreover, housing corporations face major insulation obligations under the National Performance Agreements (see Section 4.2; Ministry of Housing and Spatial Planning, 2024), requiring significant financial resources. DH investments come on top of these, and corporations often lack the capacity for both, according to the municipal respondent (interviewed on May 15, 2025). Additional measures, such as insulation, are essential for DH readiness, noted Lieven de Key's respondent (interviewed on June 4, 2025). Given limited investment space, corporations prefer insulation over alternative heating systems, since insulation directly lowers tenants' bills, while alternative systems offer no simple return, according to the Rochdale representative (interviewed on May 22, 2025). Eigen Haard's respondent also highlights the indirect but significant financial impact of insulation (interviewed on May 28, 2025). This confirms Ma et al. (2020), who link insulation obligations to the financial capacity of housing corporations, now validated in the Amsterdam context.

Fortunately, subsidies from the national government and the municipality help make DH projects more feasible for housing corporations. These funds can support DH connections, tariff compensation, and insulation work, according to Eigen Haard's Senior Advisor for Portfolio Strategy (interviewed on May 28, 2025; RVO, 2025a; RVO, 2025b). Still, even with subsidies, the municipal representative admits that a fully viable business case is not always possible (interviewed on May 15, 2025). Despite attempts to buy out fixed tariffs by the municipality, costs often remain higher than gas.

Recently, the national government's influence over housing corporations' financial capacity has become clearer. Besides providing subsidies, it can also hinder them. One major example is the recent social housing rent freeze, which directly impacts corporate finances, according to the Eigen Haard participant (interviewed on May 28, 2025). This policy threatens to push Eigen Haard below the mandatory Interest Cover Ratio (ICR), forcing cuts in maintenance and sustainability programmes. The government, which had previously promised support via the National Performance Agreements, now presents an inconsistent stance that undermines confidence and increases uncertainty around long-term investment. Long-term DH projects cannot withstand such instability, according to Lieven de Key's Strategy & Portfolio Manager (interviewed on June 4, 2025).

In summary, financial capacity, mainly derived from rents, loans, and subsidies, is crucial in determining how proactively housing corporations can engage in DH developments. When that capacity proves insufficient, it justifies withdrawal. In 'Warm Amsterdam', rising costs driven largely by external factors overwhelmed corporations' budgets, forcing withdrawal. Housing corporations maintain that they are property managers, not energy providers, and cannot be expected to finance the gap in DH feasibility.

5.4 Personnel

According to Table 3, personnel capacity refers to the quantity and quality of staff possessing the skills and expertise necessary to develop and implement sustainable energy strategies and projects (Kuzemko & Britton, 2020). However, no literature currently addresses the personnel capacities of housing corporations specifically in the context of pursuing sustainable energy developments such as DH. It remains unclear whether this gap reflects a perceived lack of relevance or represents an underexplored area of research. In either case, the academic understanding of this particular form of capacity remains limited.

Nevertheless, a number of authors provide insight into the personnel capacities required by organisations involved in DH developments. Yoon et al. (2015) note that homeowners benefit from reduced maintenance responsibilities, as DH providers take on the responsibility of system upkeep, thereby ensuring reliability and safety. Accordingly, DH is often considered a low-maintenance technology (Van Lidth de Jeude & Midden, 2014; Ahvenniemi & Klobut, 2014). This suggests that, compared to other heating solutions, DH may require fewer maintenance personnel within the housing corporation. Respondents supported this view. Rochdale's respondent acknowledged that, following the initial investment, DH systems demand less maintenance and reinvestment than hybrid systems or individual boilers (Coordinator of Programming and Quality, interviewed on May 22, 2025). This implies a lower maintenance burden and potentially lower long-term staffing costs for housing corporations, although this remains an assumption and cannot be definitively concluded.

However, Juwet (2020) emphasises that the development of DH systems imposes significant demands on housing corporations, as these organisations must manage the connection process themselves. She explains that connecting buildings to DH entails a wide range of administrative and logistical tasks, including coordinating with construction workers, signing agreements with DH providers, and planning the necessary renovations. For housing corporations, these organisational requirements may serve as barriers to participating in DH projects.

Nevertheless, Stadgenoot's representative indicated that, at present, personnel capacities do not hinder their ability to contribute to DH development (Senior Policy Advisor for Sustainability, interviewed on May 22, 2025). According to the respondent, decisions to connect to DH networks are typically aligned with natural replacement moments, such as when an existing boiler system reaches the end of its life cycle. Their staff are already organised around such moments, meaning personnel capacity does not currently act as a constraint. However, this approach is described by Stadgenoot's respondent as slow. The respondent explained that accelerating the energy transition, outside of these natural moments, would indeed require additional staffing. In the case of 'Warm Amsterdam', upscaling personnel capacity would have been necessary. However, since that collaboration was discontinued, there are no current plans for such upscaling. Instead, projects are assessed individually, following a slower pace, which minimises the immediate impact of personnel limitations.

Ymere's representative confirms this assessment, noting that staffing constraints would only emerge if DH development were to scale significantly (Senior Advisor for Strategy and Policy, interviewed on May 21, 2025). "['Warm Amsterdam'] would have been a major programme in addition to our regular activities, which would have led to staffing issues." The respondent indicated that discussions had been held with the Municipality of Amsterdam regarding workforce training initiatives, although these plans were suspended when the collaboration ceased. Nonetheless, the respondent added, "If the 2050 targets remain in place and annual targets continue to grow without sufficient progress, the labour market shortage will only intensify."

The influence of personnel capacity on the extent to which housing corporations can contribute to DH development thus depends entirely on the scale of the challenge. As the project has now stalled and no large-scale DH development is currently underway, staffing capacity is not an active constraint. However, if large-scale initiatives resume and ambition levels remain high, personnel capacity will become increasingly important in determining the role housing corporations can play. In that case, shortages are likely to emerge and must be addressed. For the time being, no staffing shortage exists, and therefore, no immediate solutions or strategic planning efforts are necessary. As such, the barriers currently preventing housing corporations from adopting a proactive role in DH development do not stem from personnel-related constraints.

5.5 Knowledge

According to Kuzemko & Britton (2020), an organisation's knowledge capacity encompasses experience, access to specific knowledge forms, sustainable learning, and innovation. While academic literature does not explicitly address the knowledge capacity of housing corporations, it is widely acknowledged that sustainable energy transitions heavily depend on accumulated learning (Meadowcroft, 2011). Roos & Manussen (2011) highlight that this is particularly relevant due to the novelty of integrating DH systems into the existing built environment. Although DH has long been used in new developments, retrofitting existing buildings remains relatively uncharted territory. The limited availability of successful examples means that relevant knowledge is still evolving. This unfamiliarity can lead to scepticism and may cause decision-makers, residents, and housing corporations to hesitate or withdraw support (Roos & Manussen, 2011).

However, various housing corporations suggest that knowledge capacity does not currently limit their ability to contribute to DH development. "Housing corporations possess sufficient knowledge and experience to carry out certain tasks independently," stated Eigen Haard's respondent (Senior Advisor for Portfolio Strategy, interviewed on May 28, 2025). This implies that the requisite knowledge and experience are available internally and contribute to cost-effective decision-making. Their limited role is therefore not attributable to a lack of expertise. The respondent from Rochdale echoed this, asserting that housing corporations either possess or have access to the necessary knowledge (interviewed on May 22, 2025). Some have even begun assuming responsibilities traditionally held by energy providers, such as installing internal piping and heat delivery systems, demonstrating robust technical understanding. Additionally, Rochdale's respondent highlighted that Amsterdam-based housing corporations actively exchange and develop knowledge, learning from one another in the process (interviewed on May 22, 2025).

The Ymere representative added that "knowledge and experience do not lead to doubt over whether DH should be pursued, but rather over how it should be implemented," citing continued uncertainty regarding the timing of DH network development and viable business cases (Senior Advisor for Strategy and Policy, interviewed on May 21, 2025). Stadgenoot's respondent similarly noted that "knowledge and experience related to connecting existing buildings to DH are accumulating rapidly," although they are currently gaining such experience only on a small scale (Senior Policy Advisor for Sustainability, interviewed on May 22, 2025).

In sum, while DH development in existing housing remains a relatively new endeavour, the necessary knowledge and expertise are already in place among housing corporations. Although uncertainty persists regarding the best way to retrofit existing properties, this has not hindered their potential role in DH development. Consequently, there is no pressing need to develop strategies or identify conditions that would enable these organisations to assume a more proactive role. The barriers preventing housing corporations from doing so do not lie in their knowledge capacity.

5.6 Energy Materialities

One key characteristic within this category is the proximity of an energy source (Kuzemko & Britton, 2020), which proves particularly important in the pursuit of DH developments. According to Lygnerud, Wheatcroft & Wynn (2019), DH projects situated close to sustainable heat sources, such as industrial waste heat, are significantly more viable in terms of both cost-efficiency and overall feasibility. Without a nearby heat source, or when the distance to such a source becomes economically unfeasible, the development of DH systems becomes nearly impossible. This not only restricts the potential for housing corporations to engage in the sustainable energy transition but also hinders broader sustainable energy governance. However, according to the Vattenfall representative, a lack of heat sources, or a lack of nearby sources, is not a limiting factor in the areas where the company is active in Amsterdam; there are sufficient heat sources available (Manager of Business Management, interview on May 13, 2025). This suggests that the argument that DH developments are rendered unviable due to a lack of local heat supply does not hold for the Amsterdam region.

Another important characteristic relates to the presence of existing heating infrastructure (Kuzemko & Britton, 2020). In the Netherlands, a large-scale gas network was established by the state to provide nationwide heating access (Bertelsen, Paardekooper & Mathiesen, 2021). Roos & Manussen (2011) confirm that many residents and homeowners remain 'locked-in' to gas-based heating systems due to a lack of incentives to switch. The entrenched nature of gas infrastructure fosters continued consumer confidence, while the residual value of this infrastructure forms a barrier to adopting alternative heating technologies (Stein, 2017). Salet (2018) characterises this as a form of path dependency, where established systems persist through self-reinforcing mechanisms that inhibit the adoption of new approaches.

However, respondents indicated that although in-home gas infrastructure may still hold some residual value and plays a role in financial calculations, it is not a primary reason for retaining gas-based heating, according to Eigen Haard's Senior Advisor for Portfolio Strategy (interviewed on May 28, 2025). Boiler systems must be replaced at some point regardless. These future write-off costs are already factored into the financial assessment of DH connection, because, as noted by the same respondent from Eigen Haard, "homes must eventually be made gas-free." In cases where boilers were recently installed, their value is offset or compensated elsewhere. Therefore, the value of existing gas infrastructure does not serve as a decisive factor for housing corporations, nor for the Municipality of Amsterdam, in determining whether or not to pursue DH connections. They do, however, take into account natural replacement moments, such as the expiration of a boiler's lifespan. Some corporations are even considering the early removal and reuse of existing boilers elsewhere, according to the municipal representative (Programme Manager for Heating, interviewed on May 15, 2025). For Eigen Haard, the primary goal is to rent out homes over the long term and ensure that the housing stock is upgraded to meet current standards (Senior Advisor for Portfolio Strategy, Eigen Haard, interviewed on May 28, 2025). "This means the financial value of existing infrastructure is weighed against the long-term obligation to become gas-free," the respondent stated. Consequently, the value of gas infrastructure does not significantly influence housing corporations' engagement in DH developments.

The influence of energy materialities on the role that housing corporations can play in DH development is thus limited, if not entirely absent. There is no shortage of heat sources, and path dependency tied to the value of existing gas infrastructure does not hinder these organisations from connecting to DH systems. Therefore, energy materialities do not constitute a barrier, and there is no need to revise the existing material context through new strategies or conditions to enhance the role of housing corporations in DH development.

5.7 Solution-Oriented Perspectives

This section outlines the solutions identified by respondents as capable of addressing the recognised barriers facing housing corporations in DH developments.

A key solution repeatedly mentioned is the forthcoming Collective Heat Act (Wcw). According to respondents, the Wcw may help secure the affordability of DH to some extent. For example, Vattenfall's representative noted that the law could enable a more equitable distribution of costs, ensuring that residents who opt for the societally cheapest heating alternative also benefit financially (Manager of Business Management, interviewed on May 13, 2025). Respondents from the AFWC and Stadgenoot further emphasised that the new pricing system, which decouples DH tariffs from gas prices, could enhance affordability for both tenants and housing corporations (interviewed on respectively May 13, 2025; May 22, 2025).

Additionally, the law introduces several key principles, including increased public ownership (specifically, majority government control) which is expected to place greater emphasis on affordability and tariff regulation. According to the respondent from Alliantie, this shift could strengthen housing corporations' confidence in the long-term affordability of DH (interviewed on June 3, 2025). The representative from Lieven de Key added that nationalising DH networks would allow for more effective tariff regulation and limit the tendency to transfer costs to residents (Strategy & Portfolio Manager, interviewed on June 4, 2025). "An actor that is not required to fully recoup investments, or that can absorb financial losses, could offer a viable solution," the respondent noted. This view was echoed by the representative from the Municipality of Amsterdam, who emphasised that the Wcw would support the development of public DH companies (interviewed on May 15, 2025). These entities would benefit not only from the absence of a profit-making obligation but also from enhanced borrowing capacity.

Rochdale's respondent noted that the 'Warm Amsterdam' case highlights the lack of control corporations have over commercial actors (Coordinator of Programming and Quality, interviewed on May 22, 2025). In contrast, municipally owned utilities (e.g., in Purmerend) are easier to coordinate with, offer better rates, and are willing to co-invest. Consequently, the Rochdale interviewee expressed high expectations of the Wcw, believing that public involvement in DH companies will ensure fair pricing and reduce dependency on private energy firms. Literature by Köhler et al. (2024) supports this, noting that policy interventions which mitigate private monopolies can enhance the authority of housing corporations.

However, the HYA respondent argues that the short-term effect of the Wcw has been the withdrawal of energy companies from DH development projects (Chairperson, interviewed on May 15, 2025). This has further revealed housing corporations' dependency on these providers, as the resulting stagnation in DH development leaves corporations unable to pursue new (large-scale) DH connections at all.

The representative from Eigen Haard also pointed to the Wcw as a mechanism to build tenant trust (interviewed on May 28, 2025). "The idea that a public company does not need to make a profit and can offer more stable tariffs certainly plays a role," although expressing scepticism about whether this would result in actual cost savings. "A local, publicly owned company that is closer to the people may inspire more trust than a multinational from distant Sweden." This shift in perception could improve the image of DH networks, which is crucial for tenant acceptance and, consequently, for the role housing corporations can play. The respondent from the Alliantie echoed this, stating that the Wcw could help rebuild fragile tenant trust by promoting cost transparency and long-term price certainty (Project Lead for Sustainability, interviewed on June 3, 2025). These two elements are seen as critical for improving tenant confidence, thereby making informed consent more realistic. This perspective aligns with Köhler et al. (2024), who underscore the importance of transparent pricing in promoting tenant trust and acceptance. Nonetheless, the tenants' association's representative warned that without clear cost structures, even a publicly managed DH network "…could be the worst idea launched this year" (Chairperson, HYA, interviewed on May 15, 2025).

Despite the Wcw's promise, several respondents expressed caution. While the Act offers a foundational framework, its actual effectiveness remains uncertain. The AFWC interviewee highlighted the ongoing need for financial support to ensure DH remains affordable (interviewed on May 13, 2025). Stadgenoot's representative questioned what 'affordability' means for tenants, noting that while the pricing model might provide clarity, it does not necessarily make DH cheaper than gas (interviewed on May 22, 2025). The respondent from Lieven de Key agreed, pointing out that the Act alone cannot resolve all dilemmas and conflicting interests (interviewed on June 4, 2025). Vattenfall's representative added that although the law provides a new foundation, it lacks sufficient detail, and it will take time for corporations to confidently resume a leading role (interviewed on May 13, 2025). The HYA respondent further warned that the Act does not eliminate monopoly risks: "Even if it is publicly owned, tenants will still be locked into a single provider with limited control over their energy bills" (Chairperson, interviewed on May 15, 2025).

In this context, respondents emphasised that additional financial mechanisms are required to make affordability a reality, with all pointing to the national government. The respondents of AFWC and Stadgenoot noted that even a cost-based model could leave DH more expensive than gas, making state subsidies essential (interviewed on respectively May 13, 2025; May 22, 2025). The representative of the Municipality of Amsterdam, which is already exploring the creation of a public DH company ahead of the Wcw's enactment, acknowledged that the current financial and regulatory conditions are insufficient (Programme Manager for Heating, interviewed on May 15, 2025). Both respondents from the AFWC and the municipality stress that national-level support is indispensable.

According to the Alliantie's representative, ensuring long-term affordability is a governmental responsibility (Project Lead for Sustainability, interviewed on June 3, 2025). The respondent suggested implementing a tariff cap or a compensation fund to cover excess costs. Certainty around upfront tariffs is crucial, given tenants' long-term commitments. The Lieven de Key interviewee pointed to the

ACM as responsible for setting affordable maximum tariffs for vulnerable residents and underscored the need for external funding to break the current deadlock: “The government should absorb the shortfall and present tenants with a compelling offer, rather than shifting the burden to housing corporations or residents” (Strategy & Portfolio Manager, Lieven de Key, interviewed on June 4, 2025). Several respondents argued that government support is essential to cover unprofitable segments and volume risk. Even Vattenfall’s representative acknowledged the need for structural compensation, noting that such support would allow corporations to ‘overcompensate’ tenants and make DH connections more attractive (Manager of Business Management, interviewed on May 13, 2025). Literature by Hoppe (2012) and Kuipers (2018) confirms that governmental financial support can enhance housing corporations’ investment capacity in energy initiatives, bridging the study’s findings and existing research.

As long as these issues remain unresolved and unclear, uncertainty persists among respondents. The Vattenfall respondent noted that the current legal framework remains vague: “As long as there is no clarity about regulations and the distribution of risks and responsibilities, there will be no large-scale development” (interviewed on May 13, 2025). This includes price caps and financing the unprofitable portion of DH projects. The municipal representative agrees, noting that improved conditions are essential for both corporations and tenants (Programme Manager for Heating, interviewed on May 15, 2025).

Beyond legal clarity, both housing corporations and HYA emphasised the need for a reliable government. “The national government is seen as highly unreliable, primarily due to inconsistent policies,” said a representative from Eigen Haard (interviewed on May 28, 2025), referencing the recent threat of a rent freeze. The HYA respondent stressed that corporations need a dependable state that avoids ambiguous policies and recognises the impact of energy poverty (interviewed on May 15, 2025). Lieven de Key’s respondent added, “The government must provide leadership and clarity. They need to decide whether the gas phase-out is mandatory and be willing to finance it” (interviewed on June 4, 2025). Stadgenoot’s representative agreed, stating that clear governmental direction is needed to define risk and cost allocation, thereby enabling DH development (interviewed on May 22, 2025).

Political will is seen as crucial. Without it, said the respondents of Rochdale and Ymere, “nothing much will happen” (interviewed on respectively May 22, 2025; May 21, 2025). Ymere’s respondent noted a lack of political courage, partly driven by public resistance to changes in home heating.

Respondents also stressed the need for greater societal awareness. Sustainable heating will be more expensive than current gas solutions, and this reality must be acknowledged. “The claim that the transition won’t cost more is simply untrue,” said a representative from Eigen Haard (interviewed on May 28, 2025). Vattenfall’s respondent agreed, noting that the notion of sustainability leading to cost reductions is politically driven: “In most cases, a sustainable solution is more expensive than a fossil one. The real issue is: who pays the difference?” (interviewed on May 13, 2025). The Rochdale interviewee added that the government must communicate the necessity and financial implications of the energy transition (interviewed on May 22, 2025).

Alongside a shift in societal mindset, a greater role for tenant participation and guidance is also deemed essential. The Municipality of Amsterdam’s representative noted that tenants often find DH processes unclear (Programme Manager for Heating, interviewed on May 15, 2025). Literature by Onencan et al. (2024) and Qazi et al. (2019) suggests that expanding tenant knowledge and engagement increases acceptance. However, municipalities should lead in communicating the broader heating transition, while corporations translate this into actionable plans for tenants, according to the HYA respondent, that further emphasised early involvement of tenants, similar to renovation projects (interviewed on May 15, 2025). Lieven de Key's representative noted that clear, honest communication fosters reciprocity and acceptance (interviewed on June 4, 2025).

The Ymere respondent cautioned that organising participation at the neighbourhood level is challenging, and technical discussions may not yield practical outcomes, though tenant associations could improve involvement (interviewed on May 21, 2025). HYA's representative added that housing corporations are unlikely to prioritise DH's public image, leaving that task to energy providers and government entities (interviewed on May 15, 2025). Restoring trust in corporations themselves remains a higher priority. The Ymere respondent confirmed that clear national leadership on the energy transition would help reduce tenants' uncertainty and foster trust (interviewed on May 21, 2025).

Regarding the municipality's role, the municipal respondent stressed the need for clear timelines and heating solutions per neighbourhood (interviewed on May 15, 2025). Rochdale's participant supported this, calling for a stronger coordinating role from municipalities (interviewed on May 22, 2025).

One mechanism to support this is the newly adopted Municipal Instruments for Heat Transition Act (Wgiw), which enables municipalities to mandate disconnections from the gas grid and designate preferred heating solutions (VNG, 2024b). Stadgenoot's respondent saw this as a major potential boost (interviewed on May 22, 2025). The interviewee from Lieven de Key stated it would relieve corporations of the burden of persuading tenants (interviewed on June 4, 2025). Eigen Haard's representative added that the 70% consent requirement could become less relevant if DH connections were to become mandatory, significantly altering the landscape and requiring housing corporations to adopt a more proactive role (interviewed on May 28, 2025). "It makes the process easier," said the respondent from Lieven de Key (Strategy & Portfolio Manager, interviewed on June 4, 2025). "Though it remains crucial to ensure that tenants don't pay too much and that their position is adequately safeguarded." The municipal participant added that the Wgiw makes the unprofitable top more manageable, especially when costs are socialised through public DH companies (interviewed on May 15, 2025).

> "The absence of cost socialisation in DH development significantly affects decision-making. Costs are currently falling on those who shouldn't bear them, namely housing corporations and tenants. A public DH company, in combination with subsidies, could help distribute these costs across a wider group and society at large, thereby lowering the financial threshold for DH investments," stated the municipal respondent (Programme Manager for Heating, interviewed on May 15, 2025).

However, the law's effectiveness depends on political willingness. The Ymere respondent noted that political hesitancy, driven by public resistance, could limit the Wgiw's impact (interviewed on May 21, 2025). Eigen Haard's representative estimated it would take a decade for public DH companies to mature and for councils to fully utilise their powers, partly due to electoral considerations (interviewed on May 28, 2025).

Although challenges remain, housing corporations must continue negotiating with heat suppliers and municipalities to ensure affordable and fair DH arrangements for both the corporation and tenants, according to the Alliantie's respondent (Project Lead for Sustainability, interviewed on June 2, 2025). As a result, some complexes in Amsterdam are still being connected on a small scale, according to respondents from Vattenfall and Ymere (interviewed on respectively May 13, 2025; May 21, 2025). The municipal respondent agrees, noting that while corporations currently adopt a cautious stance, they remain involved in discussions (interviewed on May 15, 2025). The Alliantie respondent added that housing corporations will continue to offer compensation within legal constraints, though this is not a structural solution (interviewed on June 3, 2025).

In sum, a public DH network supported by the Wcw and Wgiw can provide strategic direction and centre affordability in DH development. However, these frameworks alone are insufficient to bridge the financial gap in retrofitting existing buildings. All respondents pointed to the national government as central to both legislative and financial solutions. Political will is essential, but so is a broader societal shift away from gas as the benchmark. If the national government can provide guarantees and clarity that affordability for both tenants and housing corporations will be secured, housing corporations will gain the confidence that the heating transition will not come at the expense of affordability. This, in turn, would enable them to take up a more proactive role in DH development.

6. Conclusion

This study aimed to answer the central research question: "How can housing corporations take on a proactive role in advancing DH network developments?"

The main finding of this research into the role of Amsterdam's housing corporations in DH developments is that, despite their formal mandate to contribute to sustainability objectives, including the promotion of DH systems (Ministry of Housing & Spatial Planning, 2024), as of 2025, they occupy a limited and predominantly passive role. Contrary to the initial assumption, this role is not primarily determined by internal constraints such as staffing, expertise, or technical limitations related to energy materialities. Instead, it is shaped by complex external financial, regulatory, and interdependent factors that influence their internal capacities regarding finance, authority, and responsibility. These external challenges include rising costs, market volatility, and a strong dependence on energy companies. Consequently, neither housing corporations nor their tenants can be assured of affordable heating once DH connections are established, undermining the key prerequisites for participation (Ministry of Housing & Spatial Planning, 2024; Rijksoverheid, n.d.). As a result, housing corporations in Amsterdam are compelled to adopt a reserved stance.

The 'Warm Amsterdam' case exemplifies how inadequate regulation of commercial DH tariffs can result in the collapse of large-scale initiatives, creating a significant dependency on energy companies and, therefore, substantial financial risks for both tenants and corporations. The reliance on fair and transparent pricing from energy providers directly impacts tenant consent, which will not be granted unless affordable and transparent pricing structures are established. Although housing corporations technically retain authority over their properties (Ma et al., 2017), it appears that the broader governance context restricts their autonomy. This functional dependency on governments, energy providers, and tenants creates a 'network governance' dynamic (Hoppe & Miedema, 2020), which in turn has a paralysing effect. Even when internal capacities are sufficient, the unwillingness or inability of external actors to share risks and ensure affordability hinders the heating transition.

To enable housing corporations to take on a more proactive role, the national government must guarantee essential conditions of affordability and financial feasibility. This requires the establishment of clear legislative frameworks, with the forthcoming Wcw and recently adopted Wgiw legislation being key instruments for improving affordability. However, this is not sufficient on its own. Structural national financial compensation is required to cover the non-profitable margins of DH projects and ensure affordability for both tenants and corporations, especially given the likelihood that DH will remain more expensive than gas. A reliable and directive role from the national government, setting clear regulatory frameworks, distributing risks fairly, and sharing the costs of the energy transition, is crucial to restore housing corporations' operational capacity. Along with a strong focus on transparent communication and tenant participation, these elements are essential to revitalising the proactive role of housing corporations.

As long as these external conditions remain uncertain, housing corporations will continue to prioritise sustainability measures over which they have full control, adopting a wait-and-see attitude toward large-scale DH connections. This suggests that while housing corporations are committed to their sustainability responsibilities and continue to see DH as a viable heating alternative for a significant portion of their portfolio, external conditions are the key determinant of their capacity to contribute to DH developments.

Depending on political will and government commitment, housing corporations could once again become the driving force behind DH developments, thereby advancing the heating transition and contributing to a CO_2-neutral Amsterdam.

The findings of this study confirm and expand upon existing literature. Consistent with Späth & Rohracher (2015), the involvement of private actors under conditions of financial and institutional uncertainty presents substantial governance challenges. In Amsterdam's case, both energy companies and housing corporations withdrew from DH developments when critical preconditions, particularly financial viability, could no longer be met. This corroborates the observation that municipal governments lack the authoritative power to mandate the participation of key stakeholders, making the transition process highly dependent on actor willingness (Martínez et al., 2022; Bulkeley, 2010). Once enabling conditions deteriorated, actor motivation waned, resulting in the suspension of the transition, as described by Yoon et al. (2015). Given the substantial financial commitments required for DH infrastructure, which exceeded the acceptable preconditions of the involved actors, the transition in Amsterdam proved highly susceptible to stagnation. This finding resonates with Selvakkumaran et al. (2021), who similarly highlight the fragility of DH developments under such conditions.

The findings of this study further support the arguments made by McManus et al. (2010) and Swan et al. (2013), indicating that housing corporations are generally unwilling to pursue sustainability objectives when doing so risks undermining housing affordability. The 'Warm Amsterdam' case serves as a clear example of the inherent tension between affordability and sustainability, a dynamic previously highlighted by Bush et al. (2016). Consistent with the perspective of Wissner (2014), housing corporations also perceive it as their duty to protect tenants from price volatility.

Contrary to much of the existing literature, which often presents DH as a mechanism to combat fuel poverty, this study reveals a different reality in the Dutch context. While Bush et al. (2016) observe that UK authorities frequently promote DH systems as a tool for reducing fuel poverty, the Dutch case suggests the opposite: unpredictable DH pricing has the potential to compromise housing affordability rather than improve it.

Furthermore, this study corroborates the work of Kuipers (2018) and Devenish & Lockwood (2024), who highlight the obstructive role of tenant resistance. Factors contributing to this resistance, such as monopolistic structures and non-transparent pricing (Onencan et al., 2024; Wissner, 2014; Lavrijssen & Huygen, 2013; Li et al., 2015; Song et al., 2017), are also evident in this research.

The study challenges claims that scaling up district heating (DH) projects automatically enhances their feasibility (Wissner, 2014; Ma et al., 2017). While the findings do not necessarily refute this claim outright, they do introduce an important nuance. Specifically, the results indicate that as DH projects grow in scale—as illustrated by the case of 'Warm Amsterdam'—they tend to involve a larger number of interdependent actors. This increased interdependence can compromise the project's feasibility, as housing corporations become more vulnerable to external decisions and conditions beyond their control, thereby increasing overall project risk.

At the same time, while connection fees (Roos & Manussen, 2011) remain a relevant consideration, the study shows that they are often not the decisive cost factor in DH projects. Rather, they constitute only a small portion of the total costs involved. The findings demonstrate, for instance, that costs related to stakeholder participation can already represent a more substantial share of the overall financial burden.

Despite its valuable contributions, this study has several limitations. Firstly, its focus on Amsterdam limits the generalisability of the findings to other cities or national contexts. Secondly, the analysis reflects the situation as of 2025, meaning that future policy shifts (e.g., Wcw, Wgiw) could substantially alter the landscape. Thirdly, the relatively low number of respondents from non-housing corporations (e.g., market and government actors) introduces a potential bias, although responses were broadly consistent. Finally, the varied content of the interviews, due to time constraints, means that not all themes were addressed equally across respondents.

Nevertheless, this research refines and expands existing theoretical frameworks, such as the Kuzemko & Britton (2020) model, and enriches the still limited body of literature on stakeholder roles in the heating transition (Ma et al., 2020). In addition to broadening the understanding of barriers, the study also enhances knowledge of potential tools to alleviate DH development bottlenecks.

Thus, it is recommended that the national government assume a leading role in DH policy. This includes developing a clear strategy for phasing out gas, implementing robust legislation, providing financial support, and ensuring fair risk distribution. Municipalities should also embrace their role under the Wgiw to develop neighbourhood-level strategies that reduce uncertainty for stakeholders and stimulate DH progress.

Moreover, energy companies, municipalities, and housing corporations must all invest in transparent communication and tenant participation to rebuild fragile trust and generate support for DH.

Future research should examine the effects of the Wcw and Wgiw legislation on housing corporations' roles, DH affordability, and stakeholder dynamics. Additionally, studies should explore the long-term impact of insulation strategies on DH business cases, and conduct comparative analyses with cities where DH implementation has been more successful, to identify best practices and transferable lessons.

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Appendix

Appendix 1: Interview Guide

General Questionnaire

In preparation for our interview, I would like to send you the questionnaire below. This will give you insight into the topics that will be discussed.

Research Description

The main question within this research is: 'How can housing corporations play a proactive role in promoting heat networks in existing buildings?'.

Hereby, I focus on the Amsterdam region as a case study.

My approach is to first ascertain why they actively stopped cooperating on heat networks, and then to investigate how this relates to Kuzemko & Britton's (2020) capacity model. After that, the question is posed what housing corporations need, in terms of government policy or market reform, or what they themselves can do/change to remedy potential barriers so that they can play a proactive role in heat network developments, in order to achieve climate- and gas-related ambitions.

Recent Heat Network Developments

Q?: Why do you think housing corporations have recently withdrawn from collaborations around heat networks? What are the consequences of this?

Capacity Responsibility

Q?: To what extent do you notice that housing corporations experience tension between their sustainability responsibility and their task to offer affordable housing?

Q?: How does this tension influence their ability to play a proactive role in heat network developments?

Q?: What do you think could help housing corporations overcome this tension and still actively participate in heat network developments?

Capacity Authority

Q?: How much say do you think housing corporations have over heat network development in their own real estate, and how dependent are they on other actors (e.g., the municipality or energy company)?

Q?: How does this degree of dependence influence the ability of housing corporations to play a proactive role in heat network developments?

Q?: To what extent does tenant support play a role in the participation of housing corporations in heat network projects?

Q?: What can they do (or receive) to increase that support?

Q?: What would housing corporations need from the government or the market to get tenants on board with heat network plans?

Capacity Finance

Q?: To what extent do you experience that connection costs for housing corporations influence their decision-making regarding participation in heat networks?

Q?: To what extent do you think the financial capacities of housing corporations influence the extent to which housing corporations can proactively contribute to heat network developments?

Q?: What do you think housing corporations need from government policy, or government grants or market reform to make it financially possible for them to take a proactive role in heat network developments?

Q?: What can they themselves do/change regarding financial resources to again take a proactive role in heat network developments?

Capacity Personnel & Knowledge and Experience

Q?: To what extent do personnel capacity within housing corporations influence their role in heat network developments?

Q?: To what extent do existing knowledge and experience within housing corporations influence their role in heat network developments?

Influence of Material Characteristics

What can also influence the capacities of housing corporations according to the literature is the fact that there are physical defects in an area that can cause housing corporations to play a lesser role in heat network developments (e.g., lack of source or other physical limitations that make heat networks less feasible).

Q?: To what extent does this play a role for Amsterdam housing corporations?

Furthermore, the literature states that housing corporations can hold on to existing heat provisions, for example because the development of heat networks in built environments is relatively new, but also because the existing gas infrastructure still has certain value (it is easy that it is already there; the deprivation costs are high).

Q?: To what extent does this play a role for Amsterdam housing corporations?

Q?: What do you think housing corporations need to break this persistence to again take a proactive role in heat network developments?

Q?: What can they themselves do to break this persistence?

Dutch Legislation and Regulations

Q?: To what extent do current legislation and regulations concerning heat networks influence the extent to which housing corporations can play a role in heat network developments?

Q?: What do you think the influence of the Collective Heat Act will be on the extent to which housing corporations can play a proactive role in heat network developments?

Solution-Oriented

Q?: What do you think is needed for housing corporations to again proactively participate in heat network developments? What needs to change and where should that change take place (government policy, market reform, social domain)?

Q?: What can housing corporations do from their own capacity to again proactively participate in heat network developments?

Appendix 2: Overview of Respondents

Organisational Pseudonym	Position	Type Organisation	Date	Duration	Format
Amsterdamse Federatie van Woningcorporaties (AFWC)	Policy Advisor for Existing Buildings and Sustainability	Association of housing corporations	May 13, 2025	30 min.	Online
Vattenfall	Manager of Business Management	Energy company	May 13, 2025	60 min.	Online
Municipality of Amsterdam	Programme Manager for Heating in Existing Buildings / Programme Manager for Warm Amsterdam	Municipality	May 15, 2025	60 min.	Online
Huurders Ymere Amsterdam (HYA)	Chairperson	Tenant association	May 15, 2025	60 min.	Online
Ymere	Senior Advisor for Strategy and Policy	Housing corporation	May 21, 2025	60 min.	Online
Stadgenoot	Senior Policy Advisor for Sustainability	Housing corporation	May 22, 2025	60 min.	Physical
Rochdale	Coordinator of Programming and Quality	Housing corporation	May 22, 2025	60 min.	Online
Eigen Haard	Senior Advisor for Corporate and Portfolio Strategy	Housing corporation	May 28, 2025	60 min.	Online
De Alliantie	Project Lead for Sustainability	Housing corporation	June 3, 2025	60 min.	Online
Lieven de Key	Strategy & Portfolio Manager	Housing corporation	June 4, 2025	60 min.	Online

Appendix 3: Overview of Housing Corporations' Approaches to the Energy Transition and Affordability

Name of Housing Corporation	Approach to the Energy Transition and the Role of Affordability	Source
Alliantie	The Alliance is searching for appropriate gas-free heating solutions, taking into account the affordability for tenants, the feasibility of financing, and the contribution to CO_2 reduction. Heating solutions are assessed based on investments for the housing corporation, affordability for tenants, and sustainability. In principle, they support district heating systems as a suitable solution in densely built areas, but affordability for tenants and the conditions of the offer take precedence.	de Alliantie, n.d.
Eigen Haard	Eigen Haard aims to be completely gas-free by 2050. They opt for solutions that are affordable for tenants, use reliable technology, and provide certainty. For flats and corridor houses, they preferably choose a collective district heating system. For single-family homes, they opt for hybrid systems or a fully gas-free solution. The affordability for tenants is a crucial consideration in the decisions they make.	Eigen Haard, 2025
Lieven de Key	Lieven de Key adopts a complex approach to sustainability, aiming to make as many homes as possible future-proof at the same time. Where feasible, they make homes gas-free. The primary goal of the energy transition is to reduce CO_2 emissions. The energy transition vision states that actually phasing out gas is the final step. They do not exclude district heating systems under the right conditions.	Lieven de Key, 2024
Rochdale	'Getting off gas' is proving more complicated than initially thought, with the question of who bears which costs. Rochdale considers it important to be transparent with residents about what they can expect. They delve into the broader issue of housing costs and explore where they can (directly or indirectly) contribute to improving affordability for residents. They actively seek opportunities to connect and collaborate on studies into the feasibility of public networks in neighborhoods.	Rochdale, 2025
Stadgenoot	The transition to gas-free homes and alternative energy sources is part of Stadgenoot's sustainability and quality improvement plans. By 2050, they must and want to be CO_2-neutral. All their homes will be insulated and connected to a sustainable heat source. They first examine how to reduce the heating demand of a residential building. Then, they assess whether they can switch to district heating. To keep their homes affordable, they ensure an appropriate target rent policy.	Stadgenoot, 2022
Ymere	Ymere, in collaboration with residents, municipalities, energy suppliers, co-makers, and fellow housing corporations, aims to accelerate the insulation and gas-free transition of thousands of homes. They consciously opt for solutions that are already familiar and affordable for both tenants and Ymere, such as connection to district heating systems. They tackle homes with the worst energy labels (E, F, and G) first. They strive to ensure tenants live comfortably and affordably, while also aiming to maintain social rental housing.	Ymere, n.d.