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Why go public? Public configurations and the supportive and divergent views towards public district heating in the Netherlands

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Introduction: Cities are taking up services of social importance under the (re)municipalisation movement. The Dutch government embarked on an ambitious heat transition and proposed in 2022 to make all district heating projects public or semi-public, with a majority public share. This proposal has sparked intense debates among groups in favour of and against a shift to public ownership.

Methods: This study assessed 16 public projects through qualitative research and uncovered the arguments for and against public ownership among key public and private stakeholders.

Results: While public ownership is deemed necessary to meet social objectives and address the shortcomings of private models, critical views question the economic performance and inappropriate political choices in some public projects. These critical views propose alternative ways to safeguard public values, such as ensuring affordability and meeting climate goals. Despite disagreements, public and private actors recognise the shared responsibility and the importance of the other's role. They agree that the central government's proposed mandate for public ownership may limit flexibility at the local level and prevent other effective configurations like public-private partnerships with equal public-private shares.

Discussion: Reflecting on the study findings, it is debatable whether mandating public ownership nationwide, as proposed by the Dutch government, should become the approach to tackle current challenges instead of allowing more flexibility. The upcoming Heat Act may reduce key issues justifying public ownership, such as affordability, cherry-picking and the lack of transparency of private projects. Further research is needed to determine whether public ownership would enhance citizens' support and speed up realisation. Public ownership may still be necessary if social and cost benefits outweigh those from other configurations or long-term concession contracts are too risky. Implementing regulations protecting public values and enabling the coexistence of public, private or public-private configurations tailored to each unique local context could be an alternative, as successful district heating sectors abroad demonstrate.

KEYWORDS

heat transition, (re)municipalisation, the Netherlands, public ownership, district heating, built environment, local governments

1. Introduction

District heating (DH)[1] fuelled by renewable sources is expected to play an essential role in the transition towards low-carbon heat supply in the built environment in Europe (Persson et al., 2019; Gaballo et al., 2022). The potential for DH growth is significant, providing only 11% of the EU's final heating demand for residential and service buildings in 2018 (Manz et al., 2021). Climate conditions combined with political-, economic-, regulatory- and historic developments explain the highly diversified DH use across countries (IRENA, 2017; Sayegh et al., 2018; Paardekooper et al., 2022). The Nordic and Baltic countries integrate up to 50% DH share in their energy systems (Bertelsen and Vad Mathiesen, 2020), while other countries have significant untapped potential (Mathiesen et al., 2019).

Local governments have historically played an essential role in developing the energy systems of many Western economies (Britton, 2018). This changed with the energy market liberalisation in the 1990's (Tatahi, 2006), and the process has been ongoing for many years in different contexts (Pollitt, 2012). Economic efficiency and market competition led to traditional public services being privatised (Wollmann, 2020). Since the 2000's, various DH models have emerged, from public ownership to joint ventures, long-term concessions and design-and-build contracts (Britton, 2018). Local authorities in countries such as Denmark, Finland, Sweden, Austria and Latvia hold a significant role in managing and developing DH (Werner, 2003; Geletukha et al., 2016; Britton, 2018). Other countries, such as the Netherlands and Poland, have more market-dominated sectors (Geletukha et al., 2016; Den Dekker et al., 2020). DH assets can also be in the hands of consumer cooperatives, as is the case in Denmark (Johansen and Werner, 2022).

The Dutch DH market may see a revival of the public sector, as the central government proposed in October 2022 that all existing and future DH systems will become public or semi-public (Dutch Ministry of Economic Affairs and Climate, 2022a). As defined in this paper, public ownership encompasses when a public party (i.e., local- and regional governments and public network operators) fully or partially owns assets in the DH system fully or partially. Drawing on the Dutch case, this paper explores the desire to establish public DH and the counter-arguments to this movement. The findings are positioned within the broader scientific debate of *(re)municipalisation*,[2] a growing trend in which cities across the globe take back public services after decades of privatisation. Kishimoto et al. (2020) identified over 1,400 cases of (re)municipalisation in seven public sectors between 2000 and 2020 involving 58 countries. Other studies have also explored this trend in different contexts (Hall, 2012; Becker et al., 2017; Wagner and Berlo, 2017; Cumbers and Becker, 2018; McDonald, 2018; Kishimoto, 2019; Weber et al., 2019; Albalate et al., 2020).

Through a case study comparison of existing and emerging public DH projects, this study develops a model typology, identifies the drivers behind public ownership and finds criticisms of this trend and some of the public models developed. This 3-fold approach adds to earlier research as these have only focused on one of these objectives. Several studies illustrate the type of DH ownership models in Europe (Zeman and Werner, 2004; International Finance Corporation, 2014; Heukmès and Hofer, 2020) and the Netherlands (Sanders et al., 2017; Saxion, 2019; Den Dekker et al., 2020), but understanding the context behind these initiatives has been under-researched. Likewise, while there is growing literature on the (re)municipalisation topic, most studies focus on electricity-related projects and only a few examples are found for DH (Becker et al., 2017; Kishimoto and Petitjean, 2017; Wagner and Berlo, 2017; Britton, 2018; Cumbers and Becker, 2018). This is partly due to the dominant state- and municipal DH utilities in many countries.

We also observe that studies typically lack paying attention to understanding antagonistic views to (re)municipalisation movements and tend to focus on the factors driving the desire for more public control (Hall, 2012; Kishimoto and Petitjean, 2017; Wagner and Berlo, 2017; Cumbers and Becker, 2018; McDonald, 2018; Kishimoto, 2019; Weber et al., 2019; Albalate et al., 2020). McDonald (2018) and Albalate et al. (2020) highlight the importance of better understanding the dynamics behind this movement and the aspects that might create disagreement between the involved parties.

The research explores public and semi-public DH projects to gain insights into the drivers for public ownership and relevant lessons behind these projects. These examples and dominant lines of supporting and critical reasoning of public ownership are used to provide policy recommendations regarding the Dutch government's proposed transition towards a public DH sector. Two research questions are formulated:

> *What are the views of public and private stakeholders regarding public ownership of district heating projects?*
> *When evaluating the validity of the arguments that support public ownership, would implementing public ownership at a national level be a good strategy?*

2. The Dutch district heating sector as a case study

The first Dutch DH project dates back to 1923 in the city of Utrecht (CE Delft, 2009). DH expansion occurred primarily in the 1980's, driven by a focus on utilising residual heat for energy-saving policy (Woods and Overgaard, 2016). Following this expansion, many DH projects encountered financial difficulties due to the energy liberalisation in the 2000's. The energy companies, many operating combined heat and power plants, could no longer cover the losses of the heat projects with the income from the electricity production and supply (CE Delft, 2009). Due to energy liberalisation, particularly the unbundling law (Eerste Kamer, 2005), the commercial orientation of municipal companies

1 District heating, also known as heat networks, supply heat from a central source to consumers, via a network of underground pipes carrying hot water.

2 Following the distinction made by Kishimoto and Petitjean (2017), municipalisation refers to cases where local governments establish new municipal companies to meet certain local needs. Cases where local governments restore responsibility for local services from fully private to fully or partly public control are embedded under (re)municipalisation. Literature for (re)municipalisation can also be found under labels of reverse privatization, de-privatisation and insourcing (McDonald, 2018).

increased. Energy companies had to separate into a commercial supply and generation and a regulated network company, resulting in a surge of private acquisitions (CE Delft, 2009). Most local governments no longer saw ownership of a commercial energy company as their role (Burger, 2001).

Only 10% of DH connexions are public, and 90% are privately owned, primarily by the three largest firms, i.e., Vattenfall[3] (formerly Nuon), Eneco and Ennatuurlijk. These projects are often vertically integrated, where one party controls production, transport/distribution and delivery (Segers et al., 2020) or include partial unbundling. Approximately 6% of the buildings are connected to DH (CBS, n.d.). Individual natural gas-fired boilers are the heating system of choice (Bertelsen et al., 2021), being reliable, efficient and cheap. There is a low market appetite to develop DH in existing buildings[4] due to the high demand risks[5] (reinforced by the absence of binding regulations mandating switching to sustainable alternatives) and the substantial grid investments (Natuur and Milieu, 2018).

Despite challenges, DH expansion will become crucial for attaining national goals. The Dutch Climate Agreement of 2019 states that all buildings must be progressively disconnected from the natural gas supply until 2050 and find low-carbon heat supply alternatives (Dutch Ministry of Economic Affairs and Climate, 2019). The estimated potential is 500,000 additional connexions by 2030 in the existing 7 million households and 2,600,000 connexions by 2050 (Netbeheer Nederland, 2022). The central government has delegated municipalities to lead the local heat plans to achieve the national targets. This includes completing a heat plan in 2021, assessing potential heating systems per district (e.g., DH or individual systems), DH zoning, and selecting the DH operator in the pre-established zones.

The Dutch DH market was unregulated until 2014 and grew as a local monopoly. Then, a regulatory framework was introduced to protect consumers from high prices and guarantee supply security (Lavrijssen and Vitez, 2021), with maximum returns and prices set annually based on a cap linked to natural gas (Geletukha et al., 2016). Despite the regulation, affordability remains a concern with the current price-setting system (Ecorys, 2022). Also, some municipalities feel constrained by private arrangements. They experience excessive reliance on the expertise of private parties, lack cost transparency, and find themselves in a situation where they bear risks from market players while these players do not share the financial gains generated by the project (Natuur and Milieu, 2018; Tigchelaar et al., 2019; Attema and Boendermaker, 2022). These were the first signs of a municipalisation movement (Herreras Martínez et al., 2022).

To address these issues, a new DH regulation (Heat Act 2.0) will be implemented in 2025 (Dutch Ministry of Economic Affairs and Climate, 2022b). The draught Act stated that public and private companies could be appointed to manage a DH zone. However, local and regional governments did not support this proposal, advocating that it seemed to favour the traditional private model without sufficiently securing public interests (Dutch Ministry of Economic Affairs and Climate, 2022b).

After 2 years of heated discussions and without an explicit agreement between public and private stakeholders, the central government proposed in October 2022 that new and existing DH systems will be public—except for small systems (with <1,500 home-equivalents[6]). The reasoning behind the proposal is the pivotal municipal role in implementing local heat plans and that DH is a vital infrastructure that should be publicly owned due to its monopolistic characteristics. Four variants are proposed, including full or partial public ownership, where the public party should have a majority share on the grid (Table 1). The heat production and heat supply/retail market can be fully private in configurations C and D of Table 1.

3. Methods

The study employed qualitative research methods and embedded three building blocks linked to the two research questions posed (Figure 1). Sixteen case studies were used representing most public projects in which local authorities play a role under different configurations (Table 2). The case studies were categorised according to the degree of public sector involvement. Heukmès and Hofer (2020) describe two main public DH models: public and public-private partnerships (PPP), with public actors taking different responsibilities and risks. Our research enriched this categorisation by combining elements of ownership and unbundling levels throughout the DH chain: production, distribution/transport and supply/retail. Each segment can be publicly- or privately owned or managed by a PPP. Such classification has not been done previously and could be relevant for studies in other contexts to describe and assess public models.

The DH system can entail different levels of unbundling (i.e., the legal separation of activities in the chain). Bürger et al. (2019) distinguishes between *Partial unbundling,* in which production is unbundled from the grid[7] and supply, and *Full unbundling,* with independent parties responsible for all three levels of the supply chain. Partial unbundling for production is already widely adopted in the Netherlands, where independent producers sell the heat to the DH operator. Five governance models are identified in the case studies comprising full public ownership, PPP variants and different levels of unbundling (Figure 2). These groups helped combine projects with similar characteristics and are used to

3 Note that Vattenfall is a Swedish state-owned company but it operates in the Netherlands as a private company.

4 The prohibition to use natural gas is only in place for buildings of new construction since July 2018.

5 This risk indicates the financial risk to the heat company if fewer homes are connected to the DH project and/or the pace of connections is slower than the business case initially assumed.

6 Home-equivalent refers to a unit converting the floor space of different types of building sizes to the average size of a Dutch home (~130 m^2).

7 The network is usually divided into a primary transport network (that transports heat from the source) and a secondary distribution network (bringing the heat to the customers). These are separated by a substation in which the temperature and pressure of the primary network is lowered. In the distribution network the hot water is pumped towards the customers, where the heat is delivered to a heat interface unit to provide central heating and warm water.

TABLE 1 Public configurations put forward by the Dutch central government for DH networks as part of their proposal for the upcoming Heat Act 2.0.

Proposed configuration	Element of the heat chain where public ownership takes place			Share public ownership in the transport and distribution network
	Production	Transport and distribution	Supply/retail	
A (fully public)	x	x	x	100%
B (public/private)	x	x	x	≥51%
C (public/private)		x		100%
D (public/private)		x		≥51%

A public party can be a local and regional government and/or a public network operator.

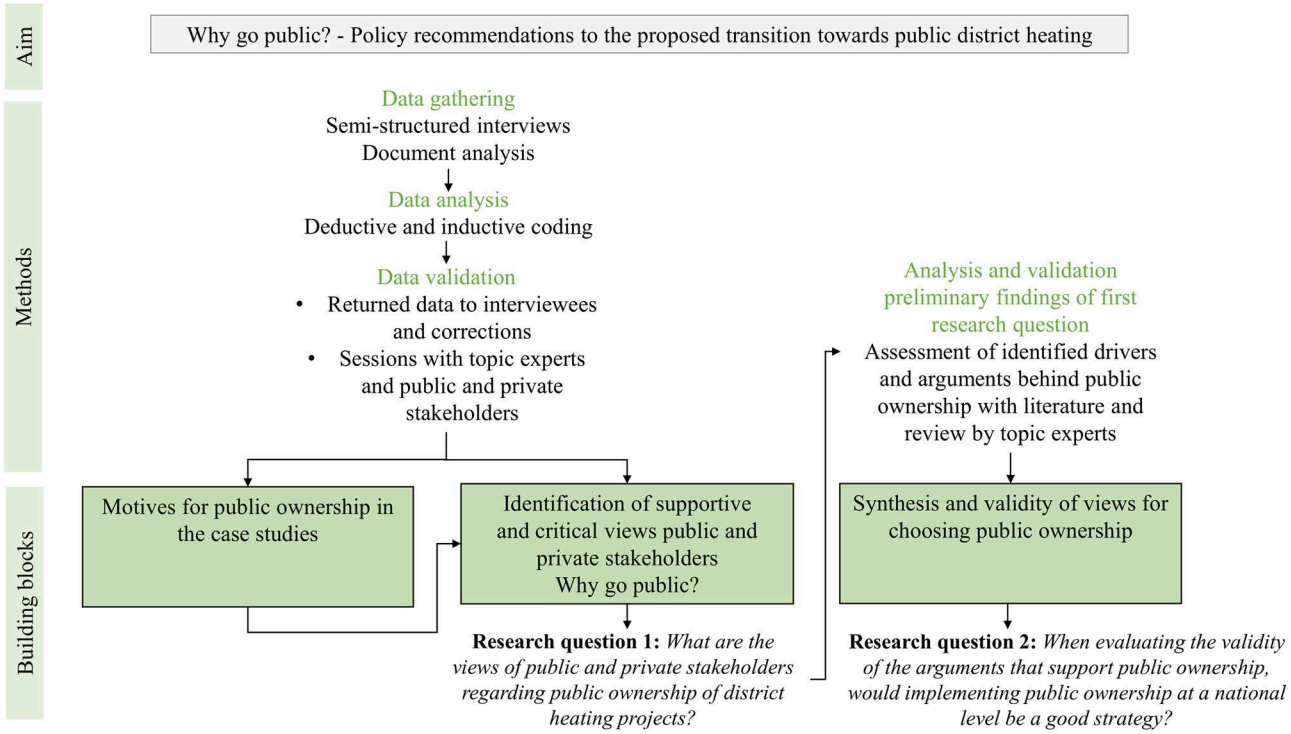

FIGURE 1
Research design related to the research questions and study's aim.

link the arguments for and against public ownership to specific model types.

The gathered data on the investigated public models and the reasoning behind the transition towards public DH are depicted in Table 3. Document analysis and interviews were used for data collection, and data was cross-checked. The reviewed documents (e.g., municipal heat plans, companies' websites and internal reports, official letters to the parliament on the regulatory proposal, and whitepapers) provided information on the context of the researched topic and the case studies. Semi-structured online interviews were conducted with 31 stakeholders, 74% from public organisations and 26% from private organisations. Despite our efforts to achieve equal representation of private and public actors, this was difficult due to limitations in the willingness to participate. To address this issue, results dealing with public/private opinions show each group's relative share. Interviewees included municipal officers, project developers, and public- and semi-public- and private DH companies and network operators, most involved in one or more case studies (Supplementary Table S1 of the Supplementary material). Participants' selection used purposeful sampling (Patton, 2014) based on their relevance to the case study, research topic, and willingness to participate. A standard interview guide was developed (see Supplementary material). Questions related to views concerning public ownership of DH were intentionally left open to elicit the participants' views inductively. Questions were slightly adapted per interview to accommodate the participant's context and role. Interviews took place between April and October 2022 and were recorded.

Interview data were transcribed using *Amberscript* (Amberscript, n.d.). Deductive and inductive coding (Fereday and Muir-Cochrane, 2006; Xu and Zammit, 2020) was employed using NVivo 1.5.1 (Bazeley and Jackson, 2013) in order to

TABLE 2 Selected case studies showing the ownership division among the public and private parties.

Name public or semi-public DH project (city)	Acronym used in the paper	Status	Ownership division among the public and private parties in the DH project
Stadsverwarming Purmerend (Purmerend)	SVP	Operational since 1981	The municipality of Purmerend holds full ownership along the DH chain, including generation assets.
HVC[a] (various regions in the Netherlands)	HVC	Operational since 2006	A regional public company with own generation assets in which 52 municipalities and five public water boards of various Northern and Southern areas are shareholders.
WarmteStad (Groningen)	WarmteStad	Operational since 2017	The municipality of Groningen and a public water company hold equal ownership and own part of the generation assets.
Warmtenet Eindhoven (Eindhoven)	Eindhoven	Operational since 2011	The municipality of Eindhoven holds full ownership along the DH chain, including generation assets.
Westpoort Warmte (Amsterdam)	Westpoort	Operational since 2000	Joint venture between public and private partners. Amsterdam municipality and the energy company Vattenfall hold equal ownership. Generation assets were owned by the municipality until 2021, when they were sold to a private party.
Warmtebedrijf Rotterdam (Rotterdam)	WbR	Operational since 2013	Joint venture between public partners comprising Rotterdam municipality (95% share) and regional government (5% share) to support economically challenging elements (transport network). Private sector owns generation assets, distribution network and supply.
Indigoleiding (Nijmegen)	Indigo	Operational since 2015	Joint venture between public partners comprising Nijmegen municipality (5% share) and a network operator (95% share) to support economically challenging elements (transport network). Public parties also owns part of generation assets. Private sector owns part of generation assets and fully owns distribution network and supply.
Warmtenetwerk Zaanstad (Zaanstad)	Zaanstad	Operational since 2019	Joint venture between public partners comprising Zaanstad municipality (39% share) and a partnership of a network operator and the regional government (61% share) which formed the company Warmtenetwerk Zaanstad. The partnership owns the transport and distribution network, while other activities in the heat chain are contracted to private parties.
Warmtenetwerk Didam (Montferland)	Montferland	Operational since 2021	Joint venture between public partners comprising Montferland municipality (5% share) and the network operator (95% share) which formed the public company Warmtenetwerk Didam. The partnership owns the transport and distribution network, while other activities in the heat chain are contracted to private parties.
Warmtenet Kerschoten (Apeldoorn)	Apeldoorn	Under development	Similar construction as in Montferland.
Warmtenet Schalwijk (Haarlem)	Haarlem	Under development	Similar construction as in Zaanstad, but the local government will have a 50% share and a partnership of the network operator and the regional government 50% share.
Warmtenet Zandweer (Deventer)	Deventer	Under development	Deventer municipality owns the network and brings significant financial participation in the project. Through Design-Build-Finance-Maintenance-Operator contracts, activities will be outsourced to one private party for 30 years. This case is the exception of model 4 because, in all the other cases, the partnership involves a collaboration with the network operator.
Warmtenet Kalkhoven (Katwijk)	Katwijk	Under development	Municipal is legally the owner of the DH project and brings small financial participation. Through Design-Build- Finance- Maintenance-Operator (DBFMO) contract of 15 years activities will be outsourced to a private party, who brings the most investments. The municipality will evaluate options to extend, tender or take over the system after 15 years.
Warmtenetwerk Lingewaard (Lingewaard)	Lingewaard	Under development	Similar construction as in Zaanstad.
Warmtenet Dukenburg (Nijmegen)	Dukenburg	Under development	Similar construction as in Zaanstad.
Gelderse Warmteinfra bedrijf[a] (various cities in Gelderland)	GWIB	Under development	Similar construction as in Zaanstad and Montferland.

[a]The case studies HVC and GWIB are different from the other local DH projects, as they are a regional collaboration between municipalities and other public actors.

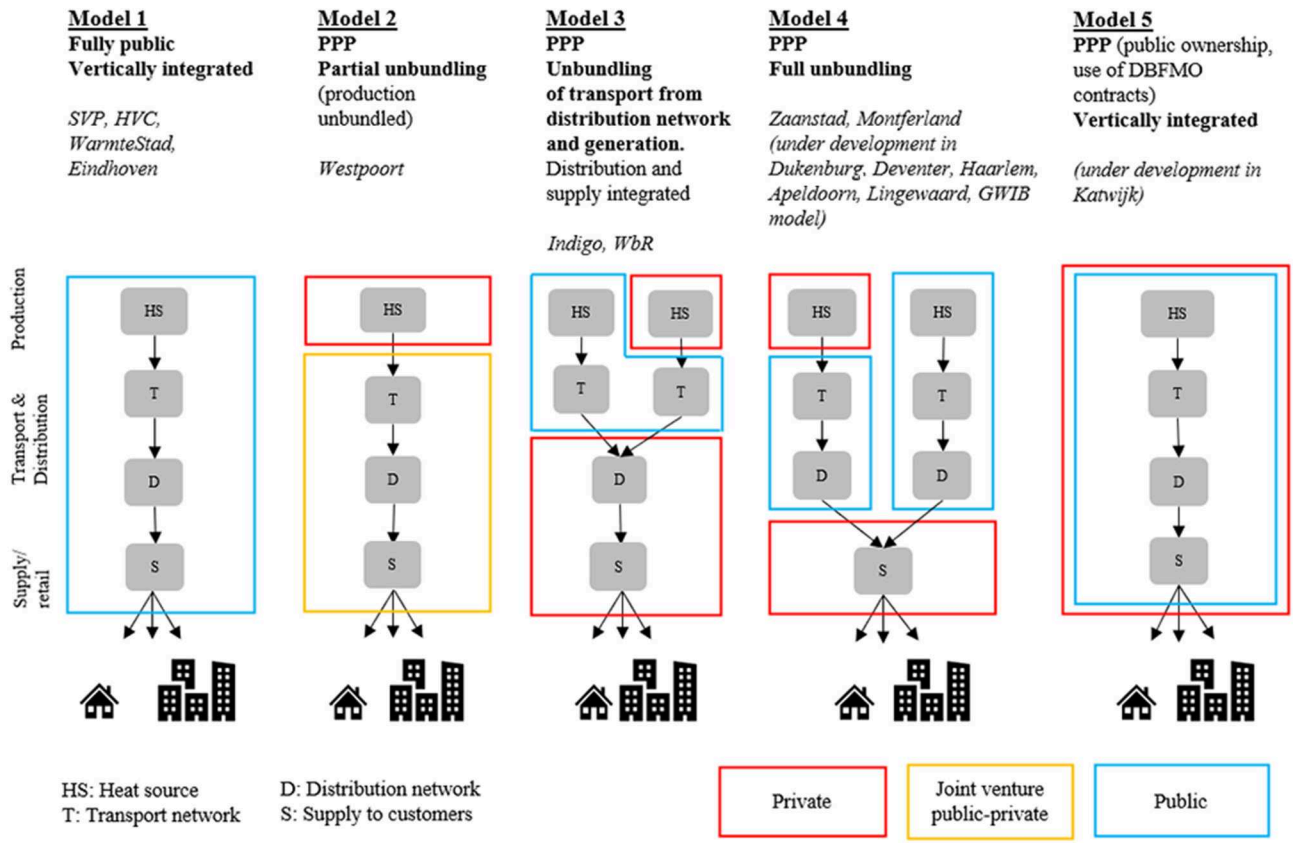

FIGURE 2
Case studies grouped by ownership type and level of unbundling (highlighted by colour boxes).

TABLE 3 Data gathered in the research to answer the first research question.

Data gathered	Description
Case study	
Motivation for public ownership	Drivers for public ownership in the case study
Background information case study	Role division of public and private actors in the DH chain
	DH system: Fuel mix used, number and type of buildings connected
	Development and expansion plans
Views public ownership of DH	
Supportive discourse	Narratives in favour of public models
Critical discourse	Narratives critical or against public models
Views on the government's proposal on public ownership	Narratives in favour of a transition to public ownership
	Narratives critical with a transition to public ownership
Relevance of public and private involvement	Value of public role in DH
	Value of private role in DH

code the data into themes in line with the first research question. Careful and systematic (re)reading allowed the identification of emerging themes, duplicates, and areas of consensus and disagreement in an inductive manner. The coding process involved several iterations in clustering codes and themes. Textual patterns and frequently occurring themes were assessed using NVivo Query tools such as "Word frequency."

The results collected via interviews and document analysis were validated. Factsheets were made for each case study describing the public project and the drivers for public ownership. These were returned to the interviewees to verify, correct or add any relevant information. Lastly, the preliminary findings were presented in three workshops, including topic experts and key representatives of public and private stakeholders. These enabled a sharpening of the findings.

To answer the second research question, scientific papers, data from public and private DH companies, the regulatory draught Heat Act, as well as other relevant reports were employed to assess the validity of dominant drivers and arguments regarding public ownership. The initial assessment conducted by the authors was further refined by soliciting input from three topic experts in the Netherlands who were familiar with the research topic.

4. Results

A few selected interview fragments are presented to support and understand the main findings. Clear and concise statements are also prioritised over lengthy ones to maintain the article's readability. A more exhaustive overview of interviewees' narratives, aligned with the topics discussed in this section, can be found in the Supplementary material (Sections 4 and 5). Interview results are presented anonymously for privacy reasons.

Note that while arguments in Section 4.1 primarily represent the views of public actors, and those in Section 4.2 cover those of private actors, there may be some overlap in the opinions of both groups, as can be seen in Figures 3, 4 and the interview fragments in Sections 4 and 5 of the Supplementary material.

4.1. Supportive views regarding public ownership

Table 4 summarises the underlying drivers that moved public actors in our sample to participate in the respective projects. Additional information on each case study's background and governance models can be found in Section 3.1 of Supplementary material. All the cases state that they aim to provide customers with affordable, reliable and sustainable heat while fulfilling local climate objectives. In many projects, it was either a consequence of an existing opportunity (e.g., use of heat available to meet sustainable goals), an undesirable situation (concerns about the effectivity of private models) and, often, multiple aspects are used to claim the importance of a public role:

> "*Projects face many constraints. Municipalities in concessions face a negotiating position with market parties, who only participate in new construction and expect municipalities to cover all unprofitable areas. Additionally, citizens' support for district heating is decreasing due to rising prices and lack of options to switch to another supplier, so we want to improve that.*" [public party]

The lines of reasoning found across the case studies and the interviews to support public ownership have been assembled into three main groups (Figure 3). The categorisation helped us structure the most dominant discourses among supporters of public DH. The aspects playing a role within each group are elaborated on below.

4.1.1. Leading, initiator and coordinating role of local governments

After the Climate Agreement's signature in 2019 by the Dutch government, municipalities received a major responsibility for the heat transition *to meet local and national climate ambitions*. This created a window of opportunity to rethink the municipal involvement and responsibility in the roll-out of DH, reinforced by the shortcomings observed in some private arrangements. This is reflected in the number of public companies since 2019 (which comprise half of the case studies, Table 2).

The government role is seen by public and private parties as crucial to *support economically challenging projects* (Figure 3). The public role is key in projects where the financial gap or the demand risks are high. These are important barriers for market parties now. Five municipalities in our sample (Table 4) have reported the lack of market initiative (also labelled as "market failure") to take on DH projects. This has to do with the oligopolistic nature of the Dutch DH market, in which only a handful of firms are active. However, other reasons may have contributed to the market disinterest in some projects. In particular, this has happened in some tendering procedures of emerging projects using model 4 (Figure 2). Most large commercial firms dominating the DH market do not endorse this unbundled configuration (Section 4.2.2).

Local governments pointed out that if the public role is needed to finance economically challenging projects, they prefer to participate in them rather than providing subsidies. This allows them to exert more control, and may deliver long-term benefits (e.g., profit on heat sales) instead of only costs. Market parties hold a contrasting viewpoint; public money should cover the financial gap through co-investments or subsidy provisions, whereas private parties with expertise should be responsible for execution.

Lastly, municipalities have a multifaceted role beyond DH, serving as *democratic representatives of public interests*. When public services like electricity, transportation, water and wastewater systems are publicly owned, it enables *the coordination of local projects and holistic and strategic planning.*

4.1.2. Mistrust and previous experience with private models

After a long period of privatisation, local authorities have taken a role at a distance. Past experiences of local governments with existing DH firms, either in their local situation or other regions, have increased the mistrust of the effectiveness of private arrangements in achieving socially desirable goals.

Some public parties point out that market entities have been *cherry-picking*. They stepped into new construction projects and rental social properties with limited demand risks and where long-term contracts can be negotiated with project developers and housing associations. The lack of regulations to mandate the transition to sustainable heat sources to connect individual households and the uncertain returns associated with such projects make it difficult to attract private investment. Local governments aim to design strategies that connect all possible areas (Figure 3).

It is often argued that *economic performance leads* the decision-making of market parties, while governments have a long-term vision and consider a broader set of social values and can price risks more leniently, as exemplified in the next section. Another problem is the *lack of transparency* regarding incurred costs, profit margins and business models of market parties. As the Dutch DH market is regulated by a natural gas cap rather than a true cost reflection, no data is available on the relation between the cost components of tariffs and how this relates to the profits made. Firms keep financial information confidential for commercial reasons and argue that profits and tariffs are already maximised by the Authority for Consumer and Market (ACM). However, companies can raise

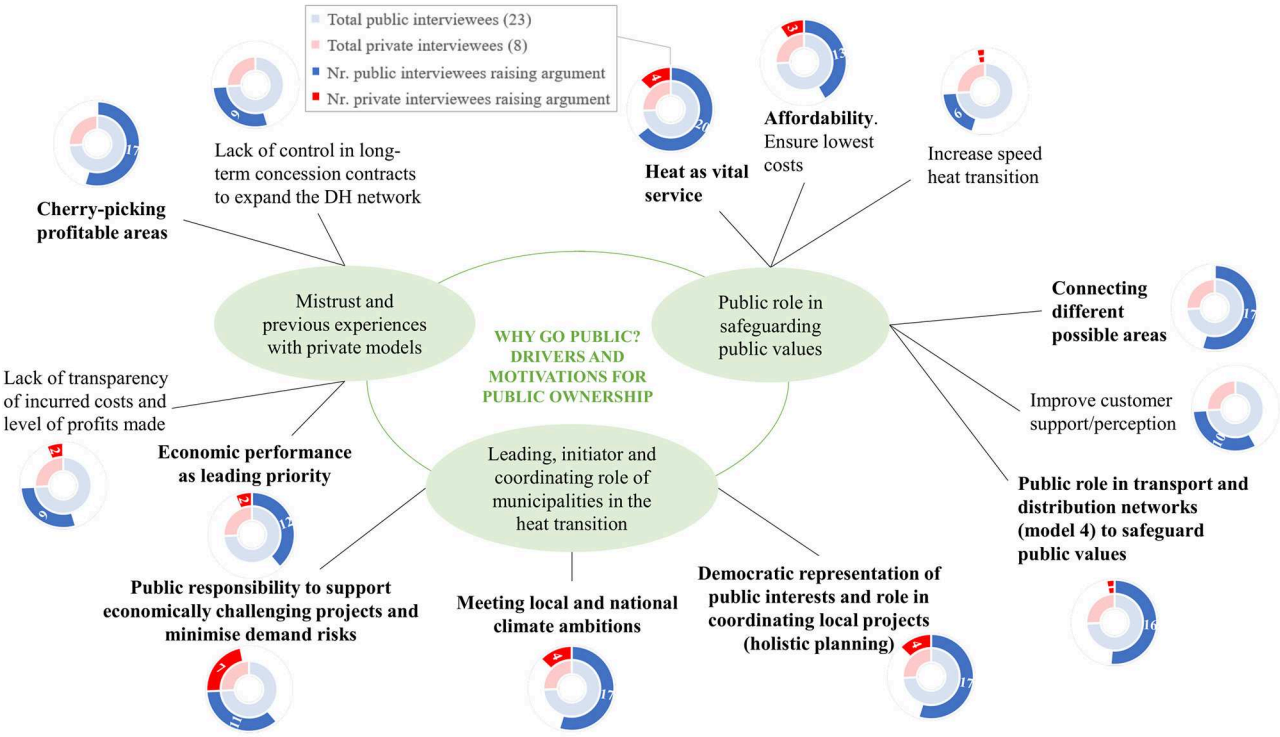

FIGURE 3
Overview of arguments raised by interviewees to advocate the need for public ownership in DH. Text in bold highlights issues addressed by more than 50% of public interviewees. The pie charts show the dominance of arguments. The number of public- and private participants raising that point is depicted in blue and red, respectively.

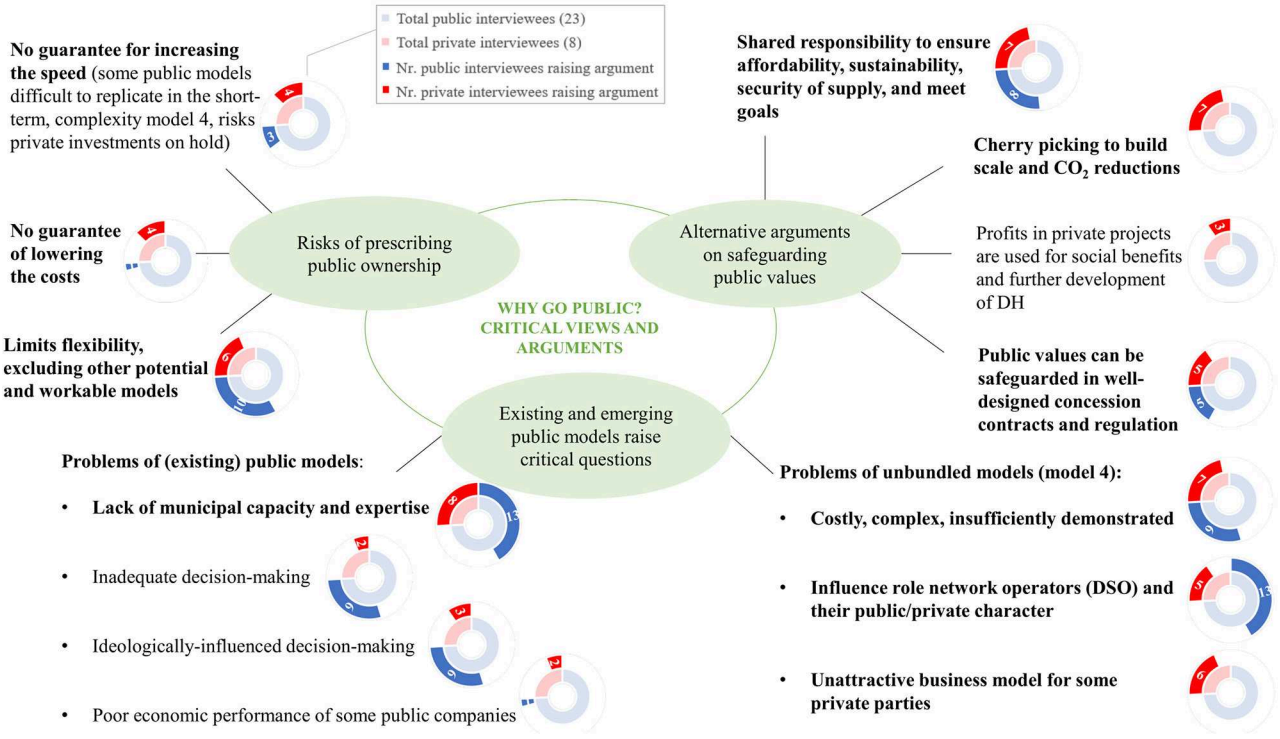

FIGURE 4
Overview of critical views and concerns interviewees raised on DH's public ownership. Text in bold highlights issues addressed by more than 50% of private interviewees. The pie charts show the dominance of arguments. The number of public- and private participants raising that point is depicted in blue and red, respectively.

TABLE 4 Drivers for public participation in the case studies.

	Case study	Drivers for public participation in the DH project
Model 1	SVP	SVP was founded due to the oil crisis to seek alternative heat systems to provide affordable heat to the growing number of buildings in Purmerend and meet climate ambitions.
	HVC	HVC started as a public waste treatment company and developed into a regional collaboration. Since 2008, they have started developing DH systems to use an asset (residual heat) that would otherwise be discharged, which helped meet environmental goals.
	WarmteStad	Groningen municipality had ambitions to provide sustainable heat to the city and meet local climate targets. A lack of market interest partly drove municipal participation.
	Eindhoven	The municipal energy company aimed to link energy initiatives in the city and meet its climate ambitions. Eindhoven municipality already owned two combined heat and power biomass plants that could use to feed the network.
Model 2	Westpoort	Amsterdam municipality wanted to reuse heat from a municipal waste incineration plant, provide it to city buildings and meet local climate goals. Establishing a joint venture between the public heat producer and the private DH operator avoided margin stacking (instead of working in a concession contract of producer-operator), allowing financial close to the project and better risk sharing.
Model 3	WbR	WbR started as a public initiative to construct a primary network to use the abundant industrial heat from the large Rotterdam seaport and provide affordable heat to citizens. This helped the municipality to meet local environmental goals. Public participation was driven due to the lack of market interest in building the transport network.
	Indigo	Indigo started as a public initiative to connect a waste incineration plant (in which the municipality of Nijmegen has shares) and a distribution network of the energy company Vattenfall in the city of Nijmegen. The aim was to provide affordable heat to citizens and meet local climate goals. Public participation in realising the primary infrastructure was needed because it involved high investments with a long payback period.
Model 4	Zaanstad	The project started as a municipal initiative to link heat generation and demand in the city while meeting local climate goals. Public participation was needed because of a lack of market interest.
	Montferland	The drivers of municipal participation in the project are to ensure affordable and sustainable heat for all residents because heat is a basic need and to avoid potential problems observed with market parties in neighbouring municipalities. Additionally, the municipality aims to establish an "open model" in the long term in which multiple sources and heat companies access the heat grid to supply their own customers.
	Apeldoorn	Similar motivations as in Montferland.
	Haarlem	Similar motivation as in Montferland.
	Deventer	The drivers of municipal participation in the project are to ensure affordable and sustainable heat for all residents because heat is a basic need and to have more public control on the roll-out of DH. Also, municipal participation was driven by a lack of market interest.
	Lingewaard	Similar motivation as in Montferland. Also, municipal participation was driven by a lack of market interest.
	Dukenburg	Similar motivation as in Montferland.
	GWIB	Similar motivations as in Montferland. Note GWIB is not a DH network but a regional vehicle to support local governments to provide expertise and financing, especially during the development phase, which is time and capital-intensive.
Model 5	Katwijk	Similar motivation as in Deventer.

prices if they stay below maximum gas rates. Rising gas prices cause DH prices to increase, even if the primary DH source is not based on gas. This tariff increase is difficult to understand for customers, but it is due to the correlation between electricity prices and national subsidies with gas prices. This issue affects public and private models (see rate increase in 2022 and 2023 of Figure 5).

In some case studies, there was a *lack of public control in long-term contracts* with private parties to expand the DH networks (Indigo and WbR in model 3) and to decarbonise the source (one case in model 4). Any conditions not well-embedded in the concessions were difficult to remedy later. The contracts did not offer the flexibility municipalities needed, and market parties seemed unwilling to negotiate or cooperate.

Despite the reasons for public participation outlined above, the national, regional and local governments acknowledge the importance of market parties in providing investment capital and expertise and play a prominent role in public projects, as seen in the models of Figure 2.

4.1.3. Public role in safeguarding public values

Different values are frequently cited in order to justify the public sector's role in protecting these. *Heat is a vital service;* everyone should have equitable access (*connecting different areas*) at reasonable costs (*affordability*). An important goal is ensuring that profitable and economically more challenging areas (typically with private households) are connected to DH and prevent cherry-picking, which is the course of past market developments. Although in the researched projects, public authorities start with the easy and most feasible projects, all have short-term plans to connect households of private homeowners in the following years (see Section 3.1 in Supplementary material).

The affordability of DH projects remains one of the main challenges. Public ownership is seen as a way to achieve the lowest costs. Municipalities have, for example, accepted low returns on investment[8] and considered longer depreciation periods than private parties in the business case (Table 5). There is a marked disparity of opinions between public and private entities regarding the appropriate level and responsible use of the returns made:

> "*Our business model saves 8–9 k euros per house compared to private parties. We use a 3% margin vs. the market parties' 6% return which includes a 16% return from shareholder capital. That is irresponsibly high for a vital heat service. Our risk analysis is robust but uses public and social assumptions, not private ones.*" [public party]
>
> "*Our profits are already maximised. Maybe it should be organised differently, that profits are allowed, but that the money is re-invested for the benefit of the Dutch State. Here municipalities are also guilty of selling own companies like Eneco to foreign countries.*" [private party]

Different opinions on this issue occur among public entities too. Public companies running for several years often use 6% (Eindhoven, HVC and SVP) and support the notion that the return on investment should be aligned with the project's risk profile. They argue that accepting a lower return brings unnecessary risks. What became evident in the talks with municipal officials is that they seek ways to lower the prices much more than any other partner. Municipalities seem to have accepted lower rates of returns when designing their business models respective other public partners, such as the spin-off companies of the electricity network operators and the respective regional government (e.g., in some projects of model 4). This has raised critical questions on how "public-oriented" other governmental organisations behave:

> "*Our assumed rate of return is 1%, but for the other two partners is 6%. Also, it was agreed that the returns of the other parties are realised first, and our returns come last. In a new agreement, I would demand equal returns. Honestly, if our public partners are so committed to the heat transition, it's weird they want such a return on their investments.*" [public party]

Supporters of public ownership argue that low costs and better transparency in the relationship between costs and tariff increases may *improve customer support and perception*. Complaints concern DH being expensive, the lack of transparency of private operators in tariff increases and lacking the choice between providers. The rationale is that groups of individuals would be more incentivised to adopt DH if they will not rely on a single private company and that local governments are deemed more trustworthy than firms. A municipality reported that citizens initiated (and won) a legal proceeding against their commercial operator because of double payments. Some municipalities (in models 4 and 5) wish to reduce the monopolistic nature of DH, enabling customers to exert some autonomy when choosing their future DH company.

Many governments supporting the unbundled model 4 believe that the public *role in the transport and distribution network*, as currently done for electricity and gas, is key because it is the most cost-intensive element and brings multiple benefits (Table 6), like allowing the optimisation of all energy systems. Here, they deemed the role of the current electricity and gas distribution system operators (DSOs) crucial. DSOs are logical municipal partners that share the same vision, are also public and can provide the capacity municipalities lack. However, there are several complexities and critics regarding DSOs' role in DH projects and the model 4 they promote (Section 4.2.2).

4.2. Critical views regarding public ownership

Private interviewees acknowledge the crucial role of public funding for economically challenging projects and view local governments as pivotal in facilitating the heat transition by coordinating various stakeholder interests (Figure 3). However, several interviewees question whether public ownership is the best strategy to address these issues. The points of concern are grouped into three categories (Figure 4) and elaborated below.

4.2.1. Alternative arguments on safeguarding public values

Accelerating the heat transition is a *shared public and private responsibility*. The realisation power must come from local, regional, and national governments, network operators, public and private investors, and DH firms. Likewise, achieving affordable, reliable and sustainable heat for citizens is fundamental in the discourse and decision-making of private parties. For instance, all interviewed private DH companies have sustainable goals, some very ambitious, such as becoming CO_2-neutral in 2035. Their short- and long-term strategies are drawn to meet these goals—including, in some cases, plans for a city to connect easy and complex buildings to DH. While market participants have traditionally focused on connecting "low-hanging fruit" areas, they are increasingly actively involved in pilot projects with existing private households. They believe that *cherry-picking,* or a more appropriate term, *starting with the feasible areas, achieves CO_2 reductions and builds scale* to expand to more complex areas gradually. Market actors also argue that despite governments' concerns about the use of profits in private projects, these are *used for social benefits such as investing in innovation* and, such as in Westpoort, *developing new networks*.

Interviewed public and private parties agreed that current problems are due to a lack of instruments to enable governments to steer the heat transition and that public ownership is not the only way to protect public values. These can be safeguarded through *an appropriate regulatory framework and well-design concession contracts* with market parties. The future Heat Act will include a cost-based tariff, and margins will also be maximised.

8 The return of investment is used to analyse and decide on the feasibility of the project and evaluate the potential return on invested capital. The higher the return, the better the expected financial project's performance and higher expected return to the company.

Furthermore, municipalities will also be able to designate DH zones, including the desired areas to connect. Local governments will also have means from 2024 to force residents to switch to sustainable heat sources, an instrument that will be crucial to accelerate the heat transition. Concession contracts can be drafted with some flexibility to deal with unanticipated development changes and provisions for the private party to implement in specific situations.

Having a cost-based tariff and maximising profits is thought to protect customers. Some actors do not support the idea that public ownership would increase citizens' support for DH. Customers appreciate other factors over the company's ownership:

> "*The belief that public ownership alone can improve customer satisfaction is misguided. Other factors such as financial stability, sustainability, low rates, and reliable supply make customers happy, not the ownership structure.*" [public party]

4.2.2. Existing and emerging public models raise critical questions

Some private and public parties are questioning the government's proposal to exclusively allow public configurations because the effectiveness of the public models has not been proven. There is limited experience with some public models, with established projects even viewed as successful. This reasoning was also used during the interviews to support the need for allowing both public and private configurations to coexist.

Inadequate decision-making of local governments influenced by political choices has led to negative outcomes in the past. An example frequently used is WbR. Two important lessons can be extracted. First, political pressure and ambitions to achieve climate targets partly drove poor due diligence. WbR signed a take-or-pay contract of 30 years with the heat producer while also taking the demand risk without being able to control these risks. WbR had excess heat that it could not sell, undergoing significant financial losses. Second, the public partners were heavily dependent on the skills and expertise of other private partners. The small organisation and insufficient competencies in WbR could not sufficiently manage the accumulation of risks and complexity. However, the problems behind WbR tend to be oversimplified. The project involved a long trajectory with many complex and unforeseen circumstances playing a role (e.g., changes in construction plans due to the economic crisis holding back the expected demand). See Supplementary material (Section 3.1) and Onderzoekscommissie Warmtebedrijf (2020).

The *poor economic performance* of two public companies is mentioned as the risk of the public models. The constantly failed business operations in the WbR have led the public shareholders to the company's recent sale to a private party. SVP has taken 25 years to reach the first positive results—see Supplementary material (Section 3.1).

Fifty-seven percent of public interviewees also acknowledge the *lack of expertise and capacity* (i.e., FTE) within local governments (Figure 4) for the heat transition. Nevertheless, not all municipally-owned companies experience these issues. HVC, for instance, has reached high professionalisation due to regional cooperation between municipalities. This has also reduced the impact of local political choices—see Section 3.1 of the Supplementary material.

Unbundled configurations are gaining in popularity among public authorities who see significant advantages (Table 6), but these are discredited by other parties. This configuration is considered *costly, complex and insufficiently demonstrated* (Table 7). Vertical integration optimises management and reduces costs, eliminating transaction costs (from multiple contracts) and profit margin stacking (from risk division). The project in Westpoort demonstrated the advantages of vertical integration, avoiding unnecessary margin stacking (Table 4). Indigo and WbR, with long-term binding agreements between different actors, have shown that contractual relations are challenging to revert when unforeseen events occur and that not all parties share the same interests. Thus, vertical integration can also ensure shared vision and interests, aligning technical, financial and legal responsibilities and climate ambitions. Although the upcoming Heat Act specifies that in model 4 one entity should ensure the overall system's reliability, affordability and sustainability, contractual agreements will be needed between different legal entities.

For the current phase, though, half of all interviewees believed that the costs of unbundled models are higher than integrated networks. A private company estimated a 20% increase in total costs in one case study. However, public parties choosing this model also consider other benefits (Table 6) and claim that dividing risks and responsibility occurs in traditional projects (e.g., between heat producers and DH companies). They argue that transaction costs are a small portion of total project costs and that growing experience with these configurations will lead to standard contracts and reduced costs.

Advocates of full unbundling seek to establish a "free-market" model in the long term. Critics of this concept argue that comparing DH systems with the electricity market—very liquid and with many sellers and buyers—is impossible. DH projects are small, unlike electricity grids, because of high transmission losses; 25% per 100 km in regional DH grids compared to 1.5% for electricity grids (It's public, 2021).

Model 4 is *unattractive for some private parties,* requiring a significant change in their business model (Table 7). These companies prefer entering public or semi-public vertical configurations (like in Westpoort) or using traditional DBFMO contracts. Nevertheless, unbundled models are attractive to smaller market players whose focus is not on operating large networks but on developing small heat generation and storage systems (e.g., heat pumps and aquifer thermal energy storage). Their expertise is in installation systems but not pipeline infrastructure. The latter accounts for only 10% of their capital investment. Unbundled configurations have created opportunities for these new entrants, reflected in the growth of projects they participate.

Some market parties have suggested that choosing to unbundle the chain entirely is not a result of considered decision-making in which all possible options and implications have been thoughtfully assessed but a consequence of the partnership with a DSO. In this configuration, municipalities (sometimes with the regional

government) partner up with a spin-off of the current electricity and gas DSOs—namely, Alliander, Enexis, and Stedin. These DSOs, which are also public companies, have established spin-offs to gain experience in the heat sector and to meet the needs of various municipalities (i.e., having an independent and public partner with knowledge of network management). Their spin-offs (Firan, Netverder, and Enpuls) operate under the same legislation as their parent company, restricting them from operating in both production and the retail markets and limiting their activities to only transportation and distribution. The *influence of this partnership* is recognised in three case studies developing model 4.

Regulatory changes may solve the problems outlined. A review of regulations is proposed to expand the permitted activities of the spin-offs of the DSOs, allowing them to operate as integral heat companies or form joint ventures with various suppliers (Netbeheer Nederland, 2022). Nevertheless, not all companies approve of this change:

> "*We strongly oppose that as it will violate the unbundling energy law and the commercial playing field. What's next? Allowing these operators to play a role in electricity generation and supply?*" [INT-18, private party]

Parties question the *role of the DSOs' spin-offs*, which act as public or private actors depending on the circumstances, asking for high market returns (Table 7). Although their shareholders are local and regional governments, the spin-offs are legally established as private companies.

4.2.3. Risks of prescribing public ownership

If all new and existing DH projects will be public or semi-public, as proposed by the central government vision, has generated support among some parties but has also intensified opposition, especially among large private companies. Fifty-two percent of all interviewees, including public and private actors, disagree with having a generic obligation and see public and private models could coexist:

> "*Private models could also be possible under the new regulation. That has always been our position. However, the final decision rests with the minister, who determines the best approach to handle the heat transition nationally.*" [INT-26, public party]

Offering flexibility allows the most appropriate governance configuration (municipality as facilitating party or as the project owner) to be selected per project. Different configurations could coexist, as is happening now. Within the North Holland region, four models are found: SVP (model 1, municipal company), HVC (model 1, regional collaboration), Westpoort (model 2, PPP) and Haarlem (model 4, PPP; Table 4). Private models have also brought positive achievements and *have proved to be workable* in the cities where they operate. An example is Wespoort, a long-standing PPP that has succeeded but is not allowed in the legislative proposal under the majority public share rule (Table 1).

Additionally, the question remains whether all local governments are interested in taking the enormous responsibility and risks a municipal energy company means. In this scenario, the relevance of the other parties, either private or public (e.g., existing electricity and gas DSOs), becomes very important. Additionally, some concerns indicate that prescribing public models may lead to forced partnerships that may not be effective (e.g., model 4) or promote small systems, as there is a regulatory exception for projects under 1,500 home-equivalents that can remain private.

Some parties have stated that public ownership alone does not *guarantee a faster heat transition*, and there are concerns that it could slow it down for various reasons. Existing public models (e.g., HVC, Purmerend and Groningen) are difficult to replicate in the short term, requiring resources, substantial professionalisation and new governance models not present in many municipalities now. Excluding the private model entirely, especially when the public route has not been demonstrated to be better, could hamper the speed. Private parties and investments may be set on hold, as has happened already in one case study (model 4) and have been publicly announced by large DH firms (PwC, 2022). As explained earlier, several existing private parties must then also redesign their business models.

Furthermore, even though collaboration between public and private actors is expected, private parties face disadvantaged decision-making as public actors hold the larger share of the distribution and transport network. This can hinder private shareholders from providing financing for projects. Moreover, some parties expressed concern that the slow decision-making process of government organisations will impede the necessary speed in achieving goals.

Another mentioned argument in the interviews is that *public ownership does not guarantee lower costs* because this has not been demonstrated, and even existing examples show poor economic performance. One interviewee suggested that the hidden costs in public models, such as hiring external advice and the long decision-making, are often underestimated. Private parties look with very different glasses at the public argumentation to lower profit margins to decrease the project's final costs (Table 5). They believe this approach brings higher and unnecessary risks.

4.3. Synthesis and reflection on the identified drivers for choosing public ownership

Table 8 shows our analysis of the validity of the identified arguments justifying public ownership. These are categorised into three groups: (i) issues that will be fully or partially solved by upcoming regulation; (ii) unclear aspects requiring further research; and (iii) issues that may justify public ownership as the preferred option.

Although fundamental issues justifying public ownership hold weight at present, a closer look into the future reveals that some of these will likely be solved or minimised by the upcoming Heat Act 2.0 (Dutch Ministry of Economic Affairs and Climate, 2022b). The regulation will implement a cost-based tariff system, maximum profits and transparency rules. Combining these measures with consumer price benchmarks has proved fundamental to ensure

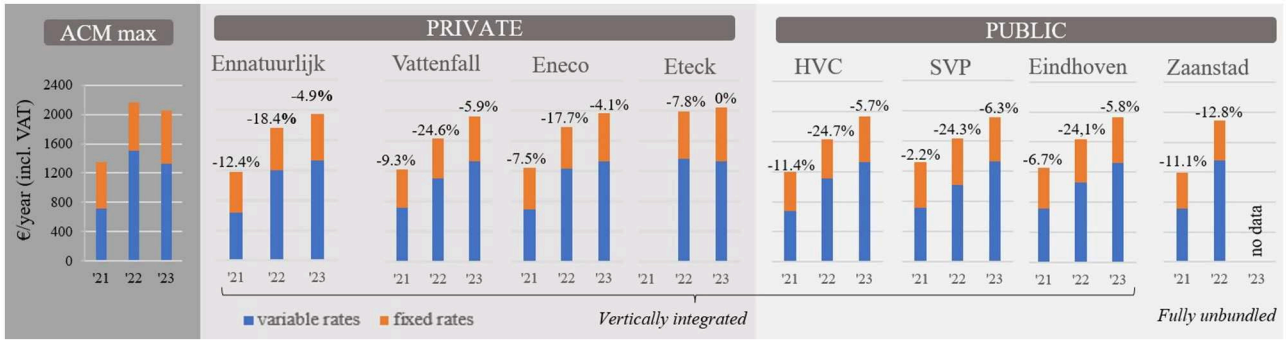

FIGURE 5
Yearly average rates paid by customers connected to public and private companies in 2021, 2022, and 2023 compared to the maximum rate based on a gas cap set by the Regulatory Authority ACM. Variable rates are calculated considering 28 GJ annual use. Data exclude the one-off installation fee. Numbers on the top of the bars give the reduction rate compared to the ACM maximum tariffs. Own figure elaborated with data from Atriensis (2021), Ennatuurlijk (2021, 2022, 2023), HVC (2021, 2022, 2023), SVP (2021, 2022, 2023), Vattenfall (2021, 2022, 2023), Berenschot (2022), Eneco (2022, 2023), Eteck (2023), Municipality Eindhoven (2023), and Woonbond (2023).

TABLE 5 Approaches adopted in some case studies to reduce costs or reach financial close.

Approaches	Lines of reasoning
Local governments can accept low returns on investment and price risks more leniently in view of achieving wider public benefits	Commercial DH companies are not flexible in their economic margins and strive for profit maximisation. Local governments see DH as a social task accounting for broader social values in their decision-making and less as a revenue model. This makes it possible to accept low investment returns (1% in Zaanstad and 3% in Deventer) or price risks more leniently to achieve long-term goals and benefit the local community. Lowering the investment's return can help achieve the project's financial close and decrease the tariffs. Lower tariffs may increase the attractiveness of DH as a sustainable alternative for future customers. Therefore, the risk premium to cover demand uncertainties can be lower if more people connect.
Use of long depreciation periods	Public ownership allows for a more extended depreciation period for fixed assets than private parties consider. This reduces the size of the regular payments by spreading these out over a more extended period. This approach is used by Deventer (model 4) and Katwijk (model 5), where the municipality considers 50–70 years of depreciation of the pipelines (see details in Section 3.1 of Supplementary material).

low rates and prevent companies from circumventing rules in other contexts (Odgaard and Djørup, 2020). The regulation will also allow municipalities to designate DH zones, serving as a mechanism to avoid cherry-picking. Additionally, the municipal role in carrying out heat mapping, planning and implementing local strategies gives them more steering options to safeguard public values and prioritise goals and benefits for the community.

Other aspects supporting public ownership (compared to the private route) will need further research before drawing conclusions, such as whether public ownership will improve current concerns among DH customers (Table 8). End-users will have freedom of choice ex-ante as the Heat Act 2.0 will not involve a mandatory connexion. Achieving competition ex-post in the long term (through, e.g., model 4) is theoretically possible but very questionable. Mature DH networks in other countries have not introduced such a design for cost-efficiency reasons (Burger, 2001; Tieben and van Benthem, 2018).

Minimal differences exist among existing public, private, integral and unbundled projects (including two of our case studies) on realisation speed, sustainability level, prices and supply security (Berenschot, 2022). When comparing yearly average rates of public and private companies and unbundled vs. vertically integrated projects, one cannot conclude that a configuration offers lower tariffs over another (Figure 5). The ranking also varies yearly. The tariffs in Figure 5 give average rates because companies usually establish a single rate for all their clients. Consequently, there will be situations where the actual costs are higher or lower than the average numbers shown. Since costs can vary locally very much—see, for instance, Næss-Schmidt et al. (2021)—further research will be needed to understand the impact of ownership and unbundling levels on the final rates of various projects. The upcoming tariff-setting and increased transparency could clarify the actual differences. Furthermore, competition with other technologies, such as heat pumps, may reduce DH prices when switching costs are low (Söderholm and Wårell, 2011).

Public ownership may be preferred or remain necessary in some situations. Instead of providing subsidies to market parties, some local governments advocate starting their own company because this can achieve cost benefits and ensures that benefits stay within the community. The fact that two of the largest private DH companies with significant market shares of the DH sector (i.e., Vattenfall and Eneco) have foreign shareholders has driven some local governments to prioritise local growth when considering the impact of their investments. Additionally, since profit motives do not drive municipal objectives, they may be more patient and willing to wait for long-term benefits than private parties (Bakker et al., 2022) and sacrifice their investment returns to achieve financial close (Table 5).

Public ownership can also make sense when outsourcing and long-term contracts are too risky. The long-term nature of DH projects, involving high uncertainty and risks (e.g., demand uncertainty), makes it very difficult to establish the responsibility of

TABLE 6 Expected benefits of unbundled networks in which public ownership takes place in the transport and distribution network (model 4) according to interviewees.

Expected benefits of model 4	Lines of reasoning
Control of DH development	Draw strategies at the city level that avoid cherry-picking.
	Exercise control on linking supply and demand.
Increase costs transparency	Having various parties operating in the DH chain will bring more transparency between the parties when allocating costs compared to vertically integrated models. This can help reduce costs and improve customer perception.
Long-term vision to achieve a "free-market" model to allow competition	To connect multiple sources and allow different heat suppliers to access the network, similar to the electricity market. This may deliver some form of competition, giving customers more freedom of choice. Supporters of this concept acknowledge that achieving such competition will not work in some cases and is abstract at this stage.
Optimisation of all energy systems, instead of only looking at the heating system	The optimisation should be sought across all energy carriers (heat, electricity and gas) in DH projects. As the current electricity and gas grid operators are involved in projects under model 4, they can look at optimising the energy system.

TABLE 7 Complexities associated with unbundled networks in which public ownership takes place in the transport and distribution network (model 4) according to interviews.

Critical views of model 4	Lines of reasoning
Costly, complex and insufficiently demonstrated	Vertical integration can reduce costs avoiding high transaction costs and stacking profit margins from multiple actors operating the different elements of the DH chain. The alignment of goals and interests becomes complex if the number of parties involved increases. A "free-market" concept, as with electricity, is not possible. DH systems are very local, usually small, and do not have the same liquidity. There are not enough experiences with these models to prove their effectiveness.
Unattractive business model for some parties	Traditional DH large companies have been running projects in a vertically integrated manner for a long time, and their investments in the primary and distribution networks represent 80% of their CAPEX. They have gained substantial expertise in developing and exploiting this infrastructure over the years. Therefore, losing this part of the DH chain significantly impacts their business model and competitive position. Finding financing can also be challenging for market parties as they lose control of the risks over the entire chain.
Influence of the role of network operators (DSO) in choosing model 4	Model 4 is not a result of considered decision-making, but it has been influenced by the partnership with a network operator and the legal restrictions that impede them from taking activities in production and supply.
Public/private character of spin-offs of the DSOs	The internal rate of return these parties demanded on their investment capital is too high (usually 6%) and is compared to market-based rates. The rate is typically higher than what the municipality is willing to accept to lower the tariffs (Section 4.2.1). Also, market parties criticise this as too high for a public party only playing a role in transport and distribution, which has lower risks in exploitation than in generation and supply. Six percent is a typical return used for vertically integrated projects, thus, also including production and supply.

the contracted parties in advance for every potential contingency. In contrast, a government, fully or partially owning a firm, can control all decisions over time (Mansor and Rashid, 2016). Yet, outsourcing could be preferable in other situations, e.g., in projects with limited uncertainties and risks or for municipalities with financial and capacity constraints.

Based on the issues discussed, we are returning to our second research question, "*When evaluating the validity of the arguments that support public ownership, would implementing public ownership at a national level be a good strategy?*" The answer is not simply yes or no. On the one hand, we understand the State is trying to steer the market and provide a clear strategy to follow in the coming years. It is a political decision, as often nationalisation or privatisation decisions are (Hart, 2003). The central government chooses a stance to bring heat provision under public responsibility, such as other vital infrastructure already is, and it was before the energy liberalisation. Another plausible reason behind the government's proposal is to avoid private companies circumventing regulatory rules, as observed in a few cases in Denmark (Djørup et al., 2021). Public ownership can enhance the current bargaining power of local and regional public authorities with the leading heat companies, which are typically large commercial multinationals. However, public ownership in DH means rapidly expanding the current (private) knowledge base in the public sector. The State recognises this challenge and relies on the current electricity and gas DSOs. These public entities can play a vital role in deploying DH systems, promoting public interests from a broad societal perspective and working towards a climate-neutral energy system (Netbeheer Nederland, 2022). They are experienced parties whose decision-making focuses on optimising all energy carriers, a crucial integration for the latest generation of DH and the overall energy transition.

On the other hand, we could respond to the question with a negative answer. Considering the aspects and uncertainties described in this section, it may be premature to mandate public ownership nationwide. Instead, it might be more prudent to remain flexible and wait for the effect of the new Heat Act and other measures on the development of DH projects. Such a mandate promotes a one-size-fits-all approach that may limit local choices. Municipalities lacking the resources or confidence to establish their public DH company or partner with private entities could benefit from having access to all options, including full private ownership through concessions. Besides, a nationwide mandate may also prevent organic system dynamics from evolving. In

TABLE 8 Authors' analysis of the validity of arguments identified in the research justifying public ownership.

	Argument	Is it a critical argument for choosing public ownership?
Issues fully or partly addressed by (upcoming) regulation or other instruments	Cherry-picking Connecting different possible areas	No, the Heat Act 2.0 will allow municipalities to design zones in municipal areas where customers will be connected to DH. This will allow them to control the network's development and prevent cherry-picking. In other countries, cherry-picking is a common strategy for the rapid development of DH where, for instance, flat blocks are first connected at low costs. If the project runs well and there is a solid business case, expansion to more expensive homes follows (Akerboom and Huygen, n.d.). Furthermore, cherry-picking of large customers will probably not occur in low-temperature DH systems to the same extent as with high-temperature DH systems, as the former are flexible and built modularly. LT systems are expected to play an essential role in the future energy system by being efficient and allowing the integration of various heat sources (Expertteam Energiesysteem, 2023).
	Lack of transparency of incurred costs and level of profits made by private firms Ensure affordability	Probably not, as new regulatory changes will significantly improve the current problems. The Heat Act 2.0 will implement a cost-based tariff, decoupling the tariffs from natural gas prices and reflecting the true costs. Prices will be set at a level where the DH company receives a reasonable return on its invested capital and associated risks. To stimulate efficiency, benchmarks will be introduced. The Heat Act will also set transparency standards for companies. It remains to be seen whether public ownership combined with tariff regulation might be more effective in achieving low tariffs than a tariff regulation alone. In Denmark, examples of municipal and, especially, consumer-owned DH companies have shown to be more successful in achieving low rates than private companies in the presence of price regulation (Djørup et al., 2021).
	Economic performance as the leading priority of private firms	No, e.g., the Heat Act 2.0 will set sustainability standards and safeguard the quality of the heat supply. It will also allow municipalities to prevent cherry-picking. Governments can set a concession agreement with goals other than financial indicators (e.g., desired realisation speed).
	Democratic representation of public interests, holistic planning	No, key public values (regulated rates, security of supply, sustainability, no mandatory DH connexion) will be regulated by the Heat Act 2.0. Municipalities lead the implementation of local heat strategies (Herreras Martínez et al., 2022) and safeguard local interests (e.g., easing the nuisance of switching to a new heating system and determining the timing and location) by coordinating and facilitating.
Unclear issues, further research needed	Increase speed heat transition Meeting local and national climate ambitions	Unclear; new regulation plans to give municipalities in 2024 the legal power to stop the natural gas supply in buildings (Dutch Ministry of Housing and Planning, n.d.). This can increase the urgency among homeowners to switch to sustainable sources. However, it is uncertain whether ambitions will be met at a faster speed through public ownership. Past research does not show differences between the realisation speed of public and private models. Different arguments can be considered on public ownership's effect on speed. Some of our case studies showed that public ownership could ensure that specific projects with uncertain and long-term low returns take off the ground. On the other hand, as stated in the interviews and a recent report (PwC, 2022), transitioning to public models may cause delays due to the lack of municipal capacity and the potential resistance of private parties in stepping in PPP with a minority private share.
	Improve customer support and perception	Public role is needed, but not necessarily ownership. Municipalities will be crucial in creating awareness within their community and encouraging the adoption of sustainable heat systems. However, whether public companies will count on greater acceptance than private companies is unclear (PwC, 2022). Complaints about DH being expensive and the lack of freedom to choose a DH operator are the primary concerns of customers across public and private projects (Interwhere, 2019; Holtland, 2022; van der Woude, 2022). Holtland (2022) underlines that clients of public companies seem slightly more satisfied due to perceived low prices and sustainability levels. Nevertheless, Hotland's study is based on one-time measurement, and other studies yield different outcomes (Berenschot, 2022).
Issues that may justify public ownership as the preferred option	Public responsibility to support economically challenging projects and minimise demand risks	Public role is needed, but not necessarily ownership in all cases. Commercial parties need public financial contribution to cover the economic gap of projects connecting existing households, representing the largest bulk of total projects. Economically-challenging projects are piling up under the government's responsibility. Municipalities can choose between insourcing (own company) and outsourcing services with public co-financing. Both approaches are possible and bring advantages and disadvantages. The choice between these and other in-between options (e.g., joint venture) could be made locally. The public role is also needed to mitigate the demand risks (e.g., via guarantees, raising awareness to adopt a new heating system). Having the legal power to end the natural gas supply will reduce demand risks compared to now. However, a certain level of risk will remain as no mandatory connexion will be introduced by the Heat Act 2.0.
	Lack of public control in long-term concession contracts with private firms	Yes. Theoretically, a government does not need to own a firm to control its behaviour: financial or other goals can be achieved via a comprehensive contract. However, our case studies, and, in general, long-term infrastructure contracts (Mansor and Rashid, 2016), showed that these could be incomplete and challenging to cover unforeseeable situations. This requires municipalities to look very far ahead in a rapidly changing market. While including some degree of flexibility in the contract will allow periodic renegotiations, it will result in higher transaction costs than a rigid contract (Saussier, 2000).
	Heat is a vital service Public role in transport and distribution (model 4) to safeguard public values	Yes. Governments have a central role in the provision and regulation of heat. Since electricity and gas grids are already owned and managed by (public) DSOs, heat is a logical next step. From this perspective, the current DSOs' role, having a public function, could be vital in ensuring integral and optimised decisions at the system level. Their knowledge of electricity and gas management can be applied to DH systems (Netbeheer Nederland, 2022). Although the DSO's role and permitted activities in the expansion of DH are still uncertain (Netbeheer Nederland, 2022), the Regulatory Authority recommends rules to ensure heat activities do not jeopardise the adequate and independent performance of their statutory responsibilities in gas and electricity (ACM, 2020).

past heat transitions, established organisations were reorganised and aligned their goals with new societal objectives (Turnheim and Sovacool, 2020; Bertelsen et al., 2021). This transformation is also happening in the Dutch context; traditional vertically-integrated private companies experiment with new business models in unbundled configurations. DSOs are widening their traditional activities. Some local and regional governments are becoming more entrepreneurial instead of taking a role at a distance.

Other countries with large DH shares and dominant publicly-owned companies do not prescribe the ownership type. Instead, they proactively established conditions to protect public values and foster DH expansion. For example, cost-based tariffs combined with a non-profit principle in Denmark have resulted in a predominantly public sector (Geletukha et al., 2016). Danish projects should meet socio-economic criteria and receive approval from municipalities (Bertelsen et al., 2021). Establishing DH zoning with mandatory connexion has reduced the demand risks and facilitated access to debt funding on non-commercial terms boosting DH growth and decreasing DH prices (Galindo Fernández et al., 2016; Johansen and Werner, 2022).

5. Discussion

5.1. Contribution of findings to the (re)municipalisation literature

Local and regional governments in the case studies were driven to establish heat companies to meet social objectives, control public services, and address the shortcomings of private arrangements. These municipalisation drivers are similar to those observed in other sectors and countries in international published literature (Albalate et al., 2020) and the DH sector in particular. See, for example, a lack of financial transparency in Lithuanian private contracts (Kishimoto and Petitjean, 2017). Germany has used insourcing to reduce costs (Weghmann, 2020). The first signals of public ownership in the British DH sector are rising to protect consumers and invest in infrastructure with uncertain returns for the market (Hawkey et al., 2013; Bush et al., 2016; Britton, 2018). The investigated case studies diverge from other national studies on (re)municipalisation as these are not isolated occurrences but are part of a nationwide movement in the Netherlands.

We identified in our paper some drivers that apply to the Dutch context specifically, i.e., public involvement to enhance customers' support for DH, as DH is not as positive as in other countries (Næss-Schmidt et al., 2021). Similarly, public ownership of the DH grid (model 4 in Figure 2), aiming to achieve an electricity-like configuration, is partly a result of the new collaborations created between local governments and the existing DSOs. Such configuration is a novelty as projects in other countries are usually integrated infrastructures for economic and operational efficiency and the small volume of DH grids, making it challenging to create fully competitive market conditions (Söderholm and Wårell, 2011; Djørup et al., 2019). Extensive and mature grids (e.g., in Copenhagen and Warsaw) are neither fully unbundled nor open (Burger, 2001).

Unlike previous studies concerning (re)municipalisation, we shed light on the potential resistance of private parties and the disparities in views among public and pro-commercialisation advocates on how to move forward. Some private actors prefer outsourcing and contractual relationships with public co-financing over public ownership. Public officials prioritise social goals ("DH as a public, affordable and fair good"), while firms' decisions seem to be led by more business-like indicators ("DH as a commodity with regulated returns that can be used for reinvestments and innovation"). According to public stakeholders, cherry-picking is a major issue, while market parties think it is a good strategy to achieve the necessary scale during the initial phase. Public and private actors also have different governance norms (e.g., costs transparency vs. commercial confidentiality, managing political agenda vs. shareholder's interests). While some differences stem from each organisation's public/private nature, they highlight potential organisational challenges of public models (or municipalisation movements), including private participation. Earlier studies that have researched alternative governance structures outside the (re)municipalisation literature also highlight potential barriers in the adjustment of existing constellations and established entitlements, in the alignment of stakeholder interests, and the need to change prevailing business models (Meadowcroft, 2011; Proka et al., 2020; Schilstra et al., 2021; Harvey-Scholes et al., 2022).

Our research shows that the current discussion around public ownership goes beyond the previous narrow debate on the pros and cons of private vs. public ownership that dominated the privatisation era of the 1990's, e.g., efficiency gains vs. political interference (Shleifer, 1998). Today's discourse encompasses broader topics, such as sustainability ambitions and a lower willingness to depend on market parties to reclaim vital services and local empowerment. This desire has led to novel governance modes. Past studies have emphasised that citizens, driven by a similar desire, can also take the lead in such governance models (Hall, 2012; Blanchet, 2015; Becker et al., 2017). Studies from various disciplines—e.g., governance (Hoppe and van Bueren, 2015; Albalate et al., 2020; Kishimoto et al., 2020) and social innovation and transition studies (Hoppe and De Vries, 2018; Itten et al., 2021; Dall-Orsoletta et al., 2022) agree that new forms of ownership from local governments and communities are a manner to achieve energy democratisation, and ultimately, empower local solutions and social wellbeing.

5.2. Limitations and research recommendations

We acknowledge a set of limitations. As shown in Section 4.3, arguments raised during the interviews may rely on perceptions. As such, a quantitative analysis of the efficiency and impacts of various models would complement our initial qualitative study by assessing the total costs of government intervention against the actual benefits (e.g., affordability, realisation speed, and sustainability levels) between different public, private and PPP configurations. When would public ownership be preferable over outsourcing? Will the national costs in public companies offset the potential benefits like reducing tariffs and increasing citizens' support? And how do the benefits of public ownership in unbundled

models compare with the potential expenses of sacrificing efficiency gains in vertically integrated structures? Assessing these trade-offs between projects already running for several years will help the central and local governments to know why and when it makes sense to adopt different models, and at what cost. Such analysis could also include the governance model with consumers' and citizens' ownership, which is not embedded in this research but is expanding quickly in the Netherlands and globally.

A broader stakeholder and case study sample would offer a more comprehensive view of perceptions. In the interviews, it was visible that critical views illustrate the shortcomings of a few experiences with private/public models, while past and more positive results from both models are often left out of the discussion. This could derive from the study's participants (public and private actors actively involved in public initiatives and/or with clear stances concerning public ownership). Likewise, the positions of the final customers on the preferred ownership structure and heat system (DH vs. individual systems) can provide valuable insights into how customers might respond to the successful implementation of planned measures.

6. Conclusion

After decades of privatisation of utility services, the world is witnessing reverse trends. Cities are taking up services of social importance under the (re)municipalisation movement. The Netherlands is no exception; in 2022, the central government proposed that all new and existing district heating networks become public or semi-public (with a majority public share). This proposal arises from the pivotal municipal role in implementing local heat plans and argues that district heating is a crucial infrastructure with monopolistic features and, thus, should be publicly owned.

This study examined 16 Dutch public district heating projects, and uncovered the main arguments and points of consensus and disagreement among public and private stakeholders for and against a public-oriented sector. The main findings are as follows:

(1) While there are limited cases of established public companies, the need for public ownership has increased after the unique role assigned to municipalities in the heat transition. Drivers for public ownership include ensuring low rates, meeting climate ambitions, creating strategies that connect low profitable areas, increasing cost transparency, and gaining citizens' support. Some believe these values are not always apparent in the profit-driven models of current market arrangements. Three case studies have experienced imperfect contractual agreements with private parties. Public ownership in the transport and distribution network in fully unbundled configurations, similar to the "electricity model," is gaining popularity. The configuration aims to interconnect different areas and sources, potentially bringing some form of competition in the long term.

(2) Sceptical opinions regarding a public-oriented sector challenge the actual advantages of public models, underlining that some projects have been unsuccessful, and those that have been effective are difficult to replicate in the short term. The uncertainties also apply to emerging fully unbundled configurations, which stakeholders argue can be costly and complicated compared to integrated models. The role current electricity and gas network operators have played in stimulating the adoption of unbundled projects is being questioned by some interviewees. Some parties suggested that public values can be protected through regulatory frameworks and well-designed public-private contracts, making public companies unnecessary. Market parties often prefer traditional outsourcing with public co-financing over government ownership.

(3) Despite the distinct views and the limitations of public and private models highlighted, public and private actors acknowledge the importance of the other's role in accomplishing what both sides struggle to do alone. Centraal government intervention is key in covering the financial gap, current demand, and regulatory uncertainties. Market parties are essential in providing capital, expertise, and other services in public models. Another point of agreement between public and private stakeholders is that a requirement for public ownership may limit flexibility, excluding other workable models.

(4) Reflecting on the study findings, it is debatable whether mandating public ownership nationwide, as proposed by the Dutch central government, currently should become the approach to tackle current challenges instead of allowing more flexibility at the local level. On the one hand, key issues justifying the need for public ownership (e.g., ensuring affordability and avoiding cherry-picking) will likely be lessened or solved through upcoming regulations. Also, it is planned that municipalities in 2024 will have the legislative power to ban natural gas use in existing buildings, which may minimise the demand risks and foster the achievement of climate goals. Besides, a nationwide prescription of public ownership may limit local choices. Municipalities lacking the resources or confidence to establish a public company or partner with private entities could benefit from having access to all options, including full private ownership through concessions. Other aspects supporting public ownership compared to the private route, such as enhancing citizens' support and increasing the realisation speed, will need further research before drawing conclusions. However, public ownership may remain necessary if social and cost benefits can be achieved or when long-term contracts are too risky.

Two policy implications are drawn:

(1) As in past heat transitions, the large-scale deployment of district heating systems will require substantial public and private participation. Developing a shared vision, trust, and successful cooperation might take time to develop fully, being essential to approach this process with patience. Our work has helped to map the different opinions between public and private partners, highlighting potential organisational difficulties in the joint-decision

making. These challenges will be particularly prominent in new collaborations and business models. Under the majority public share rule, the incentives for private companies to invest in public projects in the short term are small, considering market parties would lose control of the decision-making while remaining financially responsible. Also, the configuration in one case study, a long-standing and successful PPP, will not be allowed under this condition.

(2) Establishing timely regulations to protect public values may be more critical in the early stages of a heat transition than prescribing nationwide public ownership. Although the Dutch government's proposal attempts to steer the market and provide a clear strategy to follow in the coming years, a one-size-fits-all solution ignores that there may be significant differences and preferences locally. Central governments in other countries with large district heating shares and dominant publicly-owned companies proactively have established the right conditions to protect public values, allowing different ownership models to coexist. A generic obligation may prevent the benefits of other models and hamper organic reorganisations. New insourcing and outsourcing models will likely continue to emerge. When public values are safeguarded by regulation, steering the most suitable organisational form per project may be preferable at the local level in the early phases of transitioning to sustainable heat systems.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

SH is the lead author. All authors listed have contributed directly to the work and reviewed and edited the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2023.1220884/full#supplementary-material

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