Research Centre on ZERO EMISSION NEIGHBOURHOODS IN SMART CITIES

ZEN AND DISTRICT HEATING

Tensions and opportunities

ZEN MEMO No. 60 – 2024

Victor Andreu Banuls Ramirez, Haiping Shen, Laura Campagna, Giulia Vergerio, Stian Backe | NTNU, SINTEF

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Norwegian University of Science and Technology (NTNU) | www.ntnu.no
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Preface

Acknowledgements

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The Research Centre on Zero Emission Neighbourhoods (ZEN) in Smart Cities

The ZEN Research Centre develops solutions for future buildings and neighbourhoods with no greenhouse gas emissions and thereby contributes to a low carbon society.

Researchers, municipalities, industry and governmental organizations work together in the ZEN Research Centre in order to plan, develop and run neighbourhoods with zero greenhouse gas emissions. The ZEN Centre has nine pilot projects spread over all of Norway that encompass an area of more than 1 million m2 and more than 30 000 inhabitants in total.

In order to achieve its high ambitions, the Centre will, together with its partners:

- Develop neighbourhood design and planning instruments while integrating science-based knowledge on greenhouse gas emissions;
- Create new business models, roles, and services that address the lack of flexibility towards markets and catalyze the development of innovations for a broader public use; This includes studies of political instruments and market design;
- Create cost effective and resource and energy efficient buildings by developing low carbon technologies and construction systems based on lifecycle design strategies;
- Develop technologies and solutions for the design and operation of energy flexible neighbourhoods;
- Develop a decision-support tool for optimizing local energy systems and their interaction with the larger system;
- Create and manage a series of neighbourhood-scale living labs, which will act as innovation hubs and a testing ground for the solutions developed in the ZEN Research Centre. The pilot projects are Furuset in Oslo, Fornebu in Bærum, Sluppen and Campus NTNU in Trondheim, Mære Campus, Ydalir in Elverum, Campus Evenstad, Ny by-ny flyplass Bodø, and Zero Village Bergen.

The ZEN Research Centre will last eight years (2017-2024), and the budget is approximately NOK 380 million, funded by the Research Council of Norway, the research partners NTNU and SINTEF, and the user partners from the private and public sector. The Norwegian University of Science and Technology (NTNU) is the host and leads the Centre together with SINTEF.

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Norsk sammendrag

Miljøpåvirkningen av fjernvarme, spesielt i fjernvarmeområder med direkte klimagassutslipp fra avfallsforbrenning, kan tolkes å være i konflikt med utvikleres visjon om å utvikle nullutslippsnabolag (ZEN). Kostnadsbekymringer, samt mangel på fleksibilitet og påvirkning ved valg av energiløsninger i nabolag, kan også skape frustrasjon når utviklere av ZEN må koble sine prosjekter til fjernvarmesystemer på grunn av regulatorisk rammeverk. Denne rapporten utforsker spenningene mellom fjernvarmebransjen og utviklere av ZEN. Vi kartlegger nøkkelområder som bør videreutvikles for å skape muligheter for samordning av ambisiøse klimamål.

Datainnsamlingen inkluderte nettintervjuer for dypere innsikt og en spørreundersøkelse for å vurdere forståelsen av barrierer, utfordringer og løsninger fra ulike perspektiver.

Spenninger mellom fjernvarmebransjen og ZEN-utviklere handler om ulike roller, ukoordinerte klimastrategier, begrenset valginnflytelse på varmeløsninger, og kostnadsbekymringer.

Fjernvarmeselskapene er klar over at direkte CO2-utslipp fra avfallsforbrenning er problematisk, men de fremhever også at avfallshåndtering er et samfunnsproblem som delvis må løses med forbrenning. Noen utviklere mener avfall ikke bør være en ressurs som gir økonomisk gevinst, men heller noe man blir belønnet for å redusere. Videre ser også noen utviklere på forbrenning av biomasse som miljømessig problematisk. Fjernvarmeselskapene utforsker bruken av karbonfangst og -lagring (CCS) for å redusere/fjerne direkte utslipp fra forbrenning.

Fjernvarmeselskaper har en positiv holdning til utvikleres nullutslippsmål. De ser verdien i at utviklere presser mot nullutslipp, da det driver fjernvarmeselskapene til å videreutvikle egne klimastrategier. Forenelige klimamål mellom utviklere og fjernvarmeselskapene, samt transparente strategier, er en viktig forutsetning for å realisere nullutslippssamfunnet.

Fjernvarmesystemer med lavere temperatur vil muliggjøre energideling mellom nabolag i det samme fjernvarmenettet, noe som tillater mer integrasjon og nødvendig innovasjon relatert til varmepumper, akkumulatortanker og solcellepaneler i fjernvarmesystemer. En av utfordringene for energideling i fjernvarmenett ligger i forretningsmodeller mellom fjernvarmeselskaper og bygningseiere, samt hvem som skal investere i de nye løsningene.

Fjernvarmeløsninger bør være konkurransedyktig i form av teknologi, utslipp, og pris sammenlignet med alternative oppvarmingsalternativer. I dag er fjernvarmeprisen regulert i forhold til det tilgjengelige oppvarmingsalternativet, og tolkningen av dette prinsippet diskuteres. Fjernvarme vil sannsynligvis bli mer attraktivt hvis det oppfattes som det billigste.

Utviklere og fjernvarmeselskaper bør jobbe sammen for å foreslå regulatoriske justeringer som balanserer økonomisk og miljømessig bærekraft. Dette kan bidra til å bygge et mer samarbeidsorientert forhold mellom de to partene. Ved å ta disse strategiske skrittene, kan både fjernvarmeselskaper og utviklere jobbe mot felles mål og overvinne eksisterende spenninger. Dette vil ikke bare forbedre samarbeidet mellom de to partene, men også bidra til å oppnå bærekraftige og miljøvennlige løsninger for oppvarming på veien mot nullutslippssamfunnet.

English summary

District heating's environmental impact, particularly in areas with direct greenhouse gas emissions from waste incineration, can clash with the zero-emission goals of developers aiming to create Zero Emission Neighbourhoods (ZEN). Developers may also be frustrated by cost issues and a lack of flexibility and influence in choosing heating solutions, compounded by regulatory requirements to connect to district heating systems. This report examines these tensions and identifies key areas for improvement to align on climate goals.

Data was collected through online interviews with selected stakeholders and a survey to understand the recognition of barriers, challenges, and potential solutions.

Tensions between district heating firms and ZEN developers stem from different roles, misaligned climate strategies, limited influence over heating choices, and cost concerns.

District heating companies recognize the environmental issues with waste incineration's CO2 emissions, but they also see it as a partly necessary solution to waste disposal. Some developers view waste reduction as more beneficial than its use as a resource. Further, some developers also view incineration of biomass as environmentally problematic. To mitigate emissions, district heating companies are investigating carbon capture and storage (CCS) on their incineration.

District heating companies have a positive attitude towards developers' ZEN goals. They see the value in developers pushing towards ZEN, as it drives district heating companies to further develop their own climate strategies. Compatible climate goals between developers and district heating companies, as well as transparent strategies, are an important prerequisite for realizing a zero-emission society.

Lower temperature district heating systems will enable energy sharing between neighbourhoods in the same district heating network, allowing for more integration and necessary innovation related to heat pumps, accumulator tanks, and solar panels in district heating systems. One of the challenges for energy sharing in the district heating network lies in business models between district heating companies and building owners, as well as who will invest in the new solutions.

District heating solutions should be competitive in terms of technology, emissions, and price compared to alternative heating options. Today, the district heating price is regulated in relation to the available heating alternative, and the interpretation of this principle is being discussed. District heating will likely become more attractive if it is perceived as the cheapest heating solution.

Developers and district heating companies should collaborate on regulatory adjustments for balanced sustainability, environmentally and economically. This can foster a more cooperative relationship between the two parties, not only enhancing their collaboration, but also contributing to achieving sustainable and environmentally-friendly heating solutions on the path towards a zero-emission society.

Contents

1. Introduction

The development of zero emission neighbourhoods (ZEN) in an area with district heating causes several interesting tensions and opportunities. This arises as building developers and district heating companies have different perspectives on the development of ambitions and forward-leaning innovations in building projects and energy use in neighbourhoods, in particular related to climate-friendly ambitions.

The vision of ZEN is to develop sustainable neighbourhoods with zero greenhouse gas emissions. A key part of neighbourhoods' greenhouse gas emissions is related to energy, and most energy use in Norwegian buildings are related to space heating and sanitary hot water. Thus, how to heat a neighbourhood in the most sustainable way is an important question in the pursuit towards realizing ZEN.

District heating (DH) is an extensive system of insulated pipes to deliver heat for residential and commercial purposes based on a variety of centralized heat sources. It has been around for many decades, and it exists in most major cities globally and in Europe. The development in Norway has been slower than in neighbouring countries like Sweden and Denmark, but it now exists in most major cities in Norway. District heating offers fuel flexibility by using different heat sources, including solid fuels (e.g., fossil fuels and biomass), gaseous fuels, surplus heat from industrial processes, electricity, and more. The energy mix of district heating varies greatly from site to site depending on local conditions.

In Norway, district heating is regulated as a natural monopoly, meaning that developers are mandated to connect to district heating on certain terms. Note that the obligation/exemption to connect is ultimately decided by the municipality, and it is also legal to establish a small-scale heating network with capacity less than 10 MW within an existing licence area. Nevertheless, for a building developer pursuing ZEN, it is hard to directly facilitate how buildings are heated when they are obligated to connect. A common discussion arises in district heating networks dominated by municipal waste incineration, where it is unclear which opportunities and responsibilities different parties have related to the direct greenhouse gas emissions from burning waste.

In this document, we explore the perspectives, responsibilities and opportunities of district heating companies and building developers on the pursuit towards sustainable heating solutions. Data collection involved online interviews with relevant stakeholders. The method was chosen to enable informants to elaborate on a very complex object matter. Based on literature and interviews' preliminary results, a survey was conducted to understand how broadly the barriers, challenges, and potential solutions are understood/recognized, and to include more perspectives that we were able to compute with one-to-one interviews.

The rest of this memo report is structured as follows: Chapter 2 presents relevant references, cases, and background information with a special focus on how district heating is regulated in Norway and cost-related concerns for DH companies, users, and developers. Chapter 3 presents the district heating companies' perspective, while Chapter 4 presents the perspective of building owners & developers (referred to as 'developers', for simplicity). Finally, Chapter 5 discusses the different perspectives considering the survey results and which solutions that could lower tensions and foster more collaboration. The memo report is concluded in Chapter 6.

2. Context and background

To prepare this memo, we have analysed the existing frameworks (i.e., district heating regulation) and the implications for district heating companies, users, and the developers, in particular in relation to costs. Focus on costs is motivated by the fact that financial concerns can be both a driver and a challenge towards better alignment between DH companies and developers.

To elaborate on the potential collaboration between DH companies and developers within ambitious projects such as ZEN, we also present few cases of integration between DH and projects-specific solutions to meet energy and environmental targets (ZEN cases/pilots).

District heating regulation

In the context of northern European countries, district heating systems play a crucial role in meeting heat demands, particularly in Sweden, Finland, and Denmark, with Norway following to a lesser extent. Historically, Norway's low electricity costs, driven by a high share of hydropower in its electricity mix, have constrained the expansion of district heating, meeting only about 10% of the nation's heat demand [1], [2].

The substantial investment required for infrastructure, combined with the necessity of a certain connection density, positions district heating as a natural monopoly rather than a free-market commodity like gas or electricity [3].

District heating entails supplying heat to external customers via hot water or other heat carriers. This heat is distributed through a pipe system laid in tranches, with losses up to 10-20%. At the customer's location, a customer central is installed with heat exchangers transferring energy from the district heating water to the customer's heating system, typically a water-based system with radiators, underfloor heating, or ventilation systems. District heating usually covers both space heating and sanitary hot water demand. Customers control heat with thermostats, and consumption is monitored with energy meters, like electric PODs (Points of delivery).

A district heating system can utilize various energy sources, including surplus heat from industry or waste incineration, heat extracted from rocks or the sea through heat pumps, bioenergy, electricity, or other sources capable of heating the district heating fluid. Typically, the plant has a primary source (base load) with at least one backup source (peak load) [4]. The energy mix varies across different regions in Norway, heavily influencing the cost and CO_2 emissions of district heating.

Table 1 Overview of energy mix in selected DH networks in Norway. Source: Fjernkontrollen.no and ZEN Report 61

DATA 2022	Energy produced [TWh]	Recovered heat [%]	Bio-based energy [%]	Ambient heat [%]	Electricity from RES [%]	Fossil Oil/gas [%]	Equivalent CO2 emission B=0 [g/kWh]	Equivalent CO2 emission B=0.5 [g/kWh]
Norway	7,1	48	32	9	7	3		
Oslo	2	51	17	11	19	2	11	61.8
Bergen	0,32	88	6	-	6	-	1.5	83.1
Trondheim	0.67	76	3	-	15	5	23.2	90.4
Bodø	0.07	-	81	0.2	18	0.3	7.4	7.4

The primary source of recovered heat, the largest category, encompasses surplus heat generated from waste incineration and industrial processes. This energy is considered a CO2-neutral energy source in the Norwegian legislation, the full responsibility of the emissions related to waste incineration is allocated to the one producing the waste, unlike the Swedish one [5]. In Table 1 the CO2 emission factors are reported both considering this source with zero emissions (B = 0) and considering half of the emission produced by the waste incineration (B=0.5), with an emission factor of 188 gCO2/kWh, as reported in [6].

The second largest energy category is bioenergy, which includes all solid biofuels and bio-oil. Most of the solid biofuels are biomaterials left over from wood industry, other chips and reclaimed wood, as well as pellets. The emission factor for the bio-based energy is not considered CO2-neutral, and it depends on the type of biomass. For example, the emission factor for the bio-oil is 4 gCO2/ kWh, for biogas is 11 gCO2/kWh, while for pellets is 13 gCO2 /kWh. Additionally, a portion of electricity supplements district heating, primarily via electric boilers, utilized predominantly during periods of low electricity tariffs, leveraging Norway's surplus of renewable electricity. Ambient heat sources, drawn from fjord water, sewage, or the ground via large-scale heat pumps, contribute significantly. Solar collectors also play a role, harnessing sunlight to heat water circulated through panels. While fossil oil and gas serve as traditional backup resources for peak loads usually during high winter demands [4]. To safeguard consumer interest, Norway has established in the Energy Act [7] a regulatory framework governing access to district heating grids and service pricing.

The Energy Act defines district heating as the provision of hot water or alternative heat carriers to external consumers, emphasizing the exclusion of personal heat production from this definition. It is further established that district heating systems with a capacity greater than 10 MW require a license issued by the Norwegian Directorate of Water Resources and Energy (NVE). Licenses issued by the NVE delimit permitted construction and operation within designated geographic areas, prohibiting expansion outside these boundaries or modification of certain infrastructure [8].

To ensure a viable customer density, municipalities were granted authority through a 2013 amendment to the Energy Act. This meant that the municipalities could mandate building connections within concession areas, with customers protected by maximum pricing. The district heating payment comprises a connection fee and a fixed annual fee, with usage prices capped to not exceed those for electric heating in the relevant supply area. Customers can lodge complaints with the energy directorate

(NVE) if they believe prices violate these regulations [9]. NVE compares the price that the customer has paid for district heating, and the price that the customer would have paid by using electricity for heating instead of district heating. The electricity price includes the spot price (monthly average) with surcharges, taxes, and grid tariff.

To increase competitiveness of district heating, the Energy Law was modified in 2013 to facilitate third party access to district heating. Third-party access refers to the district heating company facilitating trade between connected customers and a third party (external/private companies) injecting heating into the concessionaire's district heating system. The Energy Law stipulates that there must be a negotiation obligation for concessionaires who receive a request for delivery or access to the district heating network from a third party [10].

Further, in response to the rise of self-sufficient buildings, the Ministry of Petroleum and Energy introduced an update in 2023, defining "local heating" as sufficiently small district heating plants that do not need licensing. Pricing in unlicensed installations is determined through agreements between companies and customers [11].

Costs for the district heating company and price for the users

The law does not specify how the company must calculate the price of heat for the users, but rather defines an upper bound on the price linked to the electricity market. This cap is general and does not specify how the time window should be defined or which technological solution (e.g., heat pump) is used for the comparison. One interpretation of this is that the upper bound on the district heating price is taken from the monthly average electricity spot price, which is the mean value of all the spot prices in a certain month where every hour has the same weight. Furthermore, in many companies the price changes depending on the electricity price, geographic location and type of consumer (e.g., business, private citizen, or apartment building). In this case, the district heating customer pays a fixed price that changes every month depending on the consumption and the average electricity spot price [12].

Since the enactment of the first district heating law, numerous changes have occurred, both technically and economically. Initially, the competitive technology was direct electric heating, but it has become less relevant in recent years. Hence, there is a need to reconsider the current regulation regarding district heating prices and its linkage with electricity costs.

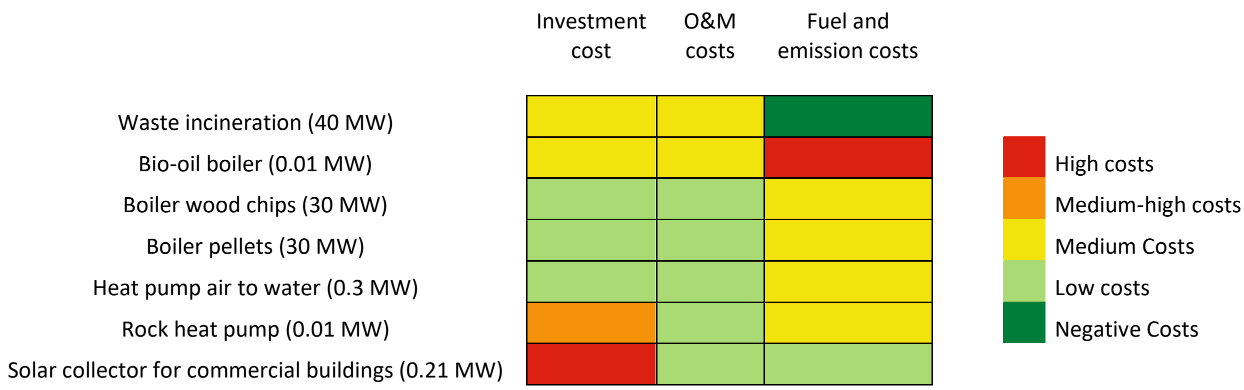
In this context, NVE has published several reports in the last years, proposing alternative methods for price calculation and assessing the profitability of the district heating sector [13], [14]. Among the suggestions put forward by NVE is a modification of the maximum price, based on the socio-economic opportunity cost of heating with an air-sourced heat pump, currently the most widespread and competitive technology for buildings not connected to district heating. Additionally, it has been proposed that this price remains stable over time and is made public by NVE itself [15].

The last update published by NVE was in June 2024, where a new system for formation of the price is proposed. The new model stipulates that the new maximum price for district heating is set equal to the spot price plus a constant value. When the spot price is higher than 100 øre/kWh, the maximum price for district heating only rises by 40% of the increase in the spot price. When the spot price is negative, the maximum price falls by 40% of the spot price. In this way, an upper and lower breaking point is introduced in the maximum price curve for the district heating price [16]. Nonetheless, at the time of writing this memo, the discussion about revising the price regulation is ongoing and it has not been finalized yet.

Addressing the issue of natural monopolies and price regulation, it is crucial to understand the costs that a district heating company must bear to calibrate the price. It must be attractive to consumers while ensuring sufficient profitability to finance investments. The main costs faced by the district heating company include infrastructure investments, including those related to the transport network, as well as heat production facilities and operation and maintenance of those. The latter are generally contained and depend mainly on the degree of automation and the cost of labor.

Costs related to the district heating facility depend on numerous factors, including the type and size of the facility (with economies of scale playing a significant role), the technology employed, and the energy mix used, including fuel costs. The latter is not necessarily related to the price of heat sold, in fact often the factors that determine fuel costs, such as wood chips, are related to other sectors and markets. It is also important to consider geographical factors such as population density, distance from the plant to users, and the distance of fuel from the heat production facility. Assessing competitiveness against other currently available technologies is therefore not a straightforward task. Table 2 presents a coarse estimate of cost data related to some of the most common heat production technologies.

Table 2 Overview of costs for DH companies related to heat production. Source: Vista Analyse AS [17]



Costs for alternative heating solutions in buildings

The comparison of DH and alternative options is not only relevant in relation to the definition of the price cap for the former, but also as an important element in developers' decision over the heating solution for their projects.

Several buildings are subsequently installing heat pumps, which are the preferred solutions when looking for efficiency, participation into flexibility services, and exploitation of local resources, as in ZEN-like projects. As such, they are the natural alternative to DH.

To set the context and the basis for discussion on opportunities and frictions connected to the presence of these alternatives, we would like to bring some clarity about what costs items should be considered when looking at the economics of a project's choice among alternatives. In simplified terms, as far as global cost of alternatives is concerned, the following costs are normally considered:

- Initial investment
- Operation
- Maintenance
- Replacement
- Residual value

within the service life of a building (30-50 years). More costs could be related to, e.g., demolition, remodeling, services and administration.

Depending on whether developers are planning to stay involved in the use phase of a building (as actual owners or managers) or not, they might be mostly interested in initial investment or on all cost items. Moreover, in Norway, it is common for developers to be accountable for maintenance and replacement due to construction defects for 5 years after delivery.

Recovering and gaining from initial investment comes from the exploitation of the product (i.e. building) in the form of revenues from renting and/or selling (besides own use). The willingness of the ultimate clients (tenants or buyers) to pay for the solution provided is an important criterion.

Cases of DH and ZEN integration

DH and heat pumps are not necessarily a binary choice in meeting economic and environmental targets of the stakeholders. Indeed, this Memo Report aims at exploring the potential opportunities from integration via collaboration between DH companies and developers when projects are in a concession area, where DH connection is, so far, compulsory by regulation.

Looking at ZEN pilots and cases, we can identify at least two examples:

- **DH exemption for part of buildings' heat demand, and developers invest in own solutions.** At Nidarvoll, Trondheim, the project gained a dispensation from DH connection only in connection to space heating demand (domestic hot water is produced with DH), where two buildings are sharing an air-water heat pump, partially fed by electricity from PV panels, with accumulator tank. The water tank is charged through the heat pump at night to use energy for space heating purposes during the day, shaving peak in heat demand and meeting higher energy targets than it could be possible with simple connection to DH [18].

- **DH is used to cover all buildings' heat demand, but DH company invests in solutions.** At Nyhavna, Trondheim, there is an idea that the DH company could own the PV panels that are required for the projects to compensate for the emissions produced during construction. The DH company is already investing in a Seasonal Thermal Energy Storage (STES) to store excess energy from incineration and from new seawater heat pumps and use it to shave winter peak demand for the neighbourhood and the city (when DH companies are typically forced to operate via electric boilers, [1]). By investing in the PV panels as well, the DH company could use the surplus energy from the buildings to operate the heat pumps, reducing its operating costs and taking the upfront costs of PV panels out the developers' shoulders, who could have the PV production they need secured to meet ZEN targets [19].

These are only two, non-exhaustive, examples of how developers and DH companies could shape their roles within the scope of a certain project in a concession area, preserving developers' energy and environmental goals. More cases and ideas are discussed throughout the Memo based on interviews and survey results.

3. District heating perspective

Views of district heating on the building developers' technical heating solutions

There is a positive attitude by district heating (DH) companies to building developers' zero emissions targets and their technology innovation to achieve zero emissions. DH companies believe that building developers require new technology and systems with zero emissions targets, and the push towards zero emissions by building developers is valuable as it drives district heating companies in the same direction. Nevertheless, it is a challenge for DH companies to find solutions that align with the new concepts of buildings.

The friction between building developers and DH when pursuing ZEN could stem from their differing views, roles and cultures. Historically, these parties have operated separately, each developing their own targets and solutions. However, in the future, collaboration between both parties will be necessary to transition towards sustainable heating solutions with zero greenhouse gas emissions.

For DH companies, this poses a significant challenge as they must consider not only individual buildings or neighbourhood projects but also the entire DH system. In the case of Trondheim, for example, the system encompasses the entire city, requiring holistic solutions that cater to city-wide needs.

Meanwhile, district heating companies continuously seek new technologies and sources, including surplus heat from industrial processes, CCS, large-scale heat pumps, and biofuel to meet these challenges.

Strategies of DH for the future

Some district heating companies have set their own targets for the future concerning climate and environment. The aim is to achieve 100% renewable energy sources (RES) in the DH mix. The companies develop internal documents that are not published those details the strategy for the next years, in the short and long term. It is very important for the future direction of the company. This document undergoes continuous review and includes estimations of future heat demand (kWh) and how production should adapt accordingly, as well as information on the types of plants to be utilized. With a focus on zero emissions, new plants will be primarily related to bio-oil, biomass, and waste. Additionally, there will be a shift towards more electric heating using heat pumps and electric boilers, which are crucial for participating in the flexibility markets for electricity (balancing markets).

Many DH companies realize that their direct CO_2 emissions are difficult to compensate, but they also highlight that waste incineration is solving a societal problem. Arguments include that direct emissions from waste incineration lies outside the responsibility of DH companies, and therefore waste heat from waste combustion is climate neutral in the DH system [6]. Nevertheless, DH companies explore the utilization of carbon capture and storage (CCS) on waste incineration to reduce/remove direct emissions from incineration. The CCS solution is the only alternative to reducing CO_2 emissions from municipal waste incineration, which improves the climate footprint for waste combustion. A new project has been working on how to establish CCS at the energy from waste plant as the main technical route in 2030. Moreover, DH companies foresee to use more biomass and biofuels in the incineration in future.

The necessity for the internal strategy document stems from building developers, customers, and the market demanding new environmentally friendly solutions to reduce carbon footprints. Therefore, although DH companies are regulated monopolies, they must adapt to market demands. Further, political regulations are surely influencing DH strategies, and DH companies work towards authorities to ensure a regulatory system that secures the future for district heating. The internal strategy document provides the company with their future plans, ensuring alignment with long-term goals.

Suggestions for the integrations of new buildings technologies with DH

DH companies should offer attractive solutions competitive with other options on the market. Besides heat supply, one significant advantage that a DH company offers is its distribution system, capable of transporting heat from areas with surplus to those with deficits, where energy production with existing resources is challenging. Looking ahead, there will be a growing emphasis on energy sharing among buildings, enabling them to exchange heat and support one another through the DH grid. Achieving this requires a well-structured system and some technical upgrades, and DH companies can provide this heat transportation service. An example of such a need of heat transportation between two neighbourhoods can be found in Trondheim, where one neighbourhood (Nyhavna) could supply heat with a superior position for heat pump to another neighbourhood (Risvollan) that needs heat.

In many networks in Norway, district heating is currently provided at a temperature of approximately above 100 degrees. One of the goals that DH companies have is to decrease this system temperature by 2030. This reduction facilitates the integration of various resources into the system, such as surplus heat from industrial processes. The subsequent step involves increasing delta T (the temperature difference between the outgoing and incoming heat), allowing operation with lower temperatures while exchanging higher volumes of heat.

One of the challenges lies in understanding who will invest in these new solutions: DH companies or building developers. Therefore, there is a need to explore business models between DH companies and building owners, where building developers may be also suppliers of technologies. There are potential various business models, including agreements such as "renting roofs" for solar collectors or hybrid PV systems. Another example is operating a seasonal thermal energy storage (STES) within a neighbourhood with local energy production (ZEN pilots Furuset in Oslo, and Nyhavna in Trondheim). Another interesting option is related to local communities that could install a larger heat pump and then feed the excess heat into the DH distribution network.

Policies and regulations related to DH companies

District heating solutions should compete in terms of technology, emissions, carbon footprint, and price with alternative heating options available to customers. In the future, the concession system could be faded out. But also, the price regulation for DH can change. Nowadays, there is a price cap related to the available alternative, according to the Energy Law. According to the current interpretation of the law, alternative is direct electricity (see Chapter 2). This system can be regarded as quite rigid and constrain DH companies to develop more flexible tariff structures. DH would be probably chosen more openly and widely if it was perceived as the cheapest.

DH companies are aware that building developers prioritize certifications like ZEN, BREEAM, FutureBuilt, etc., to showcase their commitment to climate neutrality. To achieve those targets, self-sufficient solutions and local production are preferred, also for profitability concerns (see Chapter 4). However, understanding the competitiveness of district heating solutions in terms of costs is challenging, because it is not trivial to compare with stand-alone heating solutions. The initial investment (CAPEX) and operational expenses (OPEX) for heat pumps may be lower than DH, but the costs of administrating and maintaining a stand-alone system must also be considered. A sound cost comparison on equal terms between district heating and stand-alone solutions needs to be investigated further. Their sound comparison is also relevant in the context of the definition of the price cap for DH.

Sustainability from DH companies' perspective

District heating (DH) companies' vision and values regarding sustainability is not about choosing between the environment and climate, social responsibility, or profitability. Instead, it's about embracing all these aspects together in a sustainable way, a holistic environmental, social and economic solution.

In the DH view, utilizing local resources in the most effective way by establishing DH systems in cities and towns is a societal consideration for creating a shared, efficient, and fuel-flexible heating system. Once DH is established, it is dependent on many connections and customers to be efficient, and this consideration can override the need for individual choices. Further, DH companies raise the question of whether full autonomy of heating solutions in every building could include unnecessary societal costs, e.g., by stressing the electricity grid more than needed. DH provides flexibility at the system level regarding choice of energy source in consultation with the municipality and energy authorities and can be rigged for both high and low temperature heat.

When DH companies examine the building sector as a significant energy consumer, several key elements come into play. They aim to address the issue of heat utilization through the concept of the 'heat pyramid' and manage the 'peak crisis' in energy and power through enhanced energy efficiency and DH connections in buildings. Further, they emphasize the importance of DH as an alternative to direct electric heating considering pressing climate targets, whereby many other sectors must use more electricity to decarbonize.

The "heat pyramid" serves as a communication tool to illustrate the prioritization of energy reduction strategies. Initially, efforts should focus on improving energy efficiency, followed by utilizing surplus energy and incorporating electricity through heat pumps. This approach is part of the collaborative energy mapping efforts between DH companies and municipalities, which aim to identify the most effective use of a district heating network, including heating solutions that are not possible as stand-alone solutions (e.g., re-use surplus heat).

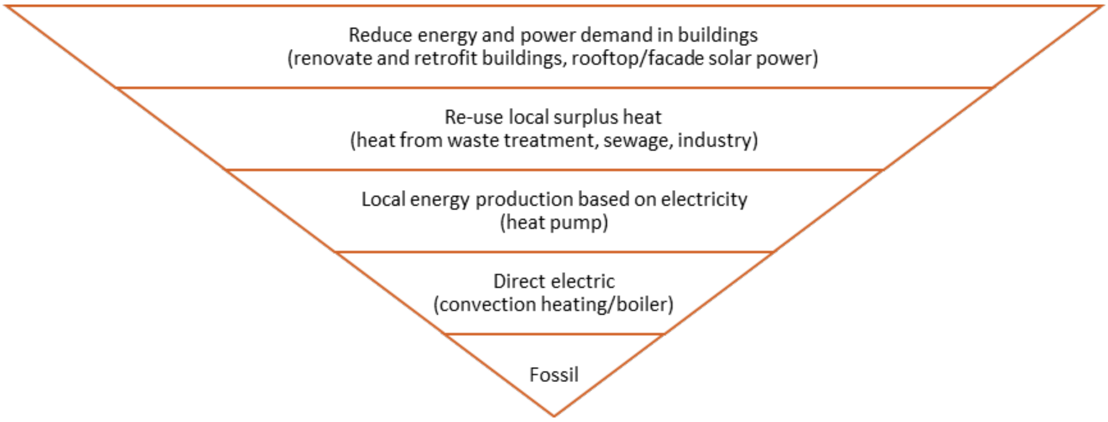


Figure 1 Priorities of solutions to meet heating demand in buildings, also referred to as the "heating pyramid".

A previous study has shown that maximizing building energy efficiency combined with district heating, where available, and local water-borne solutions elsewhere can achieve a 35% peak power reduction and a 25% energy reduction on the existing electricity grid [18]. This promising outcome supports the heat pyramid approach, demonstrating the potential for significant energy relief by increased use of DH.

District heating significantly reduces electricity demand, which in turn lowers electricity prices and reduces grid stress. This reduction has positive ripple effects, particularly in the context of green industry development in Norway, as highlighted in the "Kraftløftet" initiative [19].

4. Building owners & developers perspective

The scope of the project

For owners and developers of building projects, the scope of the project is certainly the focus. As owners, they look at how the project should look like to meet their goals (including profitability, since they are investors) and to deliver clear benefits for the users, who should be willing to pay to "use" the project (e.g., buying, renting, etc., depending on the intended use of the building), paying off the original investment. However, they operate within a certain context, made of market and societal pressures, where the rising attention on environmental issues comes with a sense of responsibility towards them and with a demand for higher and greener standards from users/clients and financial institutions (i.e., banks and green loans).

As such, besides goals related to energy, environment, and climate (if they want to develop in accordance with ZEN-like principles), developers have certain drivers when choosing among alternative solutions in their projects:

- Investment costs (CAPEX).
- Operational costs (OPEX).
- Competitiveness.
- Delivery.
- Project-specific solutions.
- Innovation and creativity.

As in any business, **profitability** is important in buildings projects. The investment cost (CAPEX) is an important criterion when choosing among alternative solutions for their projects. Other costs are related to operation, maintenance, and administration of the systems (OPEX). These cost items are mentioned by developers mostly in connection to their goal of gaining a better control over the energy costs, which they claim is easier when you can lever on increased efficiency of self-sufficient systems to lower the energy demand. This should be balanced with the goal of reducing complexity of maintenance and administration, where more centralized solutions could be better. Even though both CAPEX and OPEX are mentioned, it is unclear to what extent the decision-making over project solutions is driven by a life-cycle-cost thinking, especially given the uncertainty connected to running costs and the relative short timeframe of most developers (5 years).

However, some developers with environmental ambitions, when entering innovation processes (e.g., FutureBuilt program) know at start that their margin will be lower, but they do it to meet environmental goals and rise their **competitiveness** on the long run. They use innovation processes for a part of their portfolio for knowledge generation, to learn and scale up new solutions. Competitiveness is not only guaranteed by the fact that they are ahead, but also in terms of gained profile/image.

The economics is not only influenced by costs, but also by benefits from investing into the projects – owners and developers tend to prioritize choices that guarantee a better **delivery** to users, who are their ultimate clients (impact goals [1]). When choosing solutions for their projects, developers must look at

[1] with societal goals and performance goals, the three type of goals as defined by [20], reflecting three perspectives in a project: owner, users, and executing parties.

the market tendencies in order to be market relevant. The project must deliver to meet high standards of living because people are more aware of the alternatives and possibilities they have. Further, to ensure sustainability over time, projects must deliver environmental requirements (e.g., ZEN targets) and be accepted by future users, who need to own the solutions as they will need to live with them. The need to address these topics could be a reason, beside economics, why projects' owners prefer to have a full control over their scope (e.g., most efficient way to deliver energy, provision of cooling service, etc.), which, according to their perception, centralized solutions such as DH limit.

As project owners, project scope is what matters to them. So, it is not surprising that they look and wish for **projects-specific solutions**. They believe that solutions must match the project, be the best out of the location (which is unique in each project) and be superior in a case-by-case evaluation of all available alternatives of the location. This is probably why they are stressing on the importance of the investigation of local possibility first and on the importance of an approach where energy demand and supply are designed together. It is, however, unclear to what extent this is done, as most of the energy efficiency potential is described as connected to the system supplying energy (e.g., heat pumps), rather than the whole system.

To make the best for the project, there is a need for space for **creativity and innovation**, as any project in the Architecture, Engineering and Construction (AEC) industry is a new and unique product. This also demands for a high level of control over what it is possible to imagine for the project (the scope).

How does DH service come across in the picture?

Given the picture described above, how is DH perceived by owners and developers? Is DH, as it is perceived by owners and developers, a good response to the project's needs?

DH is seen as a service for the buildings – delivering heat. However, how this is done, under what pricing and regulatory frameworks, plays a role in how the DH solution comes across for building owners and developers, who primarily think about the projects' scope.

Against economic concerns, DH as a service is not perceived as competitive (connection fees, tariffs, concession regulations, etc.). Even though DH is described as simpler (less competences in the project, less costs and complexity for administration in the use phase), owners and developers would choose self-sufficient solutions first (heat pumps) for a better control of the energy costs and a better scope (delivering more efficiently, delivering cooling as well). They believe that self-sufficient solutions were proven to be more cost effective. However, they also claim that benefits of innovative solutions are delivered over long time, and this is why there is a need to adopt a longer timeframe than usual (from 5 to 30 years), which demands for business units staying involved in the management of the building, or at least of the energy system, to reap the financial benefits. With a shorter timeframe (typical of developers), DH can be financially good for the project if the infrastructure is close (low costs for connection) or, in case of retrofit projects, if it lowers the need of adaptation of the existing systems, reducing the investment cost.

Most importantly, DH as a service for buildings is not perceived as a choice, which does not play well with the need of the projects to look for project-specific solutions, for the reasons described above. Developers are mostly concerned about connection being compulsory. This is not in the interest of the project, as often DH supply becomes the starting point for design instead of encouraging a more dynamic approach of balancing demand and supply and exploring all available options. Local opportunities should be a priority according to them. Buildings of the future will prioritize utilization of their own energy resources, also in connection to the need to meet high standards, such as ZEN, FutureBuilt, etc.

Some understand the need to regulate DH through concession areas with mandatory connection, given the financial risks for DH companies; others have a stronger opinion about DH companies being too protected and not prone to make themselves accountable for emissions.

Even with an understanding attitude towards regulation, the latter is perceived as too strict. It is perceived as a binary choice (i.e., connect or not connect), with no space for case-by-case solutions. Project-specifical solutions and prioritization of local opportunities do not work well with the idea of concession areas that have fixed, demarcated, boundaries. They are aware of projects with special arrangements in the role of DH (e.g. provided in Chapter 2), but they are worried that such solutions will only reflect the interests of DH companies instead of those of the users[2], who are developers' ultimate clients.

From the project to the community

Any project in the Architecture Engineering and Construction (AEC) industry should also be looked at from a public perspective. Owners seem aware of the need to deliver benefits to the users (impact goals) if they want to stay competitive and pay off their projects, but also that their projects move into a bigger picture – the community.

In regions where DH system uses and/or produce heat from waste incineration, solutions like DH, which at present is not seen as the preferred heating service at the project level (as discussed above), is perceived as delivering another service to the community – waste handling. However, from a project perspective, this is seen as a quick solution to another problem (i.e., the amount of waste), with the consequence of producing emissions by burning something, i.e., waste, that should not be seen as a resource but rather as something to reduce and use as the last recourse when it comes to delivering heat to people. As opposed to the DH perspective, heat from waste is not perceived as a 'surplus' heat (see 'Heat Pyramid' in chapter 3).

Even though they are not in principle against DH, from the owners and developers' perspective, DH is not perceived as an environmentally friendly solution neither at project nor at community level because of direct greenhouse gas emissions. The fact that most heat comes from waste burning is not good for the project, as it is a cause of CO_2 emissions. Even though the users/clients might be ok with this, developers claim that they want to look at the overall picture and take care of the planet, taking responsibility for the environment (societal goal) and, as such, they want to know if delivered heat can be considered climate neutral.

However, for them as projects' investors, such responsibility must work well with the economics and the project scope as well. In the face of this, under some circumstances, DH can be good for the project,

[2] although the choice of heat solutions for buildings affects them, the users' preferences and perspectives are outside the scope of this Memo.

especially if the infrastructure is close by and it does not involve high connection costs or, in case of retrofit projects, high costs for adaptation. Furthermore, as discussed before, when selecting goals, they prioritize what the users/clients value and will be willing to pay for. This is often not the environmental performance (especially in housing), but rather location or living standards.

Project and community perspectives should be kept together, which could be a challenge for owners and developers as investors and, at the same time, theoretical holder of societal goals. A perspective more attentive to community-level implication of projects could change the solutions in the projects – when projects are made accountable for the emissions generated for producing the supplied heat via DH, more attention is given to energy efficiency (i.e., reducing energy demand), which should be a priority for the building sector, which is also in line with the "Heat Pyramid" discussed in chapter 3. This approach to emissions allocation also rises accountability of DH companies.

It is unclear how much, at present, owners and developers look at societal goals when making choices in their projects, but they understand that when widening the perspective from the project to the community, the topic becomes more complex, and the meaning of a technical solution can change, questioning their own preferences. However, the case of waste handling as community service does not look convincing enough to balance out their understanding that burning is bad for the environment and, thus, for the project. This is likely due, also, to the presence of other arguments that make DH not preferable for their projects, as discussed above (e.g., lower control over the project, costs, etc.).

How could DH service better fit in the picture?

As a response to the doubt of DH being a good solution for the project, they claim that the circumstances where they would be more inclined to connect to DH are linked to a change in DH both in term of technology, communication, regulation, and business proposal.

Regarding **technology**, they wish the DH network was not designed for waste incineration, but as a low temperature and low-pressure system, with high integration of heat pumps, and, as such, enabling exchange of heat from neighbourhood to neighbourhood within the network. Transporting heat from an area of surplus to an area with unmet demand is seen as an interesting service at the community level, especially because it is an interesting opportunity in cities, where there are many sources of wasted heat (e.g., cooling systems, tunnels, etc.). From their perspective, describing waste as a resource to burn (as it is available and cheap), besides being understood as against circularity principles (i.e., meaning here, producing less waste, reusing and recycling), does not build the proper drivers for the DH companies to move in the desired direction (i.e., less waste incineration and more heat pumps as DH supply mix).

Communication is crucial, as it seems that developers are concerned about not knowing whether the heat delivered can be considered climate neutral. If the buildings of the future must be climate neutral, the DH should be aligned with this goal. Even if there is an understanding about the reasons why DH companies might be reluctant to communicate too loud on the topic of waste burning, they wish for better transparency, possibly enforced by regulation.

According to developers, **regulatory** changes are also desirable to make the requirements on connection less strict. Because of their project-perspective, they wish for more project-specific solutions and for space for innovation and creativity in each project (most probably also for a better control over costs).

As such, they wish for non-predefined boundaries of concession areas, but rather for a future where connection configuration is negotiated in each project, prioritizing local solutions and using DH as back-up service (e.g., covering peak demands). They wish DH companies could be open about more hybrid and dynamic solutions, about variations and combinations. As connection requirements in concession areas does not imply use, there is a theoretical possibility to look for the alternatives they wish for. However, because connection implies costs, we could imagine that economic rationality would be compromised in case of connection with none or small use, and budget for other solutions is consumed by DH connection costs. Moreover, some claim that other configurations than full connection and use, even if theoretically possible, are disincentivized by pricing schemes of the DH companies (e.g., high price of supplied heat at peak events).

Business proposals that would make DH competitive as an alternative is what developers mostly wish for, rather than DH companies relying on regulatory enforcement to ensure DH is chosen. They wish for a business proposition by DH companies that is in line with the need for more climate neutral buildings. This requires all the adaptation mentioned above, but also clearer benefits from connection. Indeed, the willingness to pay from the users is an important criterion for developers (because they need to sell buildings to recover and gain from their investments), and certain solutions have no good allocation of costs and benefits. The allocation of costs and benefits, varying depending on the business model for the building projects, should then be considered when discussing opportunities for collaboration between developers and DH companies. We need a combination of solutions to correct this split, including new pricing schemes for the energy services. An alternative is considering DH companies as potential investors and owners of building-related asset (e.g., PV panels, heat pumps), if this comes at a good price for the projects. However, DH companies might have strong competitors in this regard, such as electricity suppliers and new business units of ambitious developer companies.

In general, developers wish for cooperation and dialogue between them and the DH companies to solve the doubts from the two parties and find a common point, a win-win solution. We claim that having such a dialogue would be important also as a preliminary action, to make the two parties more aware about each other's strategies.

5. Discussion and survey results

In this chapter, we discuss the main tensions between the perspectives, and which solutions that could lower tensions and foster more collaboration. This chapter is written starting from our impressions from the interviews, in consideration of the survey results presented in Chapter 7.

Potential tensions between ZEN and DH arise primarily from differing objectives, economic viability concerns, flexibility and autonomy issues, and regulatory frameworks. One significant tension is related to the environmental concerns. The tension between these actors stems from their distinct roles in society and their varied competencies and perspectives. For example, DH companies often use waste incineration and bioenergy, which building developers, especially those focusing on Zero Emission Neighborhoods (ZEN), see as conflicting with their zero-emission targets. This discrepancy is partly due to differing views on the appropriate CO2 factors for external energy production and the allocation of emissions from waste incineration. According to the survey, 47% of respondents expressed environmental concerns about DH, preferring greener and more sustainable alternatives. As a result, these differences in perspective can lead to friction, despite both parties sharing the common objective of sustainability.

Economic viability and cost concerns also present a major tension. Building developers express concerns over the cost-effectiveness of DH systems. High initial connection fees, ongoing tariffs, and a perceived lack of cost control make DH less attractive compared to self-sufficient solutions like heat pumps. The survey indicates that 60% of respondents identified cost concerns, including initial connection fees and ongoing charges, as significant barriers to adopting DH. These economic barriers can discourage developers from choosing DH, even when it aligns with broader environmental goals.

Flexibility and autonomy are additional sources of tension. Developers prefer having control over their energy solutions, not just to produce their own energy, but also to manage efficiency and related energy costs. They see DH as a rigid system that limits their ability to tailor solutions to specific project needs and innovations. Despite their view, there is still room for innovation within the context of connecting to DH. For example, district cooling enlarges the potential scope of project delivery and is not sufficiently discussed. The survey results show that 53% of respondents seek more flexibility and control over their heating solutions, highlighting the importance of autonomy in their decision-making processes . This desire for flexibility clashes with the traditional structure of DH systems, which are designed for efficiency and broad applicability rather than customization. Further, full autonomy of heating solutions within a DH area could hinder utilization of existing infrastructure and potentially stress the electricity network more than necessary.

The regulatory framework and mandatory connections to DH systems within concession areas are seen as limitations by developers. These regulations are intended to ensure the viability of DH networks. Even though they understand this need, developers, seeking project-specific solutions and greater flexibility in choosing their energy systems, find these mandatory connections restrictive. The survey results show that many respondents favour a coordinated approach involving all parties, including national and local authorities, DH companies, and the construction industry, to address these regulatory challenges. This regulatory environment can be a significant barrier to collaboration between DH companies and developers.

To avoid and solve these tensions, both parties need to take strategic steps. First, aligning on environmental goals is crucial. Enhancing transparency regarding the environmental impact of DH (potentially through regulation), especially the role of waste heat and bioenergy in reducing overall emissions, can build trust and cooperation. Developing clear metrics and certifications for DH systems that align with ZEN's zero-emission goals can help bridge the gap. ZEN developers need DH companies to commit to increasing the share of renewable energy sources and reducing reliance on waste incineration, to move in the direction of a low-temperature and low-pressure system, where heat exchange is possible (see Chapter 3). Favouring heat exchange among buildings and urban areas is perceived by developers as a more interesting community-service than waste handling, maybe because more related to the domain and not "another problem" (i.e., amount of waste) for which DH is a quick solution to. The survey highlights that integrating renewable energy into DH systems and effectively using surplus heat can influence developers' preferences for heating solutions, with 53% of respondents indicating that cost-effectiveness would be a key factor.

Economic incentives and cost reduction are also key strategies. Introducing financial incentives, subsidies, or tax reductions for DH systems that integrate renewable energy can make them more attractive for building developers. Building developers highlight that there is a spectrum of environmental friendliness within the scope of renewable energy, e.g., burning solid biomass is considered more problematic than running a heat pump with electricity from wind and solar. Therefore, it is important to communicate what and how sources are used to produce heat for DH, increasing the level of information for developers. If building developers can have a greater impact on which sources are used within the DH network, they can also have more influence on the heating solutions for their ambitious projects. Developing flexible pricing schemes that are competitive with alternative energy solutions can address developers' cost concerns. From authorities, clear regulatory standards and financial incentives are needed to support the transition to renewable energy in DH systems. DH companies need to offer competitive and transparent pricing structures that can convince developers of the long-term cost benefits. The benefit from connection being clear is a demand from developers. The survey suggests that regulatory standards for integrating renewable energy (53% of respondents), providing financial incentives (33% of respondents), and setting a minimum renewable share (47% of respondents) are seen as crucial roles for authorities[3].

Enhancing flexibility and control within DH systems is another important step. Developing hybrid DH systems that allow local integration (i.e., project level) with other technologies like heat pumps, accumulator tanks, and solar panels can provide the flexibility developers seek. Promoting energy-sharing mechanisms within DH networks can further enhance flexibility. Building developers need assurance that DH systems can adapt to their specific project requirements and provide options for integrating additional renewable energy technologies. DH companies should be open to customized solutions and innovative business models that include shared investments and risks., e.g., contracts with PV on rooftops. The survey results indicate that most respondents are open to innovative business models and cross-ownership schemes if clear regulatory frameworks and benefits are established.

[3] Note that the sum of the percentages is more than 100% because each respondent could put up to three answers on the same question.

Revising regulatory frameworks to provide more flexibility is also essential. Advocating for regulatory changes that allow exemptions for ZEN-like areas (including any initiative that document a high environmental performance) or conditional connection mandates based on project-specific assessments can address developers' concerns. Authorities should consider revising regulations to provide exemptions or more flexible connection requirements for projects with strong environmental credentials. DH companies and developers should work together to propose regulatory adjustments that balance public interest and project feasibility. The survey indicates that developers see potential for collaboration towards carbon neutrality, with many expressing a need for regulatory changes to facilitate better cooperation.

Another promising area is the potential benefits of low-temperature district heating systems with seasonal thermal energy storage. Such systems can improve the technical-economic feasibility of DH by allowing for more efficient heat exchange and reducing overall energy losses. The survey results suggest that stakeholders perceive low-temperature DH systems with seasonal storage as having significant potential, with 33% of respondents viewing them as equally feasible to traditional systems but with different sets of challenges and benefits. By storing heat when demand is low and utilizing it during peak periods, these systems can enhance energy efficiency and sustainability. This approach aligns well with ZEN's objectives of reducing emissions and improving energy management, offering a viable pathway for integrating advanced technologies into DH networks.

6. Concluding remarks

This memo focuses on analyzing the tensions between district heating companies and Zero Emission Neighbourhood (ZEN) developers regarding climate strategies, costs, and regulatory requirements, and suggests improvements to align their goals for sustainable heating solutions and zero-emission targets. This does not cover all perspectives affected by the choice of heat solutions or the allocation of costs and benefits, which can vary with different business models. User preferences, investment costs, and long-term operational costs also play crucial roles. Addressing these aspects requires a separate, detailed discussion, emphasizing the need for ongoing dialogue and pilot projects to explore these dynamics further.

DH companies work towards authorities to ensure a regulatory system that secures the future for district heating. Owners and developers largely shape the built environment project by project, and they target the users as their final clients to secure the profitability and attractiveness of their projects. DH companies work with solutions that are designed for efficiency and broad applicability rather than customization. Developers work with projects that are unique every time and want to look for case-by-case solutions. Provision of local networks (with thermal separation) is the natural middle ground.

Some local authorities, through their plans and strategies, intend to promote the establishment of local and common energy systems that can handle energy exchange, energy storage, local energy production, and energy flexibility within the system boundary and towards the surrounding areas (e.g., Nyhavna in Trondheim). Seasonal storages make the option more relevant for optimized utilization. Such solutions play a significant role to meet climate targets and requires the involvement of more actors in the process, including developers and DH companies. However, they are still expensive and at the piloting stage.

Developers seek for flexibility, and several buildings are subsequently installing heat pumps and accumulator tanks to flatten heat demand during the day. In a few examples, DH becomes a peak supplier. Examples of demand side management is one of many cases where energy data and monitoring are of vital importance. Better information about operation and more real-time energy data are needed for buildings to move in this direction and meet energy and environmental targets with a greater attention to energy efficiency and optimization of resources beyond the neighbourhood boundary.

We have identified the following key topics that needs to be developed to facilitate better collaboration between district heating and ZEN:

- Alignment and transparency regarding climate targets and strategies.
- Improved information about how each part operates, with particular attention for what and how sources in DH networks are used and developed.
- Project-specific tariff customization/agreements and competitiveness of the solutions (rather than regulatory protection).
- Clarification about possibilities for environmental certification, methods, and assumptions for emissions factor calculation.
- More pilot projects showcasing successful collaboration.

By addressing the potential tensions through strategic collaboration, transparent communication, and innovative solutions, ZEN and DH can better align on their objectives and leverage each other's strengths to achieve sustainable urban development. We recommend, as a starting point, that a better understanding of each other's strategies is ensured, exploiting platforms for exchange and communication (e.g., research projects, pilots, conferences, consultations, ...). This is an important precondition for alignment towards realization of the ZEN vision.

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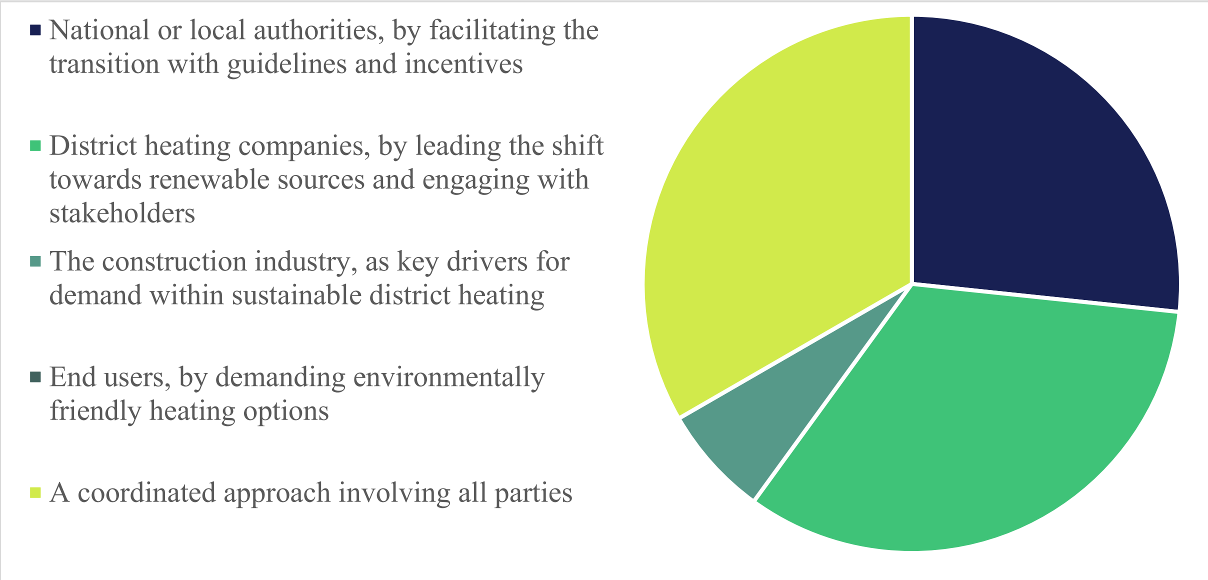
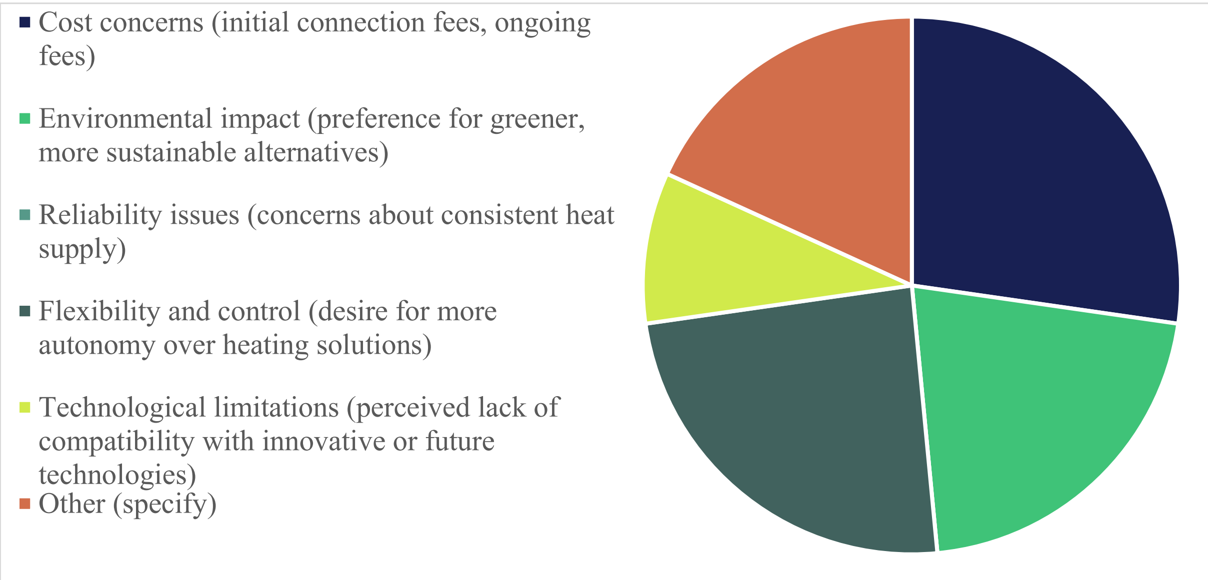
7. Appendix

7.1 Survey Results

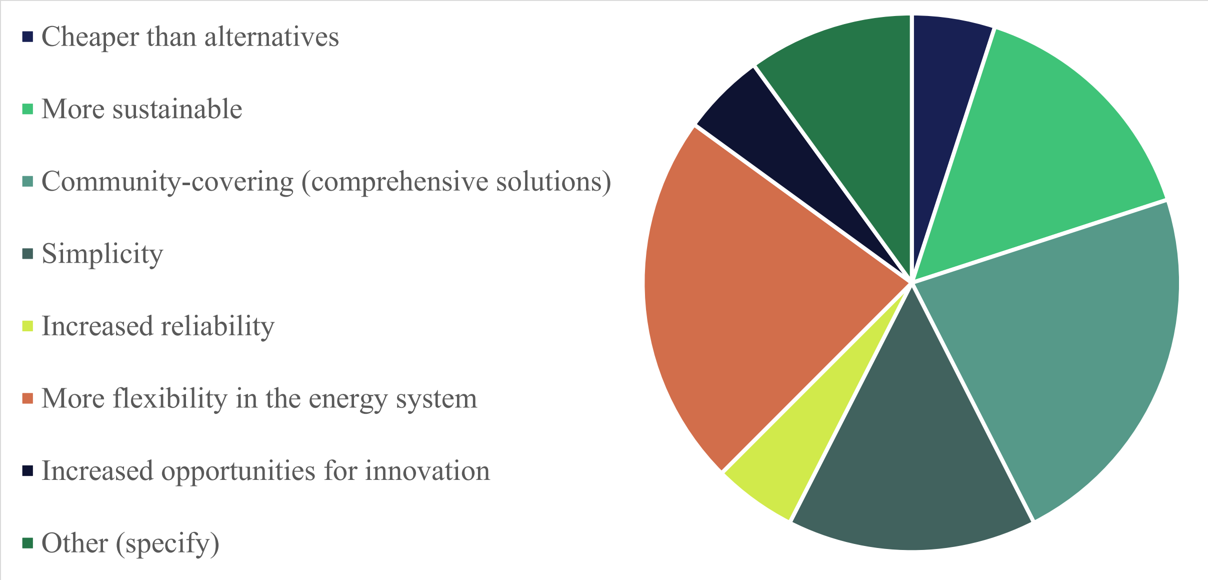
1. Who do you think should take the leading role in solving the challenges related to integrating emission-free energy sources into district heating systems?



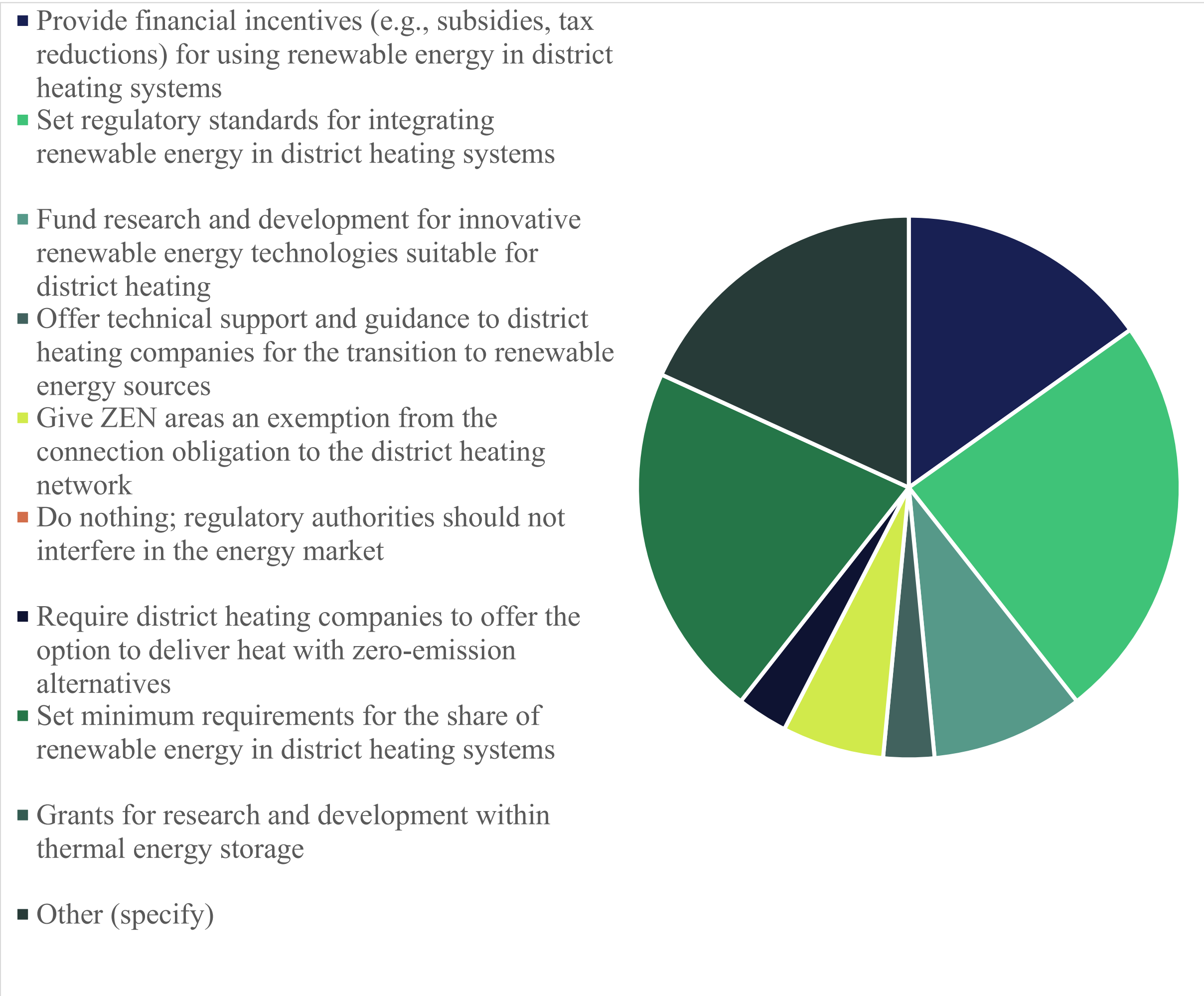
2. Why do you think some building developers are hesitant to connect to and use district heating?



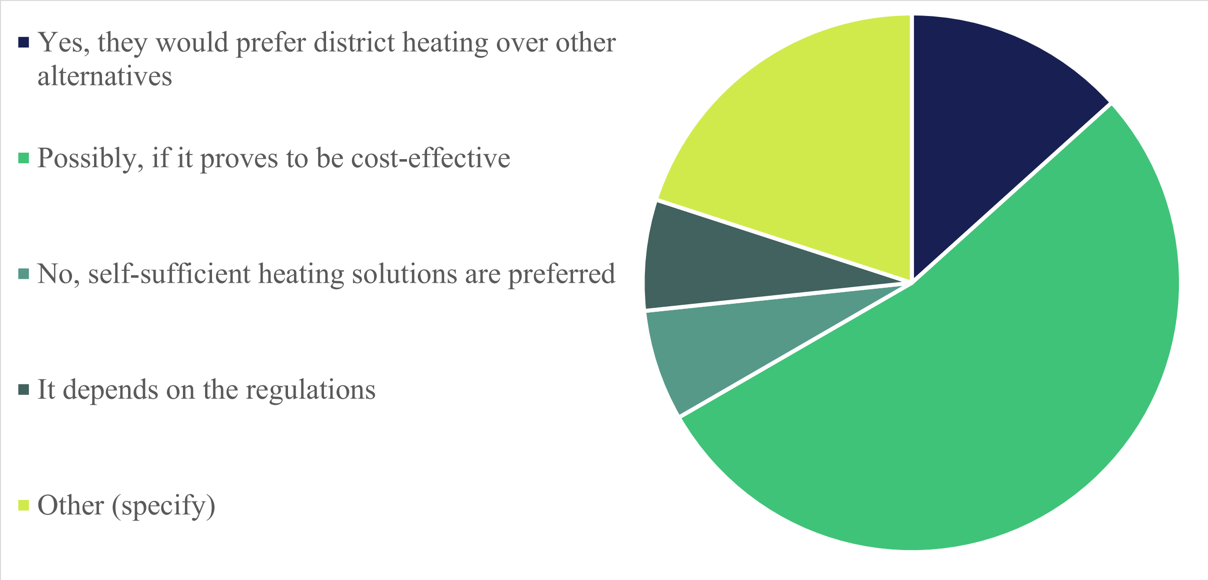
3. What do you think are important arguments for building developers to connect to district heating?



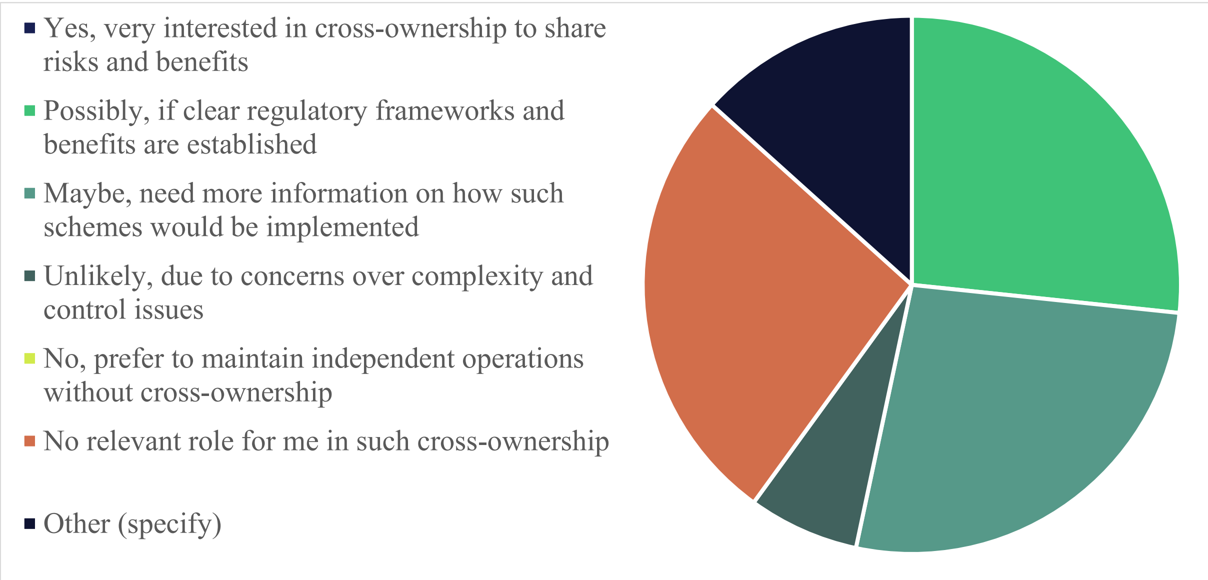
4. What role should the authorities take to ensure the integration of renewable energy in district heating systems?



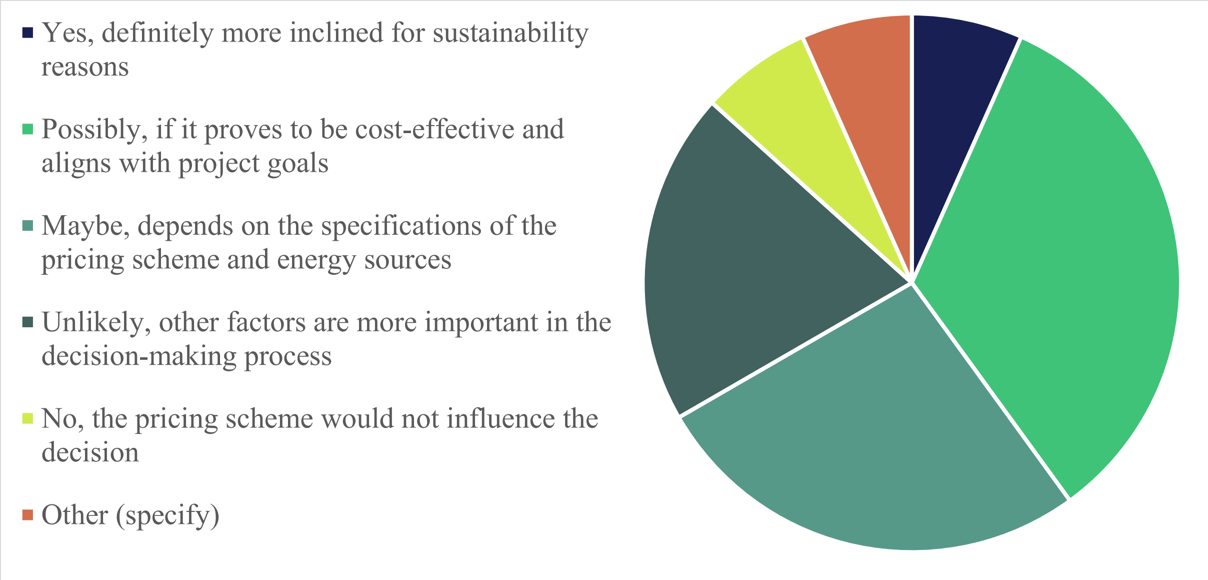
5. Do you think the integration of renewable energy and efficient utilization of surplus heat in district heating systems affects building developers' preference for heating supply options?



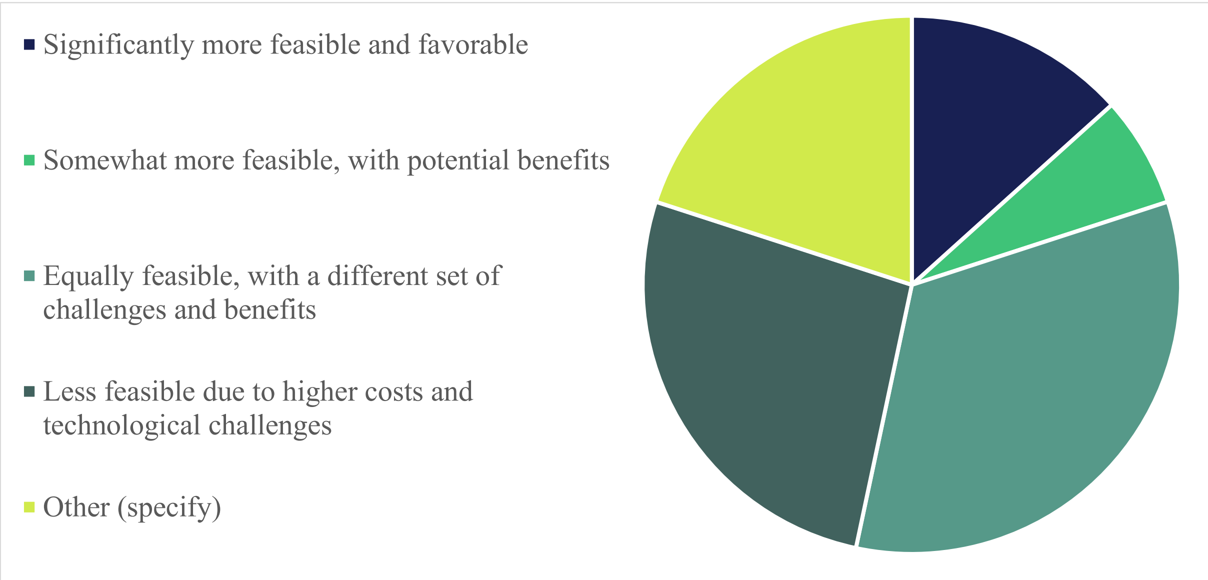
6. Would you be interested in participating in a cross-ownership scheme between district heating companies and building developers to facilitate the integration of renewable energy and thermal energy storage in district heating facilities?



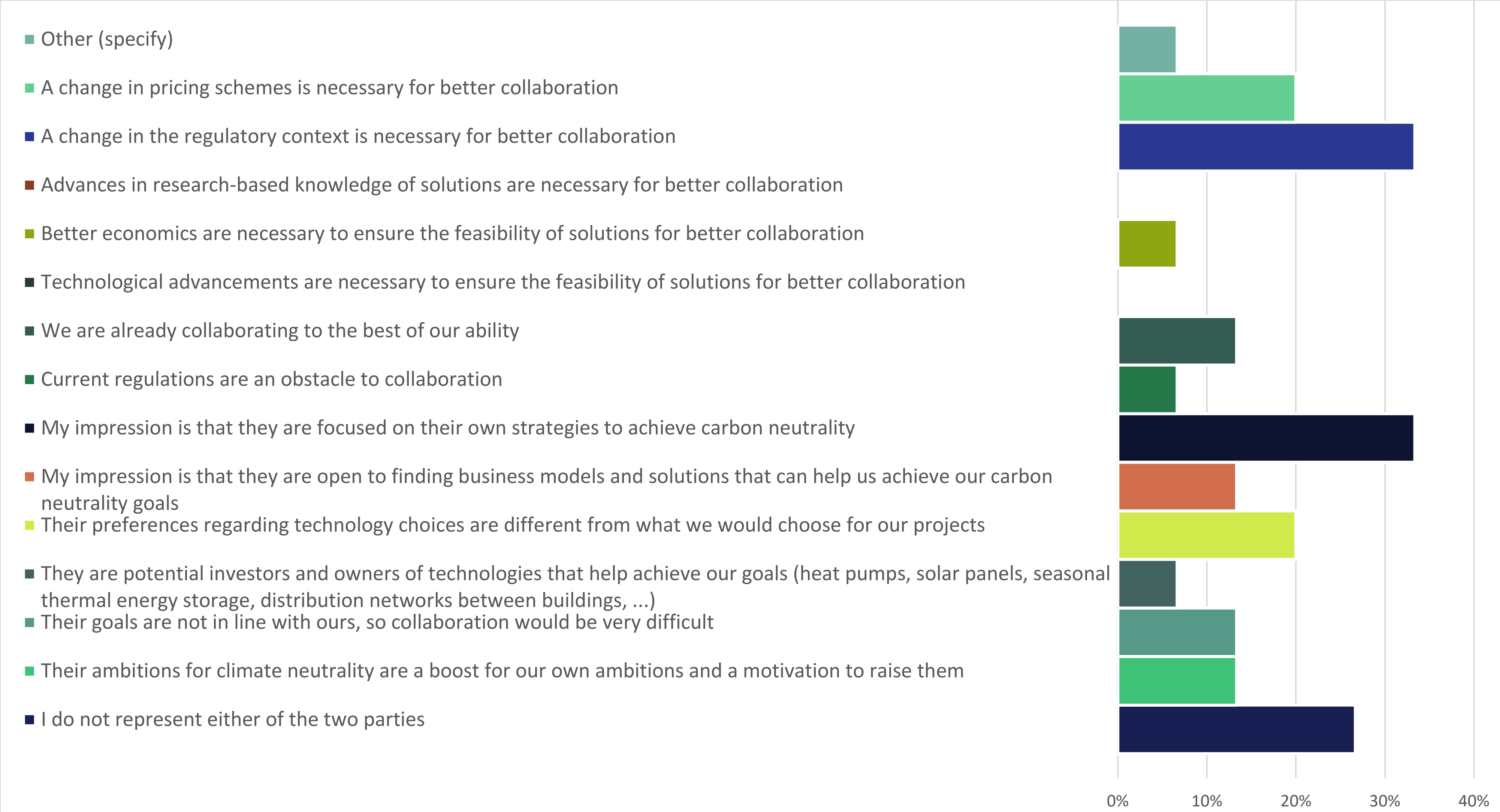
7. Do you think a building developer would be more inclined to connect to district heating if there was a pricing scheme that ensured the use of clean energy sources?



8. Based on the potential benefits of low-temperature district heating systems with seasonal thermal energy storage, how do you perceive their technical-economic feasibility compared to traditional heating solutions?



9. As a representative of the building or district heating industry, what do you think about the potential for collaboration towards carbon neutrality with the other party?



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«Sustainable neighbourhoods with zero greenhouse gas emissions»

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ZERO EMISSION NEIGHBOURHOODS IN SMART CITIES

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