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# Making Europe's homes 'Hygge': Danish lessons on district heating

## Overview of Danish district heating policy and regulation

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# Introduction[1]

Clean, smart and efficient district heating can make a strong contribution to decarbonising Europe's buildings and shifting away from fossil gas for heating.[2] Denmark has emerged as a global frontrunner for both the scale of its district heating adoption and its decarbonisation. In Denmark, decades of targeted policy and investment and careful design of the regulatory framework have led to nationwide coverage by district heating systems across urban, suburban and, increasingly, even rural areas. This has led to competitive heat prices and a high degree of decarbonisation, and has built considerable trust among end users. These outcomes drive a positive feedback loop between the scale of deployment, costs and service quality through economies of scale and learning effects. Moreover, Danish district heating is increasingly being used to provide vital energy system services such as flexibility through the integration of storage, multiple heat sources and smart controls.

As European governments plan to replace their countries' (mainly) fossil gas-based heating systems with clean alternatives, including clean district heating, Denmark's success could be of interest to many. This paper[3] provides a case study of the Danish policy and regulatory framework for district heating, and draws out lessons for policymakers across Europe. It is structured in three sections: the first gives an overview of Danish climate and energy ambitions and the role of district heating; the second identifies the main actors, roles and responsibilities and provides an overview of the main regulatory building blocks; and the final section formulates recommendations for both European and national policymakers and regulators.

# District heating in Denmark

## Climate and energy targets

Denmark is actively tackling the challenge of moving towards more sustainable renewable and low-carbon sources, increasing digitisation and automation of district heating operations, and further improving energy efficiency of both the networks and connected buildings.

Denmark is aiming for a 70% reduction in carbon emissions across all sectors by 2030 compared to 1990 levels.[4] Sector-specific targets and policy approaches have been set through

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[1] Cover image by Francis Crisostomo/Shutterstock.

[2] Oxenaar, S., Lowes, R. & Rosenow, J. (2023). *Warming up to it: Principles for clean, efficient, and smart district heating*. RAP. https://www.raponline.org/knowledge-center/warming-up-to-it-principles-clean-efficient-smart-district-heating/.

[3] The author expresses his appreciation to the following people who provided helpful insights into drafts of this paper (in alphabetical order): Duncan Gibb (Regulatory Assistance Project); Toke Liengaard (Danish Energy Agency), Susana Paardekooper (Danish Energy Agency), Daniel Møller Sneum (Lund University); Louise Sunderland (Regulatory Assistance Project). Editorial expertise provided by Erica Falkenstein (Regulatory Assistance Project).

[4] Government of Denmark. (2024). *Final Update of Denmark's National Energy and Climate Plan for the Period 2021-2030*. https://commission.europa.eu/document/download/13353c72-43bc-486e-bc82-9e8ea7588734_en?filename=DK_FINAL%20UPDATED%20NECP%202021-2030%20%28English%29.pdf.

climate and energy agreements with stakeholders. For buildings, the goal is to cease direct use of fossil gas use for space heating in households by 2030 (green gas only), and of all gas in households by 2035. To achieve this, district heating should expand to all cost-effective locations by 2028 – and, while there is no current sector-specific target for decarbonisation of heat, 81% of heat in district heating is expected to come from non-fossil sources by 2030.[5]

Danish climate law requires society to be fully carbon neutral by 2050.[6] As part of this transformation, municipalities are tasked with updating their heat plans and informing all local building owners/operators still using gas and oil boilers about the revised heat plan. Priority focus is on buildings still using gas in existing district heating areas, and connecting them to the heat network. To support this aim, the heat planning process has been adjusted so that district heating projects are no longer compared to fossil gas on cost-competitiveness, and regulatory obligations to continue serving fossil gas to existing users have also been abolished.[7] This means the gas grid operator can decide to stop delivering gas, subject to timely notification.

## Use of district heating and future projections

Denmark has been an early adopter of district heating. In 2023 around 50% of heat demand in the buildings sector and over two-thirds of homes[8] were supplied through district heating systems. In total, 44% of buildings in Denmark have a district heating connection, through which 58% of total floor area is supplied (Figure 1). District heating is thus the primary heating method for households and a major heat source for utility buildings, offices and other non-residential buildings.

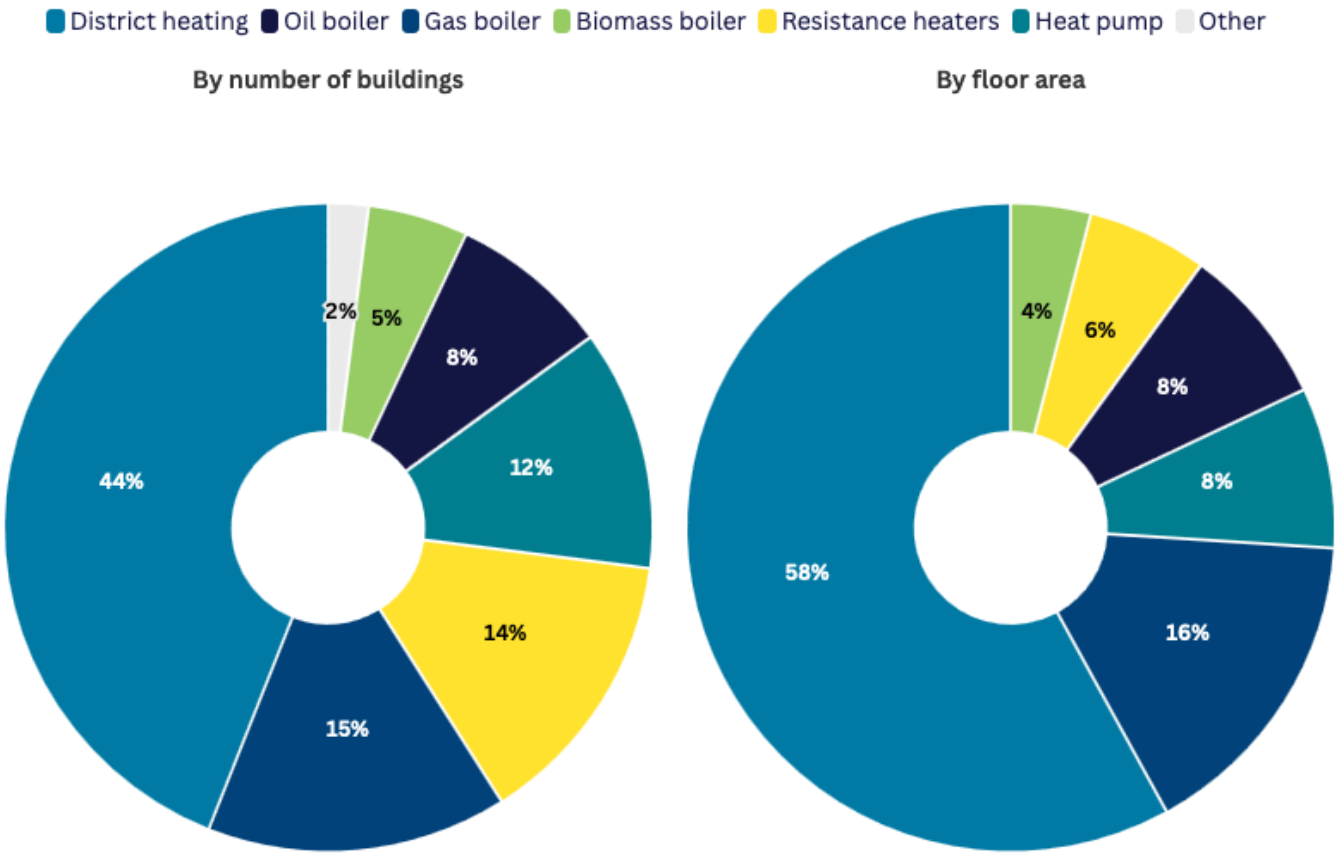
[5] Danish Ministry for Energy, Climate and Utilities. (2022). *Climate agreement on green power and heat 2022*. https://www.kefm.dk/Media/637920977082432693/Klimaaftale%20om%20gr%C3%B8n%20str%C3%B8m%20og%20varme%202022.pdf

[6] Danish Climate Law. LBK No. 2580 of 13/12/202. https://www.retsinformation.dk/eli/lta/2021/2580

[7] Government of Denmark, 2024.

[8] Johansen. K. & Werner, S. (2022). Something Is Sustainable in the State of Denmark: A Review of the Danish District Heating Sector. *Renewable and Sustainable Energy Reviews*, 158: 112117. https://doi.org/10.1016/j.rser.2022.112117

**Figure 1. Types of heating in Denmark (share) by number of buildings and by floor area, 2024**[9]




Source: Statistics Denmark, BYGB40

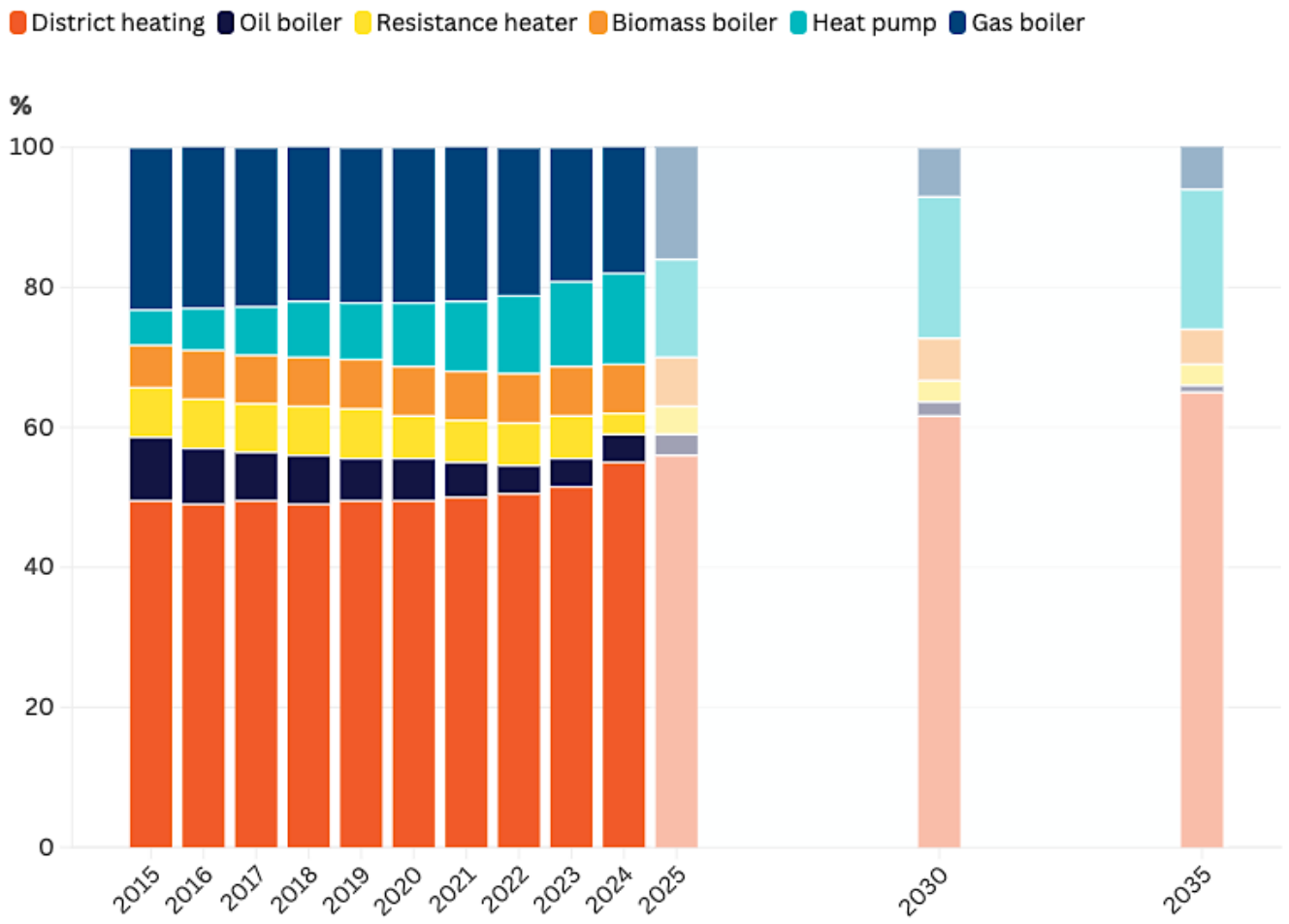
Denmark is currently seeing strong growth in district heating connections due to increased interest from building owners and users following the energy crisis, and in light of government policy to stop all use of fossil gas for heating by 2030. New connections have largely replaced fossil boilers in suburban areas for a total of 1.89 million homes on the networks in 2023, up from 1.74 million in 2018, and projected figures for 2024 and beyond show at least 60,000 more connections.[10] By 2035 district heating is expected to cover 65% of all buildings. In terms of

[9] Statistics Denmark. (2024). *BYGB40: Buildings and Their Heated Area by Region, Unit, Type of Heating, Use and Year of Construction*. https://www.statbank.dk/BYGB40

[10] Bertelsen, L. (2024, 9 February). *Strong Support for DH: 40,000 Homes Connected in 2023*. DBDH. https://dbdh.dk/strong-support-for-district-heating-40000-connected-in-2023-many-more-on-the-way/

network length and share of connected buildings, district heating networks are most established in Denmark's six larger urban areas, which have high heat demand density (see Figure 2).[11] There are many smaller district heating systems operating in more suburban and rural areas with lower heat demand density, however.[12]

**Figure 2. Types of heating in buildings by units/connections, 2015 to 2035**




Source: Danish Ministry for Climate, Energy and Utilities

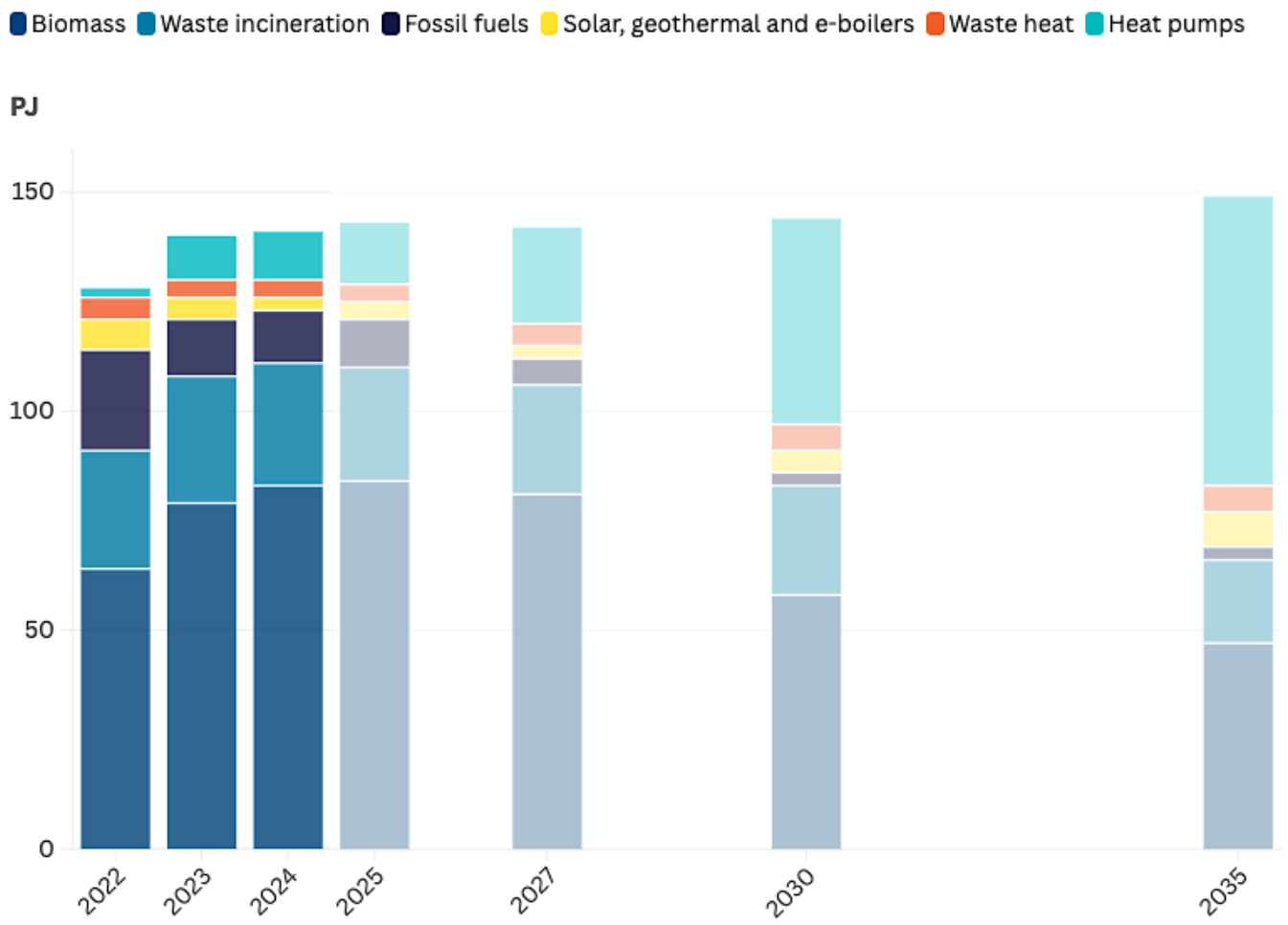
Using combined heat and power installations and boilers running on waste incineration and biomass, Denmark has already largely made the switch away from oil, coal and gas as sources of heat in district heating. In 2023 only 13% of heat provided was generated using fossil fuels,

[11] Klima-, Energi- og Forsyningsministeriet. (2024). *Klimastatus og – fremskrivning 2024, 23 El- og fjernvarme* [Climate status and protection 2024, Chapter 23 Electricity and District Heating]. https://www.kefm.dk/klima/klimastatus-og-fremskrivning/klimastatus-og-fremskrivning-2024.

[12] Johansen & Werner, 2022.

compared to around 50% a decade earlier.[13] Currently, most renewable energy is coming from biomass and municipal waste incineration. The Danish government expects that over the coming decades large heat pumps will become the prime heat provider, due to a combination of government policy and incentives, and projected lower electricity prices. Gradually, as can be seen in Figure 3,[14] this will lead to the replacement of biomass-based combined heat and power plants with heat pumps.

**Figure 3. District heat production in petajoules (PJ) by type, 2022 to 2035**




Source: Danish Ministry for Climate, Energy and Utilities

Typically, district heating systems in Denmark are vertically integrated, with a single entity handling heat production, distribution and retail, and they use multiple sources of heat. Several

[13] Danish Energy Agency. (2024). Energy Statistics 2023. https://ens.dk/sites/ens.dk/files/Statistik/energistatistik_2023.pdf

[14] Based on Klima-, Energi- og Forsyningsministeriet, 2024.

very large systems have developed over time, with the largest in Copenhagen (see box, below). In addition, most larger systems are owned or operated by municipal governments, with smaller systems more often owned or operated by end users.

**Continuously improving: The Greater Copenhagen district heating system**

Although the Greater Copenhagen district heating system still faces considerable decarbonisation and efficiency challenges, it is an example of a larger system which is expanding through the connection of multiple smaller systems while being continuously improved to achieve decarbonisation and efficiency targets.

The district heating system covers 25 municipalities and delivers heat to around 98% of end users, supplying 10,000 GW/h per year to more than 1 million inhabitants.[15] Over time, the three transmission companies and 24 distribution companies have developed into an interconnected system with a single operator managing heat dispatch.[16]

Early on, Copenhagen made the switch from coal and gas to biomass for heat production. Heat is now generated using a mix of combined heat and power plants, waste incineration and peaking plants, achieving a renewable heat share of 35%. The challenge now is to increase the share of modern and decentralised renewable energy from heat pumps, geothermal and industrial waste heat to reduce dependence on (partially fossil) municipal waste heat incineration and biomass.

Increasing thermal storage capacity plays an important role in providing the flexibility required, ensuring that heat production can reliably and efficiently meet demand at all times. Although it is not yet cost-effective to completely phase out waste incineration, the operator is planning to install carbon capture and storage to reduce emissions. In addition, total system efficiency can still be improved through lowering flow temperatures and reducing heat demand from end users. Winter temperatures remain high, between 90 (distribution) and 110 degrees Celsius (transmission), and should be lowered to around 70 and 90 degrees Celsius.[17] This has been found to be technically possible to do at relatively low cost, but it will require intensive cooperation between the different district heating and cooling (DHC) companies.

[15] Directorate-General for Energy (European Commission), Fraunhofer ISI, Institute for Resource Efficiency and Energy Strategies GmbH, Tilia GmbH, TU Wien, Öko-Institut, Alexandre Bacquet, et al. *District Heating and Cooling in the European Union: Overview of Markets and Regulatory Frameworks under the Revised Renewable Energy Directive. Annexes 3 to 5 : Final Version*. Publications Office of the European Union, 2022. https://data.europa.eu/doi/10.2833/220399

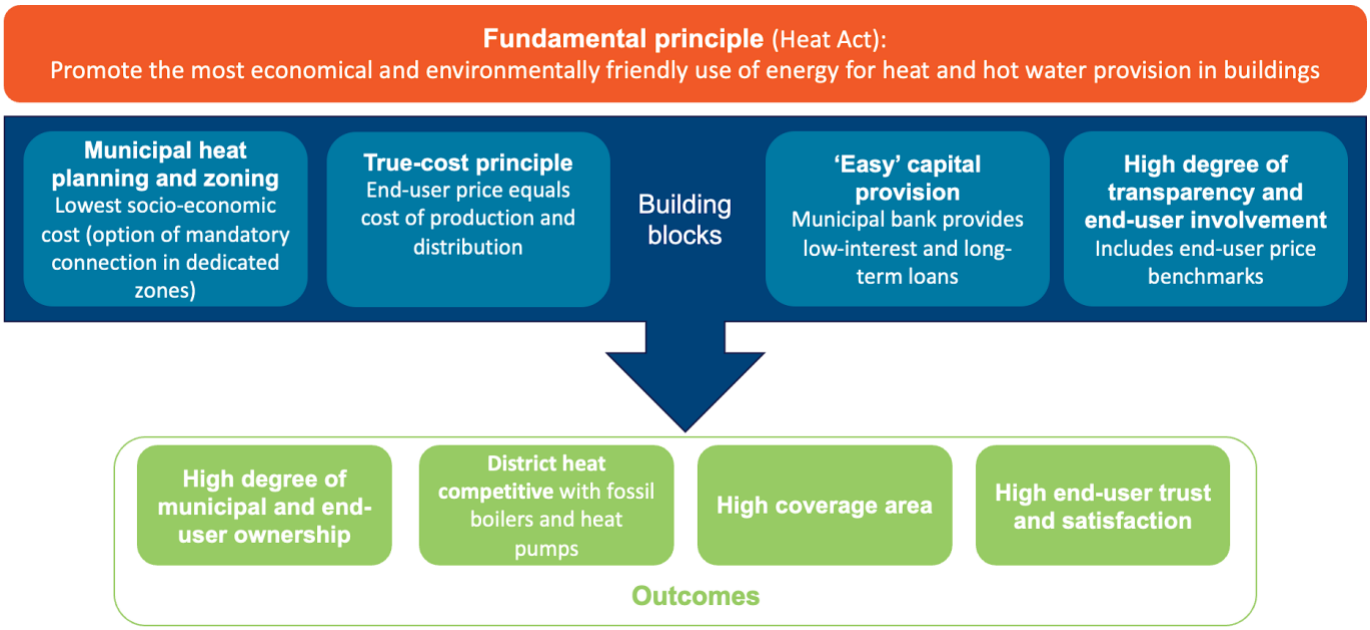
[16] Gullev, Lars. (2023, 5 July). *DH in Greater Copenhagen – History and Status 2023.* DBDH. https://dbdh.dk/dh-in-greater-copenhagen-history-and-status-2023/

[17] Gullev, L. 2023

# Danish district heating policy and regulation

The Danish framework for district heating is based on the core principles of promoting the most economical and environmentally friendly use of energy for heat and hot water provision in buildings and reducing dependence on fossil fuels. Over time this has led to the development of several key 'building blocks' (Figure 4. The Danish district heating model) that guide the deployment of clean district heating systems in Denmark. The subsections in this chapter provide an overview of the actors involved, their roles and responsibilities, and the four main building blocks.

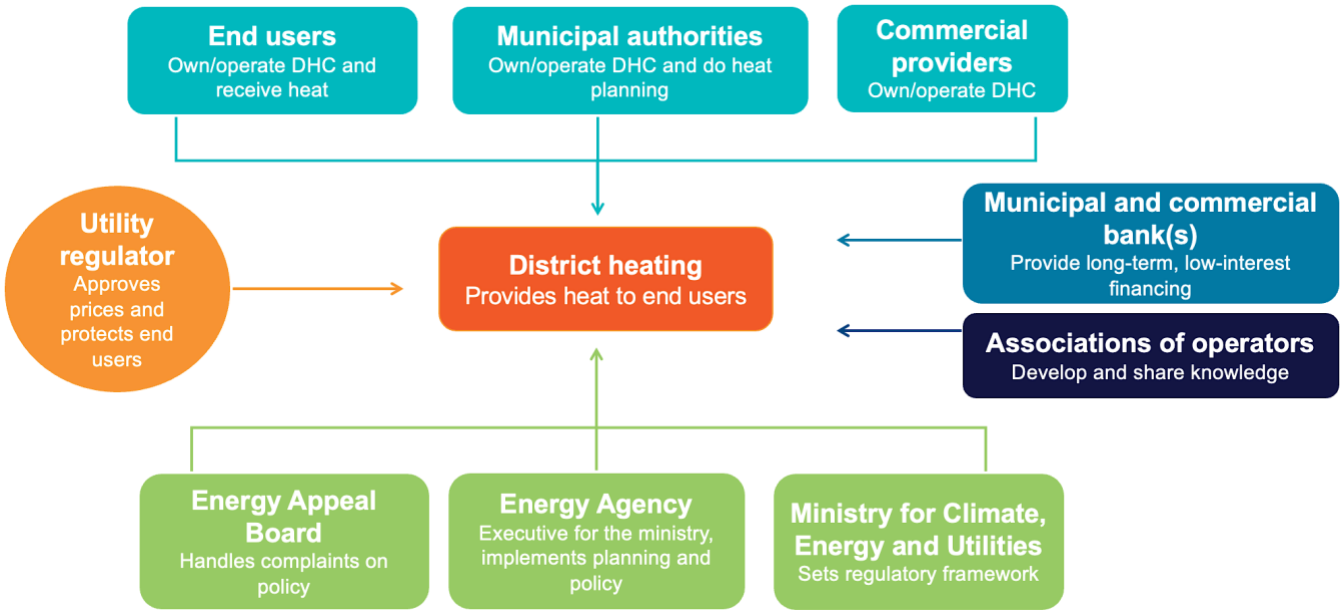
**Figure 4. The Danish district heating model**




## Actors, roles and responsibilities

This section gives an overview of the main actors in the Danish district heating framework and describes their roles and responsibilities. As can be seen in Figure 5, multiple actors are involved in ensuring delivery of district heat in Denmark.

**Figure 5. Actors, roles and responsibilities in Danish district heating and cooling**




The Danish Ministry for Climate, Energy and Utilities sets the regulatory framework according to government policy.

The Danish Energy Agency – part of the Ministry for Climate, Energy and Utilities – is responsible for long-term energy planning and energy and climate policy, and acts as the Ministry's executive arm. This includes setting the general conditions for establishing and operating district heating and cooling, for example through the publication of mandatory standardised methods for heat planning and project feasibility studies, and the provision of the technical catalogue with standardised parameters for these processes.[18]

The Danish Energy Appeals Board is also part of the Ministry for Climate, Energy and Utilities. It decides on complaints about government decisions, and deals with the interpretation of policy measures and regulations.

The Danish Utility Regulator, as an independent body, supervises the electricity, fossil gas and district heating sectors.

Municipalities are responsible for heat planning and zoning, and for ensuring that district heating construction and expansion take place in accordance with the local heat plan and national legislation. In addition, many municipal governments are (partial) owners of the district heating system operating in their area.

[18] Danish Energy Agency. (2024). Supply and consumption: Heat. https://ens.dk/en/supply-and-consumption/heat

The Danish Municipal Bank (KommuneKredit) provides long-term funding at low interest rates for the construction and expansion of district heating systems. As the district heating model is now well known and the regulatory framework is clear, commercial banks are willing to provide funding with similar conditions. Municipal governments can provide guarantees to community-owned projects looking for capital.

End users own and/or operate district heating systems, especially in rural areas and smaller towns, through cooperative and energy community models.

The Danish District Heating Association represents the district heating industry and decentralised energy producers, and promotes knowledge-sharing in the sector. The Danish Board of District Heating plays a similar role but focusses on the international promotion of district heating and of Danish expertise in the field.

# Regulatory building blocks for district heating

## Municipal heat planning and zoning

Heat planning and zoning is mandatory for local governments and has been key in achieving a high rate of district heating coverage in urban and suburban areas. The legislation[19] describes clear roles and responsibilities and provides local authorities with planning, zoning and decision-making powers. Municipal councils thus have the final decision on heat planning and approval of (district) heat projects. At the same time, municipal councils have strict legal limits, set by the national government, on approving new fossil gas and biomass heating. Figure 6 below gives a short summary.

Heat planning is based on assessments aimed at identifying the clean heat solution with the lowest socioeconomic cost for each specific area. Planning must be done in cooperation with utilities and other stakeholders, including potential heat users and/or producers. Standardised methods are set at the national level, ensuring comparability of heat plans across regions and use of best practices. In addition, the Danish Energy Agency provides default methodologies and (socio-economic) input data for the municipal heat planning process through its technology catalogues,[20] and offers general guidance and support to municipalities on the planning process.[21] This includes data on, for example, (projected) fuel and electricity prices, costs of emissions, discount and interest rates, and technology costs and specifications. This data can be used as an input for the modelling and assessment process if more recent or site-specific

[19] The 'Danish Heat Law', Ministry of Climate, Energy and Utilities. (2024). *Bekendtgørelse af lov om varmeforsyning. (Proclamation of the Heat Supply Act).* LBK no. 124 of 02/02/2024. https://www.retsinformation.dk/eli/lta/2024/124 and 'Project Executive Order, Ministry of Climate, Energy and Utilities. (2023). *Bekendtgørelse om godkendelse af projekter for kollektive varmeforsyningsanlæg (Executive Order on approval of projects for collective heating supply systems)*. BEK nr 697 af 06/06/2023. https://www.retsinformation.dk/eli/lta/2023/697

[20] Danish Energy Agency. (2024). Technology catalogues. https://ens.dk/en/analyses-and-statistics/

[21] Danish Energy Agency. (2024). Socio-economic assessments. https://ens.dk/en/analyses-and-statistics/socio-economic-assessments

data cannot be obtained. The standard feasibility study compares the levelised cost of energy (average total cost per unit of heat generated) of heat projects over a 20-year period.[22]

Municipalities can also get technical and organisational support from the Danish Association of Municipalities and the Danish District Heating Association. Planning processes are financed through municipal budgets and, on an ad-hoc basis, the Danish Energy Agency launches dedicated financial support programmes for activities such as consultancy services or project implementation.[23]

In the past, municipalities could choose to put in place a connection mandate for households in areas zoned for district heating, to increase the economic viability of the project. End users were obliged to pay the annual connection fee but were not obliged to use heat, meaning they could use other heating systems if preferred.[24] Since 1 January 2019, mandatory connection in new areas is no longer allowed, giving end users the option to disconnect from uncompetitive district heating operators.[25] Mandates created before 2019 remain in force, and end users in these areas are granted up to 10 years to connect to the local district heating system. Mandatory connection has played a key role in achieving high connection rates during the development phases of district heating systems in Denmark, however, and could be a useful tool to ensure system viability as long as sufficient end-user protection is in place.

[22] Odgaard, O. & Djørup. S. (2020). Review of Price Regulation Regimes for District Heating. *International Journal of Sustainable Energy Planning and Management* 29: 2020–2127. https://doi.org/10.5278/ijsepm.3824

[23] Energy Cities. (2024). EU Tracker – Local heating and cooling plans in Denmark. https://energy-cities.eu/countries/denmark/

[24] Johansen, K. (2022). A Brief History of District Heating and Combined Heat and Power in Denmark: Promoting Energy Efficiency, Fuel Diversification, and Energy Flexibility. *Energies* 15 (24): 9281. https://doi.org/10.3390/en15249281

[25] Danish Ministry for Climate, Energy and Utilities. (2018). Danish Energy Agreement 2018. https://www.kefm.dk/media/6646/energiaftale2018.pdf

**Figure 6. Heat planning in Denmark**


## True cost principle

As set out in Danish heat law, district heating operators must deliver heat at prices based on the 'true cost' principle.[26] True cost means that the end-user price has to equal the cost of heat production and distribution, including asset depreciation and costs of capital. Factors that can be included in total system costs include investments in production facilities and the distribution network, production facility and distribution network maintenance and operation, cost of heat/fuel source, taxes and VAT. Prices are further affected by system size and location, system efficiency (production efficiency and distribution loss), efficiency of operational management, available subsidies/grants, and electricity prices.[27] As these costs can differ between systems, end users in different geographic locations could pay different prices for their heat. Within systems, the heat and connection tariffs can be partially socialised with larger homes paying (slightly) higher connection fees than apartments in multi-family buildings, but costs for additional capacity and grid expansion to connect new buildings are usually shared equally among all end users.

The Danish Utility Regulator oversees tariff setting and handles end-user complaints on pricing. The true cost principle requires substantial reporting, monitoring and verification by the regulator

[26] Also known as cost-based pricing or cost-plus, where the 'plus' in the Danish case is zero.

[27] Böttzauw, K. Planning and Regulation – A Prerequisite. (2021). In: *District Energy: Green Heating and Cooling for Urban Areas*, 3.2. State of Green. https://stateofgreen.com/en/publications/district-energy/

to ensure the principle is adhered to.[28] Although this leads to a high degree of transparency, it does require a well-resourced and functioning regulator.

The main downside of the true cost principle is that, as all costs can be passed on to the end user, district heating operators have limited incentives to reduce costs and improve heat production and distribution efficiency. End users are also vulnerable to increased costs due to inefficient management by the operator.[29] The Danish Utility Regulator attempts to use voluntary performance benchmarking and accessible end-user complaint processes to stimulate economic efficiency improvements by district heating and cooling (DHC) operators.[30]

## Capital provision and municipal guarantee

Initially, most district heating projects were financed through the Danish Municipal Bank, which provides long-term loans (20 to 50 years) at low rates, reflecting its high creditworthiness and non-profit principle. Conditions are fixed and equal for all municipalities and regions. Nowadays, both the Municipal Bank and commercial banks provide loans at similar rates. Banks must charge contribution rates in addition, and, due to EU state aid rules, Municipal Bank rates are higher than they used to be. Nevertheless, despite these increased costs, both funding sources remain very attractive and their long-term loans at relatively low rates make district heating a low-risk investment in Denmark. In addition, community-owned operators can receive municipal guarantees on their loans, lowering their interest costs.[31]

## Transparency and end-user protection

End-user price benchmarks for both fixed and variable heat tariffs are published two to three times per year by the Danish Utility Regulator. Operators are required to provide data to the regulator in a standardised format. This transparency on tariffs provides clarity to end users and, at the same time, an additional incentive for DHC operators to improve their economic performance.[32] In particular, voters and members of municipally- and cooperatively-owned operators – the large majority of operators – may voice complaints when their heat price is

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[28] Odgaard & Djørup, 2020.

[29] Köhler, B., Hünecke, K., Fischer, C., Berneiser, J., & Hebrstritt, C. 2024. (2024). *Akzeptanz der leitungsgebundenen Wärmeversorgung: Status quo in Deutschland und internationale Erfahrungen*. https://www.umweltbundesamt.de/publikationen/akzeptanz-der-leitungsgebundenen-waermeversorgung

[30] Salite, D., Miao, Y. & Turner, E. (2024). A Comparative Analysis of Policies and Strategies Supporting District Heating Expansion and Decarbonisation in Denmark, Sweden, the Netherlands and the United Kingdom – Lessons for Slow Adopters of District Heating. *Environmental Science & Policy* 161: 103897. https://doi.org/10.1016/j.envsci.2024.103897.

[31] Jensen, J. & Jensen, J. (2024). Community-owned district heating networks in Denmark, *Hot Cool magazine.* https://dbdh.dk/how-to-help-communities-establish-district-heating-networks/

[32] Odgaard & Djørup, 2020.

significantly higher than elsewhere. Price transparency also contributes to a high level of end-user trust in district heating.[33]

## Supportive policies

The Danish regulatory framework for district heating is supported by a set of policies across the built environment, heat and gas sectors.

### Setting incentives through taxes, levies and carbon pricing

Denmark has made good use of economic instruments to advance its climate and energy objectives. The government has consistently refined its taxation and tariff frameworks to align with evolving policy goals. Notable examples include the introduction of preferential tax treatment for biomass-based heat production and state aid for biomass-powered electricity generation, measures designed to reduce fossil fuel dependency in district heating systems.[34] A special feed-in tariff for electricity production from small decentralised combined heat and power units was also in place between 1990 and 2005. As it provided a time-varying subsidy for electricity production, it supported flexible operation and installation of thermal storage, key elements in district heating decarbonisation and renewable electricity absorption in the grid.[35] This approach builds on earlier successful interventions, such as the waste management reforms of the 1980s. These introduced differentiated taxation, imposing high rates on landfill while maintaining lower rates for incineration,[36] and effectively encouraged the integration of waste incineration with district heating networks.

Current incentives to support clean district heat include:

- Exemption of renewable energy for heat from energy tax.[37]

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[33] Billerbeck, A., Breitschopf, B., Preuß, S., Winkler, J., Ragwitz, M. & Keles, D. Perception of District Heating in Europe: A Deep Dive into Influencing Factors and the Role of Regulation. *Energy Policy* 184: 113860. https://doi.org/10.1016/j.enpol.2023.113860

[34] State of Green. (2021). *From Black to Green – a Danish Sustainable Energy Growth Story*. https://stateofgreen.com/en/wp-content/uploads/2021/05/SoG_FromBlackToGreenReport_210x297_V06_WEB.pdf

[35] Sneum, D. (2020). *Flexibility in the interface between district energy and the electricity system*. https://backend.orbit.dtu.dk/ws/portalfiles/portal/216181703/2020_DMS_Flexibility_in_the_interface_between_district_energy_and_the_electricity_system.pdf

[36] State of Green. (2011). *Making the most of waste in the City of Copenhagen.* https://stateofgreen.com/en/solutions/making-the-most-of-waste/

[37] Historically, as part of the environmental taxation system energy use in Denmark has been subject to a tax, the 'energy tax'.

- Promotion of heat pump use in district heating through a favourable tax rate of 1 euro per MWh (the minimum rate permitted in the EU).[38] At the same time, the tax on fossil fuels used for heating was increased.[39]
- Reduction of energy tax for heat delivered in district heating from a combined heat and power plant.[40] With the switch to modern renewables, this incentive has become outdated.
- For certified businesses, elimination of a tax on using surplus heat to incentivise waste heat re-use.[41] Reporting requirements were also made less strict.
- Replacement of the existing energy taxation system with a carbon tax from 2025 onwards, leading to higher taxes on – especially – oil and coal used for heating.[42]

## Providing financial support through grants and loans

Denmark has used a range of direct measures to support the development and extension of clean district heating. These include:[43]

- Investment subsidies for the installation of large heat pumps in district heating.
- Subsidies to district heating companies to develop new systems in areas still using oil and gas boilers.[44]
- Subsidies to decouple buildings from the gas grid.[45]
- A State-backed loan scheme for the replacement of oil and gas boilers in areas without district heating access.

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[38] Trier, D. (2024). *Danish Solar District Heating Systems*. Presented at the Solar Thermal Workshop, CET Partnership, May 2024. https://www.cetpartnership.eu/sites/default/files/documentation/7_Danish%20SDH%20systems%20%E2%80%93%20Solar%20Thermal%20Workshop%2C%20CET Partnership%2008-05-2024_compressed.pdf.

[39] Government of Denmark. (2024). *Final Update of Denmark's National Energy and Climate Plan for the Period 2021-2030*. https://commission.europa.eu/document/download/13353c72-43bc-486e-bc82-9e8ea7588734_en?filename=DK_FINAL%20UPDATED%20NECP%202021-2030%20%28English%29.pdf

[40] Danish Tax Office. (n.d.). E.A.4.4.11.1.7 Tax rules on the production of electricity and cogeneration - info.skat.dk. Accessed 27 November 2024. https://info.skat.dk/data.aspx?oid=2186130

[41] RAMBOLL. (2024). *Meta: surplus heat to district heating*. https://www.ramboll.com/projects/energy/meta-surplus-heat-to-district-heating

[42] EY. (2024). *Danish Parliament Introduces CO2 Tax on Fuels and CO2-Emission Tax on Industry from 2025*. https://globaltaxnews.ey.com.

[43] Collier, U. (2018). *Renewable Heat Policies: Delivering Clean Heat Solutions for the Energy Transition*. IEA/OECD; Government of Denmark, 2024.

[44] Danish Energy Agency. (2022). *The Danish Energy Agency allocates more than DKK 450 million for the deployment of district heating to new district heating customers*. https://ens.dk/presse/energistyrelsen-tildeler-mere-end-450-mio-kr-til-udrulning-af-fjernvarme-til-nye

[45] Danish Energy Agency. (2024). *The District Heating Pool*. https://ens.dk/service/tilskuds-stoetteordninger/fjernvarmepuljen

## Phasing out oil and gas boilers

Denmark banned the installation of oil and gas boilers in new buildings from 2013 onwards, and the installation of new boilers in existing homes within a district heating zone as of 2016.[46] This gave end users a clear perspective for the future, and supported DHC expansion in the zoned areas. A scrappage scheme for oil (2017) and gas (2020) boilers was introduced to enable households outside of district heating zones to take part in a leasing scheme for heat pumps, reducing the financial and organisational barrier of making the switch to clean heating.[47]

## Lowering flow and return temperatures in buildings and district heating

Both policymakers and DHC operators in Denmark have recognised the importance of lowering the flow temperature of heating systems to improve the energy efficiency of DHC systems and their connected buildings.[48] Typically, heating systems in Europe use water flowing through pipes and emitters (radiators) heated to high temperatures (70 to 90 degrees Celsius in the building, 90 degrees Celsius or above in the DHC system). Reducing this flow temperature while ensuring the required internal building temperature and pressure can still be met allows district heating systems to run more efficiently and on renewable heat sources.[49] Over time, flow temperatures have shifted from 90/70 (flow/return) to around 65/35 degrees Celsius in today's smaller systems and 75/45 degrees Celsius in larger ones. In new buildings, temperatures can be reduced even further to enhance energy efficiency. In some Danish DHC systems, end users are given a financial incentive to reduce their return temperatures[50] by, for example, receiving a discount/penalty for each degree their return temperature is above or below a determined benchmark. Additionally, lowering flow temperatures can be promoted through policies such as building, heating system and product standards; energy performance audits; smart meters; preconditions for financial support; and awareness raising.[51] In the past, Denmark has also promoted energy efficiency in district heating systems, including via flow temperature reductions, through its energy efficiency obligation scheme.[52]

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46 IEA. (n.d.). Danish Energy Agreement for 2012-2020 – Ban on Fossil-Fuel Based Heating – Policies. Accessed 29 October 2024. https://iea.org/policies/606-danish-energy-agreement-for-2012-2020-ban-on-fossil-fuel-based-heating

47 Danish Energy Agency. How to Be Climate-Friendly – Subscribe to a Heat Pump and Scrap Your Old Oil Boiler. Accessed 29 October 2024. https://ens.dk/media/5086/download

48 European Commission. Joint Research Centre. (2021). *Integrating Renewable and Waste Heat and Cold Sources into District Heating and Cooling Systems: Case Studies Analysis, Replicable Key Success Factors and Potential Policy Implications.* LU: Publications Office. https://data.europa.eu/doi/10.2760/111509

49 Pehnt, M., Lawrenz, J., Nast, M., Mellwig, P., Oxenaar, S. & Sunderland, L. (2023). *Towards Low Flow Temperatures: Making Buildings Ready for Heat Pumps and Modern District Heating*. https://www.ifeu.de/publikation/towards-low-flow-temperatures-making-buildings-ready-for-heat-pumps-and-modern-district-heating

50 State of Green. (2024). *District Energy: The Backbone of a Flexible, Resilient and Efficient Energy System*.

51 See Pehnt et al., 2023.

52 Government of Denmark. (2024). *Final Update of Denmark's National Energy and Climate Plan for the Period 2021-2030*. https://commission.europa.eu/document/download/13353c72-43bc-486e-bc82-9e8ea7588734_en?filename=DK_FINAL%20UPDATED%20NECP%202021-2030%20%28English%29.pdf.

# Outcomes

The Danish framework for district heating described in the subsections above has led to the following outcomes (among others):

- High nationwide coverage of district heating networks across urban, suburban and, increasingly, rural areas.
- Competitive heat prices between district heating and both fossil fuel boilers and building-level heat pumps. District heating in less dense areas is not always as cost-effective as all-electric heat pumps, however.
- Significant decarbonisation of heat in buildings through the use of renewable energy, albeit through a heavy reliance on biomass combined heat and power plants and boilers.
- High degree of trust by end users in district heating as a reliable and affordable way to provide heating.
- A sizeable amount of municipal (in larger cities) and end-user (in smaller towns) ownership and involvement in district heating, as commercial operators have limited interest due to higher return-on-investment expectations.
- The substantial penetration of DHC and growing use of multiple heat sources in each system increases the potential for flexibility and thermal storage.

These outcomes support and strengthen each other, with a positive feedback loop existing between scale of deployment, costs and service quality through economies of scale and learning effects. Over time this can build trust among end users, which is further strengthened by a high degree of transparency, end-user involvement, a stable policy framework, and considerable support from national and local authorities. The subsections below highlight specific interesting outcomes of the Danish DHC framework regarding cost and affordability of heat, municipal and end-user involvement, and end-user trust and satisfaction.

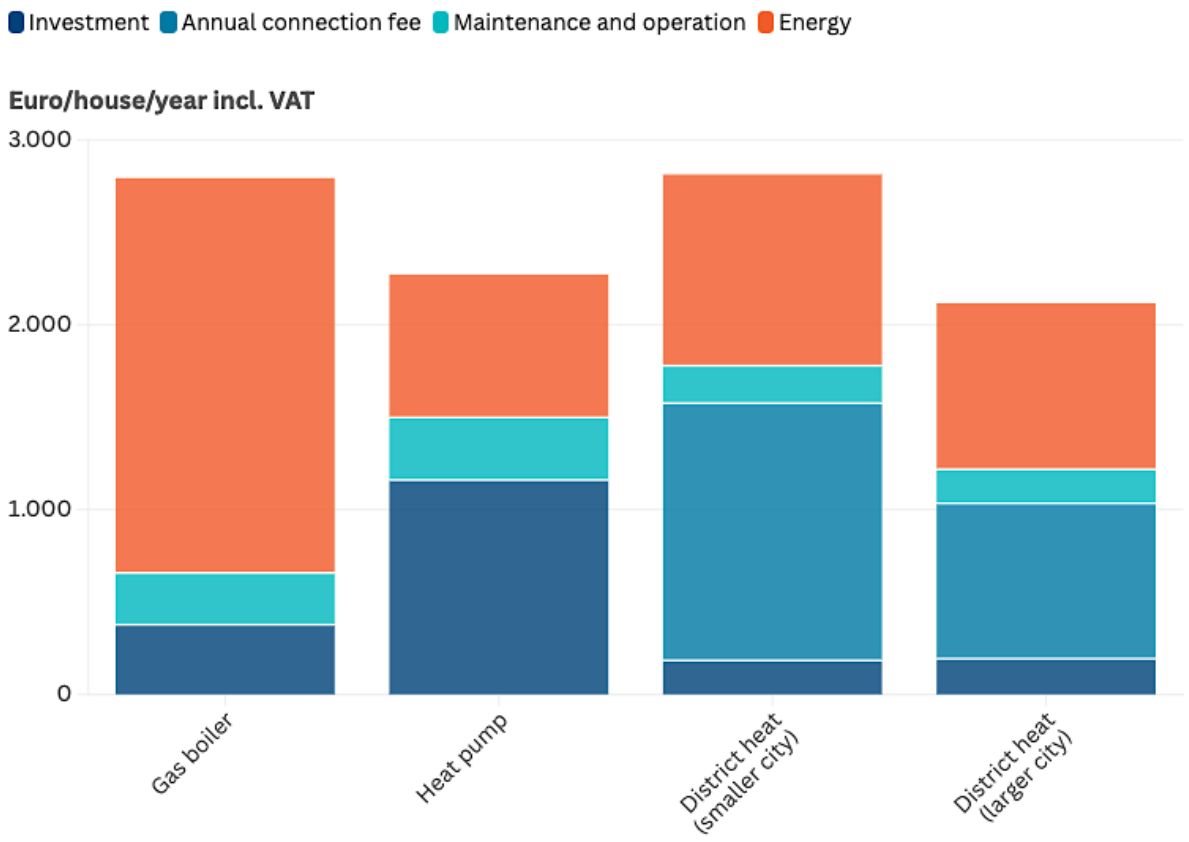
## Cost and affordability of heat

In Denmark, district heating systems generally provide a cost-competitive alternative to other clean heat options such as heat pumps, or conventional fossil fuel-based solutions like condensing gas boilers. For an average house in a larger city, the total annual cost of district heating-based space heat and hot water provision amounts to around €2,100. However, in smaller cities, the cost of district heating rises considerably, reaching approximately €2,800 per household per year. This discrepancy is primarily due to higher annual connection costs and slightly elevated energy expenses in smaller systems, as they are unable to fully capitalise on the economies of scale achievable in larger networks. Interestingly, district heating in smaller cities is now, on average, more expensive for end users than a building-level heat pump, which would cost around €2,300 annually. Conversely, the use of a gas boiler would incur annual

expenses of approximately €2,800, comparable to district heating costs in smaller communities. It should be noted, however, that actual heat costs from district heating in Denmark can differ significantly between local systems.

As seen in Figure 7,[53] heat pump costs are lower than some other household heating systems. Although it is unlikely that district heating users would make an immediate switch to lower-cost heat pumps, this price differential could, over time, lead to users disconnecting from the district heating system.

**Figure 7. Annual heating cost for an average Danish household, 2023**




Note: This is the modelled average cost for new connections including projected costs for the necessary grid and heat production plant investments.

Source: NEKST

[53] Costs include estimations on needed investments in heat production and heat networks. Recreated from NEKST. (2024). Farvel til gas i danske hjem. https://www.kefm.dk/Media/638459533724126884/Nekst_Farvel%20til%20gas%20i%20danske%20hjem.pdf

As heat pump installations become more widespread and accessible at competitive prices, district heating systems will gradually lose their cost advantage, especially in areas of lower heat density where heat production costs are higher, or in cases where the system is not being managed efficiently. This underscores the critical importance of good heat planning when building new district heating systems, to ensure the most socioeconomically cost-effective clean heat solution for local conditions.[54] For both small and large district heating systems the key factor in achieving cost-effectiveness is the share of connected users; in Denmark a 90% connection rate is needed (in most cases) for district heating to be more cost-effective than building-level heat pumps.[55] Figure 8 below gives an overview of additional factors that influence district heating cost.

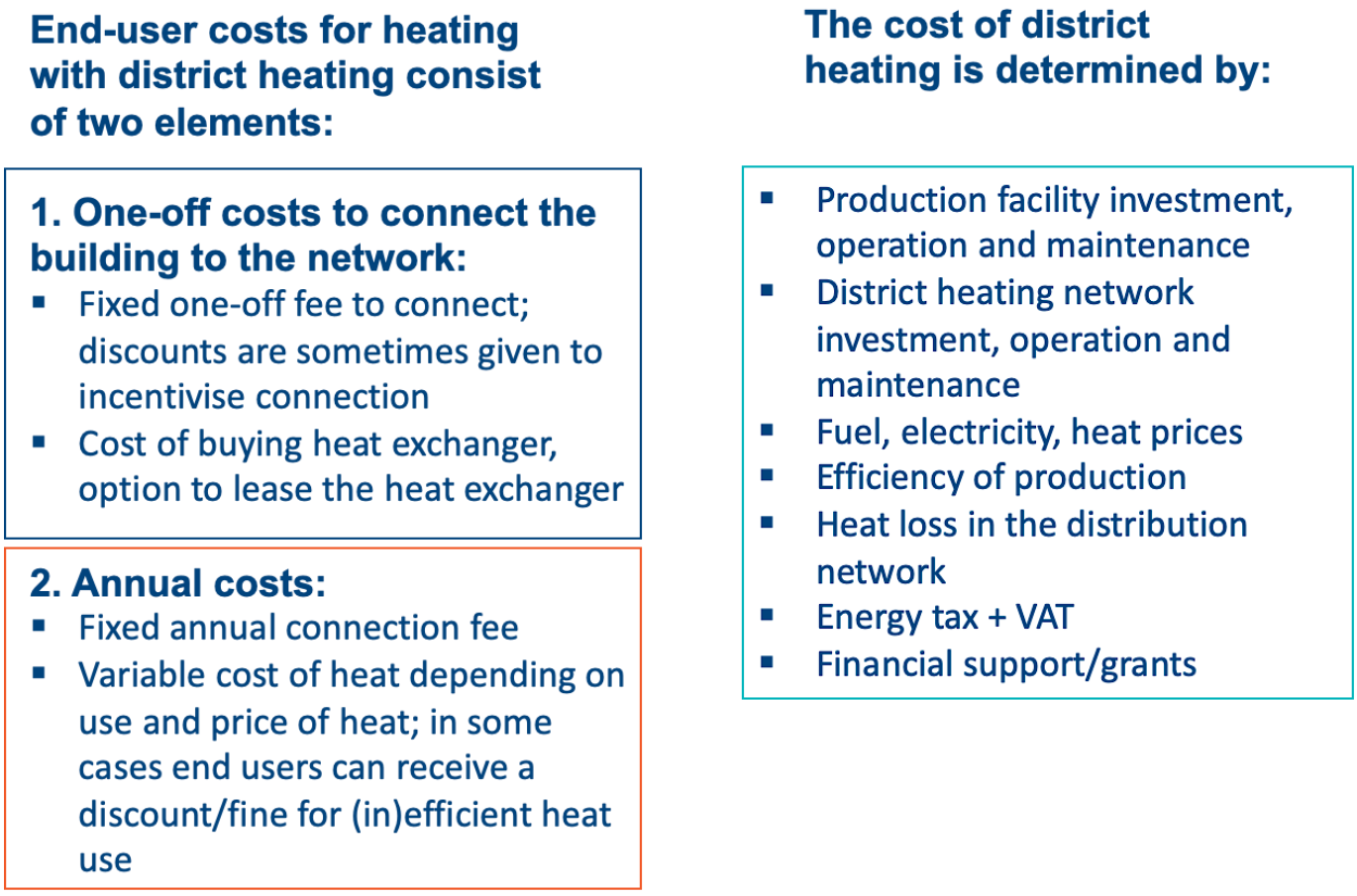
Of course, these costs are seen solely from an end-user perspective. There can be system-level advantages to having a district heating system rather than building-level heat pumps, such as storage and flexibility in production, which are currently often not being taken into account in heat planning or translating their benefits into a lower connection and/or heat price for end users. A recent study by the Danish Climate Council found that total socioeconomic costs for building-level heat pumps and district heating in Denmark are very similar, with only low-temperature district heating (flow temperature <60 degrees Celsius) utilising heat pumps and/or access to excess heat being cheaper than direct electrification. High temperature biomass-based district heating was the most expensive heating solution.[56]

[54] Danish Council on Climate Change. (2022). *From Gas to Clean Heating: Recommendations for an Accelerated Transition from Natural Gas to District Heating and Individual Heat Pumps*. https://klimaraadet.dk/sites/default/files/node/field_files/From%20gas%20to%20clean%20heating%20-%20English%20summary.pdf

[55] Danish Council on Climate Change, 2022.

[56] Danish Council on Climate Change, 2022.

**Figure 8. End-user cost composition for district heating**




## High degree of municipal and end-user involvement

As the market for district heat is less attractive for commercial companies due to its true cost pricing, operators are mostly municipally owned in urban areas (60%) and communally owned in rural areas (35%); only 5% of operators are commercially owned.[57] This, together with the required price transparency, leads to a high degree of end-user influence on price setting through engagement with the operator either as members or as voters. Commercial providers are obliged to have a board of end users to ensure end-user involvement.[58] There is also some evidence that the high degree of local ownership can again lead to lower prices, as

[57] Bacquet, A., Galindo Fernández, G., Oger, A., Themessl, N., Fallahnejad, M., Kranzl, L., Popovski, E. et al. (2022). *District Heating and Cooling in the European Union: Overview of Markets and Regulatory Frameworks under the Revised Renewable Energy Directive*. LU: Publications Office of the European Union. https://data.europa.eu/doi/10.2833/962525

[58] Fischer, C. & Koehler, B. (2024). *Akzeptanz der leitungsgebundenen Wärmeversorgung: Status quo in Deutschland und internationale Erfahrungen.*

municipalities and cooperatives of end users are likely to accept longer payback times on their investments.[59]

## High end-user trust and satisfaction

Compared to other European countries, district heating has a very good public image in Denmark. Danish end users trust in the price, quality and reliability of district heating.[60] The high degree of price transparency, price-setting regulation, and municipal and end-user ownership have been cited as key factors driving end-user trust in Denmark.[61] Clear and accessible information provision and communication by (local) governments and district heating operators has further supported end-user trust.[62]

# Lessons from the Danish framework for district heating

Based on this brief overview of the Danish policy and regulatory framework for district heating and analysis of its key outcomes, seven main lessons can be drawn for other governments aiming to develop and expand clean district heating in their country, region or city. These lessons build on each other and are mutually reinforcing.

## Start with local heat planning

Local heat planning is critical in switching building heat from fossil fuels to clean sources. It should be aimed at determining the option with the lowest socioeconomic cost in each geographic area and making the most of locally available clean heat. Nationwide standardised methods, guidance and best practice should be provided by a national-level agency to ensure comparability and allow for replication and verification of the results. The next step would then be to integrate planning across the heat, electricity and gas sectors (integrated planning) to maximise system efficiency and cost-effectiveness.

## Make district heating secure and predictable

Key to Denmark's success has been its long-term outlook on making district heating a secure, and increasingly clean, source of heat for end users. This accomplishment is based on stable

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[59] Gorroño-Albizu, L. & de Godoy, J. (2021). Getting fair institutional conditions for district heating consumers: Insights from Denmark and Sweden. *Energy* 237: 121615. https://doi.org/10.1016/j.energy.2021.121615

[60] Bacquet et al., 2022.

[61] Djørup, S. (2023). *Enabling Policies for District Heating*. DBDH. https://dbdh.dk/enabling-policies-for-district-heating/

[62] Fischer & Koehler, 2024.

and predictable policy starting with clear, long-term target setting, accompanied by a regulatory framework with defined roles, responsibilities and boundary conditions.

Transparency and standardised methods and frameworks such as technical standards and guidelines have been critical in both de-risking district heating investments and in facilitating information and knowledge dissemination, resulting in cost reductions.[63] Moreover, transparent and stable pricing leads to higher end-user support for district heating as a heat solution. This, in turn, fosters high connection rates among end users, which is vital to achieve economic viability. Heat planning should give end users an understanding of what the future heating solution for their building will be, and a clear timeline for connection.

## Leapfrog outdated technologies: Go for clean, efficient and smart

Denmark is continuously making its district heating systems cleaner, more efficient and smarter. New district heating projects across Europe should aim to leapfrog fossil fuel-based and outdated solutions. Key to this is 1) going for the lowest viable flow temperature, 2) integrating multiple heat sources and thermal storage, and 3) adopting smart digitised and automated controls and metering.[64] For example, Denmark invested heavily in biomass-based combined heat and power, but is now seeking to replace these systems with more sustainable and lower-cost sources. Lower-temperature district heating with supply (flow) temperatures below 60 degrees Celsius, using heat pumps and/or excess heat, currently has the lowest societal costs in Denmark – and, whenever feasible in an area, is the preferred clean heat solution.

## Start small and aim for gradual expansion

Denmark has only been able to achieve such extensive district heating coverage over decades of careful planning, policymaking and investment, reflecting the benefit of years of compounded learning effects, developed value chains and economies of scale. Countries with low current rates of deployment will likely face higher development costs than Denmark.[65] Countries and cities with limited district heating experience could start with implementing several smaller projects that can, over time, develop into larger district heating systems. Initial efforts should be focussed on the locations with highest viability, for example because there is an abundant heat source available alongside easy-to-connect end users with high heat demand (anchor loads) such as hospitals, university campuses or malls, and in new-build areas where grid construction

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63 Salite, D., Miao, Y. & Turner, E. (2024). Comparative Analysis of Policies and Strategies Supporting District Heating Expansion and Decarbonisation in Denmark, Sweden, the Netherlands and the United Kingdom – Lessons for Slow Adopters of District Heating. *Environmental Science & Policy* 161: 103897. https://doi.org/10.1016/j.envsci.2024.103897.

64 Oxenaar, S., Lowes, R. & Rosenow, J. (2023). *Warming up to It: Principles for Clean, Efficient, and Smart District Heating.* RAP. https://www.raponline.org/wp-content/uploads/2023/11/RAP-Oxenaar-District-heat-policy-principles-11.2023.pdf

65 Fallahnejad, M., Kranzl, L., Haas, L., Hummel, M., Müller, A., Sánchez García, L. & Persson, U. (2024). District Heating Potential in the EU-27: Evaluating the Impacts of Heat Demand Reduction and Market Share Growth. *Applied Energy* 353: 122154. https://doi.org/10.1016/j.apenergy.2023.122154

costs are lower. These projects can provide space for learning and institutional development that can benefit future district heating projects in the country.

## Set incentives that reward clean, efficient and smart district heating

Over time, Denmark has continuously adjusted the economic incentives for operators and end users to guide developments in line with policy targets. Both national and local governments could use the tools at their disposal – ranging from taxation, subsidies, and fees and levies to permitting and standard-setting – to incentivise the development and expansion of clean, efficient and smart district heating.

## Regulate heat prices and ensure price transparency

Some form of price regulation is needed to ensure end-user trust and competitiveness with other clean heat solutions. Regulations can ensure price transparency for end users to increase trust and public acceptance. For countries with high investment needs, a balance must be found between the affordability of heat and the economic viability of the network investment. If government funding is limited or unavailable, additional economic incentives could be needed to attract commercial investors. In addition, a well-resourced regulator could ensure efficiency in monopolistic or near-monopolistic systems, and guard the balance between end-user protection and return on investment.

## Foster end-user participation

Allowing and actively supporting end-user involvement in new district heating projects, including through the possibility of ownership, can improve project viability. Especially for neighbourhood-level systems and in rural areas and smaller towns, this involvement can help build trust among potential end users. In some cases it could boost economic viability, as end-users or municipal operators are sometimes willing to accept lower returns on investment than commercial providers.

# Recommendations for EU policy and legislation on district heating

Given the regulatory tools at the EU's disposal and the limited harmonisation of its heating sector, standard setting and benchmarking to drive transparency, protecting consumers and providing targeted funds for the development of clean, efficient and smart district heating is recommended to be explored at the EU level.

- **Set EU-wide standards** on data reporting, monitoring and verification for topics including prices, end-user satisfaction, energy efficiency, environmental performance and emissions. Work together with manufacturers and operators to increase harmonisation by setting EU-wide standards for, for example, district heating construction, parts (manufacturing), controls and automation, metering and contracting. Value chain cooperation can support much-needed cost reductions in district heating system construction and expansion. Other valuable parameters include pricing, end-user satisfaction, energy efficiency, environmental performance and emissions.

- **Set obligatory minimum requirements on transparency and accessibility of reporting, monitoring and verification outcomes based.** After setting an EU-wide standard on data reporting, monitoring and verification, an obligatory minimum standard should be established to ensure all operators provide data in a transparent and accessible manner.

- **Set up an EU-wide system for performance benchmarking of district heating** to drive insight into industry performance, inform enhanced policy decision-making, and improve industry performance on key indicators. Initially this could be a voluntary system.

- **Provide direct funds to municipal governments** for clean, efficient and smart district heating projects through both existing and new schemes.


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