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Warming up to it:

Principles for clean, efficient and smart district heating

By Sem Oxenaar, Richard Lowes and Jan Rosenow

Executive Summary

Decarbonising space and water heating is key for reaching European climate goals and ensuring a reliable and affordable supply of heat to citizens and businesses. District heating systems are an important part of heat provision in many European countries, while other localities have yet to exploit their significant potential.

District heating can play an important role in the energy transition. It has the potential to enable the use of waste heat from industry and other processes; ambient heat from the ground, water, and air; and renewable heat from bio-, solar and geothermal energy. In addition, district heating can provide valuable flexibility and storage to the energy system at large through coupling with the electricity sector, contributing to grid balancing and supporting increased integration of renewable energy.

To take up this role, however, many existing district heating systems must be decarbonised. Newly developed district heating will need to be connected to buildings now using fossil fuel-based heating systems. Making district heating energy-efficient and smart are prerequisites for achieving a decarbonised system.

In this report, we[1] propose a set of principles for district heating decarbonisation and development, and explore policy approaches for both EU and national levels that are in line with these principles. Although the size and scope of the challenge facing policymakers and regulators will vary – as the status quo on district heating differs between countries – these high-level principles are applicable across the board.

Put efficiency first in the production, distribution and consumption of heat; this vastly reduces the size of the decarbonisation challenge while lowering costs at the same time.

Use local heat planning to enhance alignment between developments in heat supply, distribution and demand, including, where relevant, the phase-out of gas grids.

Give value to unavoidable waste heat. Harness the huge potential of available and unavoidable waste heat through local heat planning and incentive setting, to replace fossil fuels and save consumers money.

Ensure end-user protection and enable viable business models. End-users should be shielded from potential monopolistic behaviour by district heating operators. A balance needs to be struck between ensuring the economic viability of business models (to attract the necessary investments for decarbonisation and modernisation of district heating systems), affordability of heat, and quality of service.

Reward energy system integration. Through coupling with the electricity sector, district heating can provide much needed flexibility and storage. This potential needs to be recognised and incentivised.

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Introduction

Policy context and urgency

Decarbonising space and water heating is key for reaching European climate goals and ensuring a reliable and affordable supply of heat to citizens and businesses. Space and water heating is responsible for around a third of final energy demand in the European Union (EU), and over 75% of this heat comes from burning fossil fuels.[2] Most heat is provided by the direct combustion of gas (43.4%), oil (15. 2%) and coal (3.2%), and the remainder indirectly through the fossil share of the fuel mix used in district heating and electricity generation. The building sector as a whole is responsible for 36% of greenhouse gas (GHG) emissions; a significant share of this comes from heating and cooling.[3]

Decarbonisation of heating needs to accelerate if we are to meet EU climate, renewable energy and energy efficiency targets.[4] The updated Renewable Energy Directive (RED III) sets an indicative target of 42.5% renewable energy in final energy consumption by 2030 to meet the Union's 2030 55% emissions reductions target.[5] To achieve this, the renewable energy share in heating and cooling should reach around 43% by the same date.[6] In addition, RED III sets a binding target for Member States to increase the percentage of renewable energy in heating and cooling by at least 0.8% per year at national level until 2026, and 1.1% per year from 2026 to 2030. As Figure 1 shows, the binding targets do not put the sector on track to reach the headline target, however.[7] Instead, renewable energy in heating should grow by around 2% annually.[8]

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[2] Kranzl, L., Fallahnejad, M., Büchele, R. et al. 2022. *Renewable space heating under the revised Renewable Energy Directive: ENER/C1/2018-494: final report*. Publications Office of the European Union. https://data.europa.eu/doi/10.2833/525486

[3] Vitali Roscini, A., Rapf, O. & Kockat, J. 2020. *On the way to a climate-neutral Europe.* https://www.bpie.eu/publication/on-the-way-to-a-climate-neutral-europe-contributions-from-the-building-sector-to-a-strengthened-2030-target/

[4] European Environment Agency (EEA). 2023. *Decarbonising heating and cooling – a climate imperative.* https://www.eea.europa.eu/publications/decarbonisation-heating-and-cooling

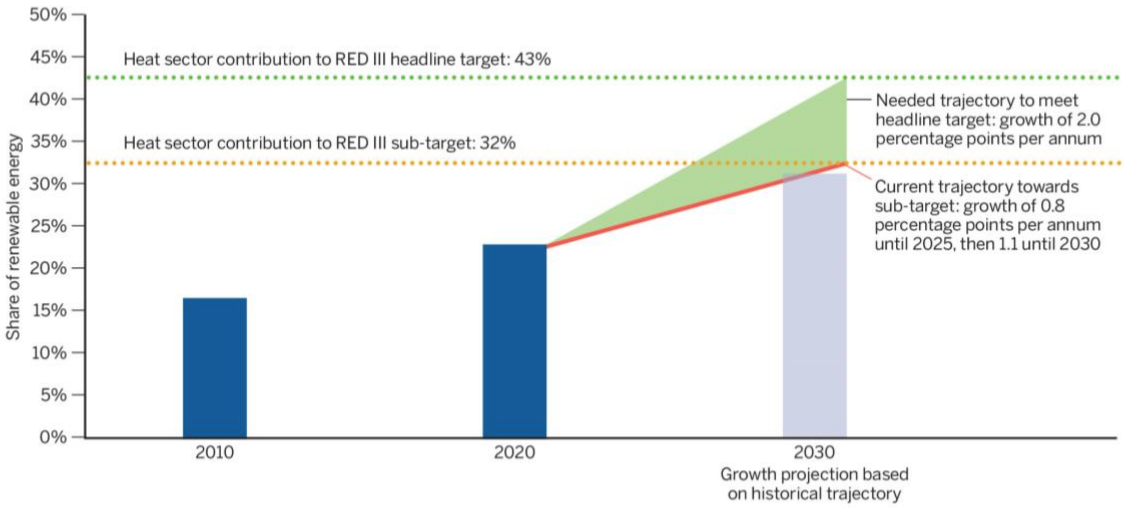
[5] Directive of the European Parliament and of the Council of amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021PC0557

[6] Gibb, D. 2023. Business as usual? Heating and cooling in the EU's updated Renewable Energy Directive. *Energy Monitor*. https://www.energymonitor.ai/sectors/heating-cooling/opinion-business-as-usual-heating-and-cooling-in-the-eus-updated-renewable-energy-directive

[7] Gibb, D., Thomas, S., & Rosenow, J. 2022. *Metrics matter: Efficient renewable heating and cooling in the Renewable Energy Directive*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/metrics-matter-efficient-renewable-heating-cooling-renewable-energy-directive/ based on data from Eurostat. 2022. *Energy from renewable sources; shares.* https://ec.europa.eu/eurostat/web/energy/database/additional-data#Short%20assessment%20of%20renewable%20energy%20sources%20(SHARES)

[8] Gibb, 2023.

Figure 1. Share of renewables in energy for heating and cooling based on current trajectories and targets



Source: Gibb, D., Thomas, S., & Rosenow, J. (2022). *Metrics matter: Efficient renewable heating and cooling in the Renewable Energy Directive*.

As part of its Renovation Wave strategy, the EU has set a 2030 target of reducing emissions in buildings by 60% compared to 2015. To contribute to this target, energy consumption for heating and cooling will have to reduce by 18% over the same period.[9] Thus, in addition to increasing the share of renewable energy, we also need to achieve significant energy savings in the heating and cooling sector.

To realise these ambitious goals, many buildings now using fossil fuel boilers or inefficient direct electric heaters will have to be fitted with clean heating systems – mainly full-electric heat pumps[10] – or connected to clean district heating systems; while many existing district heating systems will need to be modernised and decarbonised.

District heating in Europe: status quo and challenges

In 2017, the latest year for which comprehensive data is available, district heating supplied 12% of EU space and water heating (414 TWh).[11] Around half of this was for residential needs. Most heat provided through district heating systems is still produced by burning fossil fuels, with gas amounting to around 32%, hard coal 20%, lignite 6% and oil 3% (see Figure 2).[12] Although the share of renewables in district heating has increased slowly but steadily in recent years – from 24% in 2012 to 32% in 2017 – this has mainly been through replacing fossil fuels with biomass (22%) and renewable

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[9] European Commission. 2020. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0662

[10] Toleikyte, A., Roca Reina, J.C., Volt, J., Carlsson, J., Lyons, L., Gasparella, A., Koolen, D., De Felice, M., Tarvydas, D., Czako, V., Koukoufikis, G., Kuokkanen, A. & Letout, S. 2023. *The Heat Pump Wave: Opportunities and Challenges*. Publications Office of the European Union, Luxembourg. doi:10.2760/27877

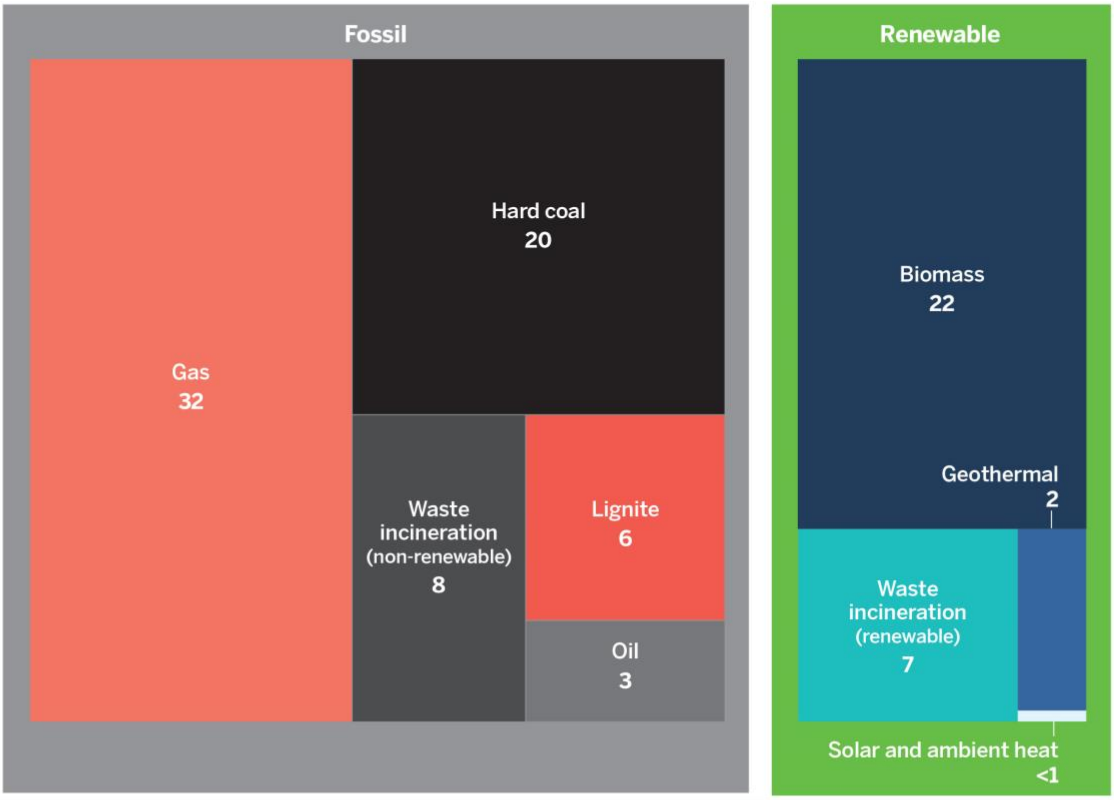
[11] Kranzl, L., Fallahnejad, M., Büchele, R. et al. 2022.

[12] Kranzl, L., Fallahnejad, M., Büchele, R. et al. 2022.

waste (7%). Renewables such as geothermal (2%) and ambient heat through heat pumps and solar (<1%) are growing but make up only a marginal share, and the same goes for waste heat (<1%).

In 2023, Euroheat & Power, the European district heating industry network, carried out a member survey on the state of district heating in Europe. It reports that there are currently more than 17,000 district heating systems supplying heat to European buildings, including the homes of 70 million citizens. The survey, covering a subset of EU and non-EU countries in Europe, also showed that the share of renewable energy in heat production has continued to grow since 2017, in particular bioenergy and renewable waste[13] which grew from 29% to 36%, mainly as a replacement for fossil gas. Although still minor, the use of heat pumps and waste heat is also expanding, respectively reaching around 2% and 2.5% of the heat mix in 2021.[14] Although EU-wide data is not yet available for 2021, the trends will likely be similar.

Figure 2. District heating fuel mix (%) in EU (without UK), 2017



Source: Kranzl, L., Fallahnejad, M., Büchele, R. et al. (2022). *Renewable space heating under the revised Renewable Energy Directive: ENER/C1/2018-494: final report*.

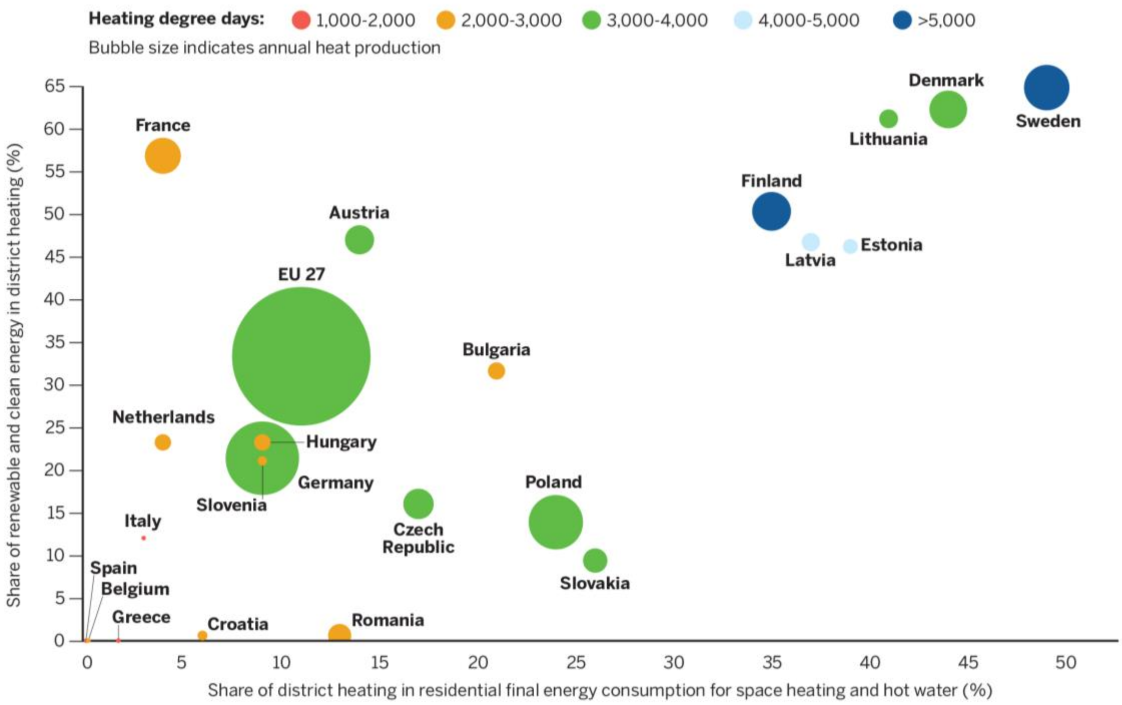
The use and state of district heating systems varies greatly between countries in Europe. For example, while the Nordic and Baltic countries have district heating shares above 30% of final energy use in the residential sector, other countries such as

[13] Mainly consisting of the organic elements of household and commercial waste.

[14] Euroheat & Power. 2023. *Market Intelligence Report 2023*.

Belgium, Ireland, Portugal and Spain have almost none (<1%).[15] Generally, countries with higher shares of district heating, and colder climates,[16] have also achieved higher levels of decarbonisation (Figure 3).[17]

Figure 3. District heating deployment and share of clean heat in EU (without UK), 2017



Bubble size indicates the amount of annual heat delivery through district heating systems.

Source: Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

Beyond decarbonisation, many countries in Europe also face challenges around modernisation and energy efficiency, the economic viability of district heating, service levels, and end-user satisfaction.[18] These issues are especially prominent in coal and oil-reliant systems, with over 70% of these plants still operating beyond their technical lifetime,[19] in systems with badly or uninsulated pipelines and (very) high operating temperatures, and in countries with older and lower-performing building stock.

[15] Bacquet, A., Galindo Fernández, M., Oger, A. et al. 2022. *District heating and cooling in the European Union: overview of markets and regulatory frameworks under the revised Renewable Energy Directive*. Publications Office of the European Union. https://data.europa.eu/doi/10.2833/962525

[16] Cooling degree days are an indication of heating needs in the country, more days means higher heating needs.

[17] Bagheri, M., Mandel, T., Fleiter, T., Viegand, J., Naeraa, R., Braungardt, S. & Kranzl, L. 2022. *Renewable space heating under the revised Renewable Energy Directive: ENER/C1/2018 494: description of the heat supply sectors of EU member states space heating market summary 2017.* Publications Office of the European Union. https://data.europa.eu/doi/10.2833/256437 & Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

[18] E Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

[19] Engelmann, K., Cavar, M., Buganova, J., Martinkrista, S., Cizman, J., Mladenovic, M., Tomliak, K., Shlapak, M., Segon, V., Krajacic, G., Matak, N., Capan, T., Merse, S. & Shamray, T. 2020. *Improving the performance of District Heating Systems in Central and Eastern Europe.* KeepWarm project. https://keepwarmeurope.eu/learning-centre/policy-recommendations/

Tackling these challenges is key, as energy efficiency and competitiveness of district heating are prerequisites for achieving decarbonisation.

District heating is generally used in areas with high heat demand density, such as in cities or commercial and industrial areas, as shorter transport distances increase the economic attractiveness of heat networks. Some countries such as Denmark have nevertheless also made district heating available in less dense regions, by using lower-temperature heat sources, insulated piping and more efficient buildings.

Beyond decarbonisation and modernisation, district heating faces challenges when it comes to regulation and public perception. A 2022-2023 EU-wide survey identified several key issues affecting the district heating sector: market power (and dependency); free market entry and switching of suppliers; competition; transparency of pricing; and billing services. Moreover, the survey found that the perception of district heating among households varies significantly between countries, with households in Lithuania, the Netherlands and the Czech Republic rating district heating below average for service quality, pricing, metering and billing; in Sweden and Denmark district heating is perceived more positively than average.[20]

The large differences in the state of the sector between regions and countries means that decarbonisation challenges will also vary between territories. The overall principles outlined in this paper should be tailored to local situations.

Way forward for district heating in Europe

The challenge and opportunity to both decarbonise existing and build new district heating infrastructure across Europe is significant, but making this shift will be crucial in reaching our climate goals and keeping our heat supply secure and affordable. These changes will not happen by themselves, but instead require targeted policy support to ensure that district heating can play a meaningful role in the energy transition.

This paper sets out general guidelines to accomplish this mission and formulates five principles to guide policy and regulation on decarbonising district heating. It is structured in four main chapters. First, we set out the benefits of clean district heating and its role in the future energy system. This is followed by a discussion of the main pathways towards a fully decarbonised and expanded district heating system. Third, we present the five principles for clean district heating. The final section provides an initial overview of key policies available to decision-makers to accelerate clean district heating.

Clean district heating: potential and role in the energy system

District heating can play a key role in decarbonising our heat supply and facilitating the broader transition to renewable energy. Heat networks can deliver waste, ambient and

[20] Breitschopf, B., Wohlfarth, K., Schlomann, B., Billerbeck, A., Preuß, S., Bagheri, M., Berger, F., Schmidt, R.-R., Pantelic, D., Stefanica, D., Scotton, S., Egea Saiz, I., Muinzer, T.L., McKenna, R. & Gilmore-Maurer, M. 2023. *Overview of heating and cooling: Perceptions, markets and regulatory frameworks for decarbonisation: final report.* Publications Office of the European Union. https://data.europa.eu/doi/10.2833/962558

renewable heat – combined under the header of 'clean' in this paper – to buildings and provide crucial energy storage and flexibility to the wider energy system.

Potential of clean district heating

One main benefit of district heating is that it allows us to make use of clean heat sources that would otherwise be difficult to access. For example, readily available waste heat close to urban areas could cover around 10% of the EU's current building heating needs,[21] while waste heat from industry and processing could provide another 5-10%.[22] The economies of scale of district heating networks can make it cost-effective to harness such waste heat sources. This also applies to sources which are generally uneconomical to tap into for a single building, such as (deep) geothermal. Although technologies such as solar thermal, sustainable biomass, and ambient heat coupled with heat pumps are viable building-level heating installations, district heating can offer attractive economies and efficiencies of scale.

Combining significant energy efficiency measures with the use of renewable sources in heat distribution and buildings, clean district heat can cover a large share of Europe's heat demand.[23] Heat Roadmap Europe – a comprehensive 2018 modelling study for the development of the heating and cooling sectors in Europe – estimated that in the 14 European countries analysed, representing 90% of EU heat demand, clean district heating could meet up to half of all heating needs by 2050. With additional investments in energy savings in production, distribution and buildings, this could even reach 68%.[24] Figure 4. shows the modelled cost-effective district heating deployment for scenarios with different decarbonisation ambition levels, and compares them with the 2015 baseline.[25] Although modelling outcomes are dependent on fuel and technology price developments, the ambitious Heat Roadmap Europe 2050 scenario clearly indicates that larger shares of district heating deployment in Europe are both feasible and cost-effective.

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[21] Lygnerud, K. (ed.), Nielsen, S., Persson, U., Wynn, H., Wheatcroft, E., Antolin-Gutierrez, J., Leonte, D., Rosebrock, O., Ochsner, K., Keim, C., Perez-Granados, P., Romanchenko, D., Langer, S. & Ljung, M. 2022. *Handbook for increased recovery of urban excess heat*. ReUseHeat Project, European Commission. https://www.reuseheat.eu/reuseheat-handbook/

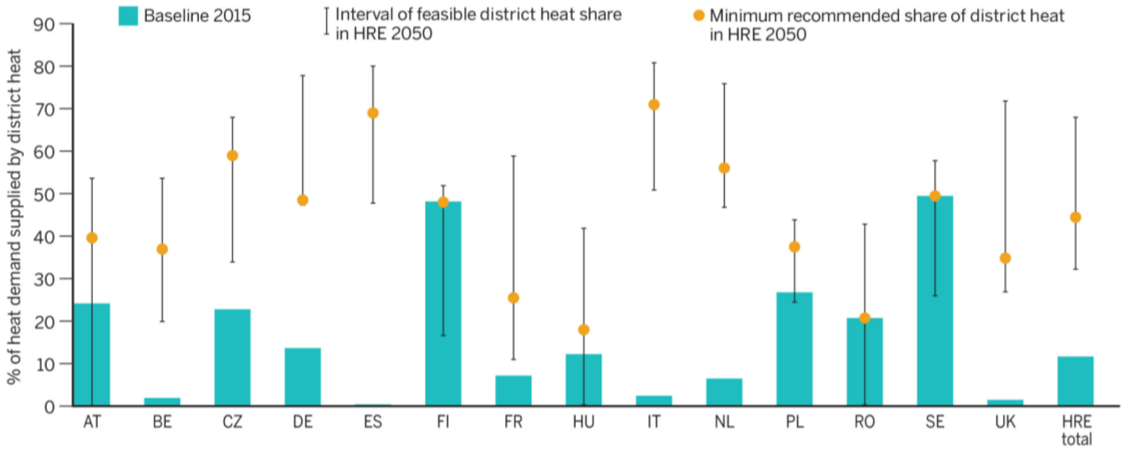
[22] Fleiter, T., Manz, P., Neuwirth, M., Mildner, F., Persson, U., Kermeli, K., Crijns-Graus, W. & Rutten, C. 2020. *Excess heat potentials of industrial sites in Europe.* https://www.seenergies.eu/wp-content/uploads/sites/25/2020/04/sEEnergies-WP5_D5.1-Excess_heat_potentials_of_industrial_sites_in_Europe.pdf

[23] Vad, M., Bertelsen, N., Schneider, N., Luis Sanchez, G., Paardekooper, S., Thellufsen, J. & Djorup, S. 2019. *Towards a decarbonised heating and cooling sector in Europe: Unlocking the potential of energy efficiency and district heating.* https://vbn.aau.dk/ws/portalfiles/portal/316535596/Towards_a_decarbonised_H_C_sector_in_EU_Final_Report.pdf

[24] Paardekooper, S., Lund, R.S., Mathiesen, B.V., Chang, M., Petersen, U.R., Grundahl, L., David, A., Dahlbæk,J., Kapetanakis, I.A., Lund, H., Bertelsen, N., Hansen, K., Drysdale, D.W. & Persson, U. 2018. *Heat Roadmap Europe 4: Quantifying the Impact of Low-Carbon Heating and Cooling Roadmaps.* Aalborg Universitetsforlag. https://vbn.aau.dk/ws/portalfiles/portal/288075507/Heat_Roadmap_Europe_4_Quantifying_the_Impact_of_Low_Carbon_Heating_and_Cooling_Roadmaps..pdf

[25] Paardekoper et al., 2018.

Figure 4. Modelled cost-effective district heating levels in 2050: Heat Roadmap Europe scenarios



Source: Paardekooper. (2018). *Heat Roadmap Europe 4.*

In addition to enabling the cost-effective use of renewable energy, district heating that uses locally available sources also reduces the need for fuel imports. This, in turn, increases energy security while stimulating local economies, as previous expenditure on fuel imports is switched to construction and maintenance of regional infrastructure.

Expected role of district heating in the energy system

District heating can play an important role in energy storage and flexibility. As the share of renewable energy on the electricity grid increases, energy storage and flexibility play an increasingly valuable part in matching energy demand with supply.

A district heating system is an attractive way to store energy as heat, as the stored heat can be directly utilised (in contrast to having to convert the heat into electricity, leading to substantial energy losses). Moreover, adding extra heat storage to district heating improves the energy and economic efficiency of the entire system (see box on thermal energy storage, below). Finally, it is more cost-effective and energy-efficient to build one large storage facility supplying many end-users than to instal small tanks at each individual building.[26] District heating can offer this scale.

Current installed thermal energy storage capacity in Europe is substantial, but it is mainly comprised of building-level electric boilers and storage tanks for solar thermal systems. Although an overview of the current installed capacity of thermal storage in European district heating is not available,[27] installed capacity at the global level is estimated to be around 105GWh for district heating and 91GWh for buildings (excluding domestic hot water tanks).[28]

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[26] Sveinbjörnsson, D., Laurberg Jensen, L., Trier, D., Bava, F., Ben Hassine, I. & Jobard, X. 2019. *Large Storage Systems for DHC Networks.* FLEXYNETS project.

[27] Hoogland, O., Fluri, V., Kost, C., Klobasa, M., Kühnbach, M., Khanra, M. et al. 2023. *Study on Energy Storage.* Publications Office of the European Union. https://data.europa.eu/doi/10.2833/333409

[28] IRENA. 2020. *Innovation Outlook: Thermal Energy Storage.* Abu Dhabi: International Renewable Energy Agency. https://www.irena.org/publications/2020/Nov/Innovation-outlook-Thermal-energy-storage

Strong growth of large-scale thermal storage in Europe is expected, especially in countries with high levels of district heating deployment. In one scenario with ambitious district heating deployment, 50% of total heat demand is supplied through district heating by 2050, alongside 224TWh of storage.[30] While Solar Power Europe's ambitious 'Paris compatible' scenario (a 100% renewable Europe in 2040) would require huge amounts of thermal storage – 800TWh in 2040 and over 1,000TWh by 2050[31] – the potential for such large-scale energy storage is closely connected to the expansion of district heating deployment. Failing to achieve this expansion would mean needing to invest more in other forms of energy storage, and would risk delaying Europe's transition to a 100% renewable energy system.

Thermal energy storage in district heating systems

Energy storage is key to ensure supply can reliably meet demand, as production and use of energy do not often overlap in time and geographic space. For example, currently, Europe stores fossil gas produced and imported in the summer to ensure it can meet high winter demands. As we phase out fossil fuels and integrate more variable sources such as wind and solar into our energy systems, the need for storage increases.

Thermal energy storage, or storing energy as heat, can make an important contribution to meeting this need, as it is generally cheaper and enables longer storage than storing electricity. The International Renewable Energy Agency (IRENA) expects global installed capacity of thermal storage to triple from 234GWh in 2019 to over 800GWh by 2030.[29]

There are different thermal storage technologies and mediums. For (district) heating purposes, mainly water is used. For short durations of hours or days hot water can be stored in pipes and small tanks such as electronic boilers, while larger tanks in the ground, boreholes and aquifers can be used to store heat for both short and longer periods (days to months).

Thermal storage in district heating offers the flexibility to shift production of heat to different times during the day, week or even year. For example, some waste heat from industry may only be available in the summer but can be stored for use in winter. When there is plenty of renewable electricity available from wind and the sun, heat pumps and electric boilers can be utilised to produce heat for later in the day or week, if they have sufficient storage available.

This flexibility provided by thermal storage offers benefits such as:

- Increased integration of renewables on the grid, preventing curtailing of low-cost and low-emissions renewables or allowing expansion of renewable energy production capacity.
- Reduced peak load production, often increasing efficiency (as peak load boilers are usually among the least efficient heat production means) and reducing emissions (in the case of gas peak boilers), and lowering investment costs in heat production capacity.
- Increased energy efficiency of heat production, with storage acting as a buffer to meet unexpected demand. Sudden ramp-ups or ramp-downs of heat production can be reduced, allowing production plants to run more efficiently.

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[29] IRENA, 2020.

[30] Directorate-General for Energy (European Commission) et al., 2023.

[31] SolarPower Europe & LUT University. 2020. *100% Renewable Europe: How To Make Europe's Energy System Climate-Neutral Before 2050.* https://api.solarpowereurope.org/uploads/Solar_Power_Europe_LUT_100_percent_Renewable_Europe_mr_804d34f698.pdf

Making district heating clean, but also efficient and smart

Increasing energy efficiency and digitisation and automation are key enablers for district heating to maximise its potential as a provider of clean heat and energy system flexibility.

Energy efficiency is needed to ensure that locally available heat supply can meet demand while keeping heat affordable. Without significant energy savings, future investment in supply capacity will need to be greater, and end-users will have higher heat bills. This is why all modelled pathways to a zero-emissions building sector include substantial energy efficiency improvements.[32]

Digitising and automating district heating systems – making them 'smart' – supports increasing energy efficiency in heat production, distribution and use, and facilitates the delivery of flexibility and storage services. With increased insight into the real-time performance of the district heating system, operators can make better decisions optimising production (supply-demand matching); preventing, detecting, and fixing leaks or malfunctions; and improving distribution system layout. An integrated system of sensors, smart meters and end-users connected with software solutions facilitates this improved decision-making, leading to increased energy efficiency, better service, increased options for flexibility including demand response, and the facilitation of heat and cold exchange between buildings.

The three elements of clean, efficient and smart are in line with the concept of 'fourth generation' district heating, which is the widely accepted state-of-the-art in district heating system design and operation.[33] This concept emphasises energy efficiency, smart integrated energy systems, the use of local renewable resources, low-flow temperatures, increased use of ambient heat with heat pumps, and seasonal storage.

The different generations of district heating as shown in Figure 5 are rough indicators of technologies and operational methods used in district heating systems from each period. Many systems, however, have integrated technologies from different eras over time. For example, the Paris main system, one of the oldest in Europe, still uses coal and pressurised steam in some places, which is a characteristic of first-generation district heating systems. It also relies heavily on household waste incineration (second generation), and at the same time has started to integrate small shares of third- (biomass and biogas) and fourth-generation (geothermal) heat sources.[34] Many systems will thus not fall neatly into one specific category, and even systems built today are not by default constructed as fourth-generation systems. From an energy transition and decarbonisation perspective, however, all systems should integrate as many aspects of fourth-generation district heating as possible, as soon as possible.

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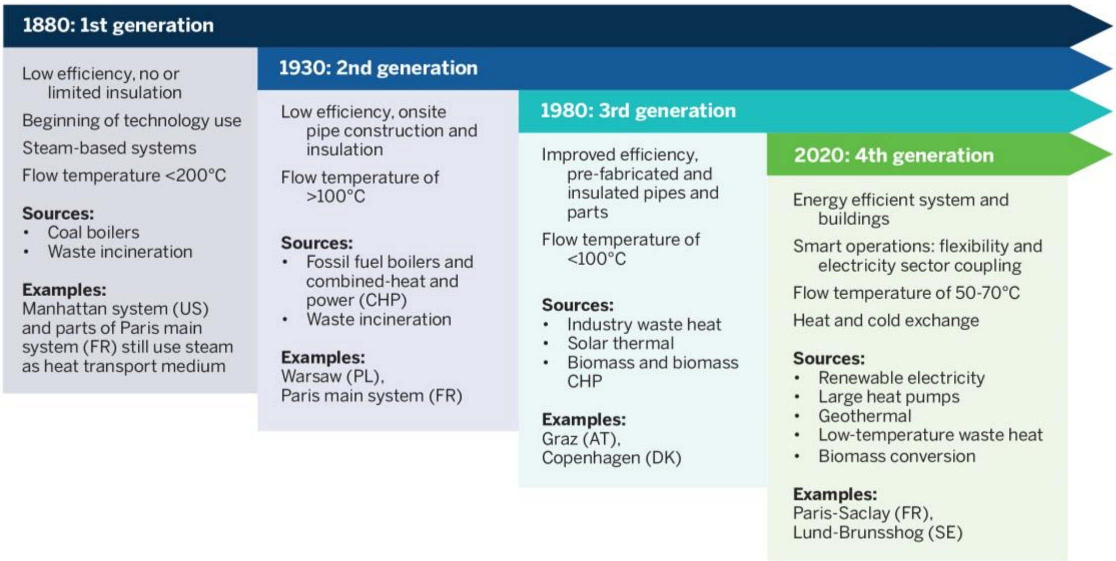
[32] Rosenow, J. & Lowes, R. 2020. *Heating without the hot air: Principles for smart heat electrification.* RAP. https://www.raponline.org/knowledge-center/heating-without-hot-air-principles-smart-heat-electrification/

[33] Lund, H., Østergaard, P., Nielsen, T., Werner, S., Thorsen, J., Gudmundsson, O., Arabkoohsar, A. & Mathiesen, B. 2021. Perspectives on fourth and fifth generation district heating. *Energy* 227, 120520. https://doi.org/10.1016/j.energy.2021.120520

[34] APUR. 2020. *Quelles perspectives pour le réseau de chaleur de Paris?* https://www.apur.org/fr/nos-travaux/perspectives-reseau-chaleur-paris

Figure 5. Generations of district heating



Getting to clean, efficient and smart district heating

As the district heating sector and related regulatory frameworks vary widely throughout Europe, the challenges and opportunities faced by policymakers, regulators, and district heating owners and operators will also differ. Although the underlying policy principles will be similar in each location, the district heating sector in some countries has advanced further towards clean, efficient and smart than others. Generally, the challenge is twofold: 1) to decarbonise and expand existing district heating systems while making them efficient and smart; and 2) to develop new district heating systems that are clean, efficient and smart by design. Although these two scenarios are different, the policy principles proposed and recommendations made in this paper are applicable to both. For example, the actions to improve efficiency in existing systems, as outlined below, also apply to new systems. New systems can be built with state-of-the-art technologies, however, so these issues can be considered in the early planning stages. On the other hand, new systems must tackle other important elements such as identifying suitable heat sources, creating viable business models, and ensuring enough heat demand is willing to connect.

Decarbonising existing district heating systems

Decarbonising district heating systems requires a coordinated policy approach at all government levels to align developments on both the supply and demand sides of heat. Such a coordinated approach should bring together transformation pathways for each individual district heating system, including integration of local clean heat sources, with local heat planning and zoning and building renovation strategies.

On the supply side of the district heating system, actions required include:

- Integrating heat production from clean local sources into the network.

- Lowering flow temperatures to improve system efficiency and facilitate integration of lower-temperature heat sources.
- Modernising and optimising the distribution system and substations – the heat exchange between network and buildings – to increase efficiency and performance.
- Improving data collection on performance and metering using smart meters, and digitising and automating operations to optimise the management and layout of the network (e.g., reducing bypasses); to facilitate the detection and repair of leaks, malfunctions and faults in pipes and substations; and to better match heat supply and demand, increasing the efficiency of heat production.[35]
- If appropriate, adding thermal storage to increase flexibility, leading to further efficiency improvements.

On the demand side, the connected buildings will have to be made 'low-flow ready', meaning reducing heat demand and upgrading heat emitters where needed so lower flow temperatures in heating systems can be achieved.

Lowering flow temperatures in district heating and buildings

Most district heating systems in Europe use high flow temperatures – referring to the temperature of the water in the distribution pipes – to deliver heat to buildings. This often entails burning fossil fuels or biomass to heat water to 100°C+ to achieve a temperature of around 22°C inside a building. This is highly inefficient and unnecessary, as modern heating systems such as full electric heat pumps with correctly sized emitters can achieve the same result with flow temperatures as low as 35°C.

Flow temperatures need to be lowered to reduce distribution losses, improve efficiency of heat production and storage, and enable the use of a broader range of clean heat sources. Moreover, without increasing energy savings in district heating – to which lowering flow temperatures can make the largest contribution – more energy will be needed to cover heating demand, meaning fewer emissions reductions will be achieved or higher investments in renewable supply will be needed. Additional benefits are lower pipeline costs, as plastic pipes can be used with lower temperatures; lower wear and tear on components; and increased safety due to reduced scalding risk for maintenance workers.

In production and distribution, improving efficiency and allowing reductions in flow temperatures mainly involves optimising the matching of heat production and demand and improving pipe insulation to reduce heat loss. On the demand side, buildings will need to be made 'low-flow ready'. Enabling heating to the desired level of warmth with lower flow temperatures than before requires a mix of envelope improvements to reduce heat demand, and emitter and piping optimisation. Buildings with the highest temperature and pressure needs in a district heating system determine the overall temperature and bypasses are not preferred, so any weak links in the network should be identified as part of transformation planning and addressed with priority. In cases where only a few connected end-users require high(er) temperatures, local temperature boosters, such as high(er)-temperature heat pumps, could be installed. If the district heating system also delivers hot water, legionella prevention measures will need to be taken following national regulations.[36]

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[35] Averfalk, H. et al. 2021. *Low-Temperature District Heating Implementation Guidebook.* IEA DHC Report. https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts2

[36] For an in-depth analysis of lowering flow temperatures in district heating see Averfalk et al., 2021.

The toughest decarbonisation challenge can be expected in district heating systems with high(er) heat prices and therefore with older infrastructure, older connected buildings and limited scope for adding upgrade costs. These systems will face strong competition from other clean heat solutions in addition to substantial modernisation costs. If heat pump installation prices decrease, for example, and government renovation strategies start having the desired effect, there is a risk that groups of building owners – those with the financial means and technical suitability – will disconnect from high-cost district heating systems and install individual heat pump systems.

Case: Developing the Oostende district heating system

In the Belgian coastal town of Oostende, a growing district heating network has emerged. In 2015 the municipality asked developers to submit plans for developing a district heating network to make use of the waste heat coming from the municipal waste incinerator. The local citizen-owned energy cooperative Beauvent won the contract. This was not easy, as at the time there was no legal framework for heat in the region and banks were hesitant to fund a model they were not familiar with. Luckily, Beauvent had existing revenue from its wind energy projects, which, combined with EU funding, was enough to get the project started and convince the banks.

In 2017, planning for the new heat network, 'warmtenet Oostende', began. A prerequisite for the economic viability of the network was the availability of a cheap heat source and enough heat demand in its vicinity. The first heat deliveries began in 2019 to just six customers; these were factories located around the waste incineration plant. Using 12km of pipes, 4GWh was delivered. By 2022, heat delivery grew to 17GWh, supplying 21 business customers including local hospitals, the town hall and 346 households in large apartment buildings.

With their higher heat demands compared to households, the factories and public buildings function as anchor loads that support the economic viability of the network as it connects more domestic end-users over time. A nearby military base and more domestic customers were newly connected in 2023. In the future, Beauvent hopes to connect more residents, integrate heat production from heat pumps and, potentially, storage, and work on lowering the flow temperatures in the system. [37]

Developing new district heating systems

In the coming decades, many buildings now using fossil fuel boilers will have to switch to clean heat. Clean, efficient and smart district heating has the potential to supply heat to a significant share of these buildings. A large share of the potential for clean district heating in Europe lies in countries that currently have relatively minor shares of district heating deployment, especially the UK, Ireland, France, Belgium, the Netherlands and Hungary.[38] In these countries, the main challenge will be to develop the right policy and regulatory frameworks to facilitate the development of new district heating networks that are clean, efficient and smart by design.

Heat planning and zoning is a key element of tackling this challenge. With proper foresight, local clean heat supply can meet demand and ensure that the heating

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[37] Based on a site visit of the Oostende warmtenet and a presentation by Beauvent energy cooperative on 30 June 2023.

[38] Paardekooper et al., 2018.

solution with the lowest societal cost is implemented in each geographic area, taking into account system considerations such as electricity grid capacities, flexibility and storage needs, and building upgrade costs for clean heat readiness. In places where fossil gas grids are present, it is recommended to align heat planning with grid phase-out planning.

As the switch to clean heat is gaining momentum in Europe following energy price spikes and the EU's 'Fit for 55' policies, the identification of areas with high potential for district heating should be expedited, to bring forward investments and prevent issues of insufficient demand arising. For example, since heat pump sales in Europe are booming, demand for district heating will be reduced. As it will take time to identify areas suitable for district heating and start the development of a district heating system, it is inevitable that some building owners will have already switched to other clean heating solutions. To accommodate this issue, governments and district heating owners and operators could investigate ways to make it attractive, and technically feasible, to integrate buildings with existing clean heat solutions into the network. They could do this, for example, by providing a discount on connection and heat fees or providing financial remuneration for heat provided to the grid by the building-level system, or for demand response.

Enabling regulatory frameworks for district heating

Putting in place enabling regulatory frameworks is crucial to both decarbonising and modernising existing district heat and developing new district heating networks. In many cases, existing frameworks will have to be brought in line with the new needs arising from making district heating clean, smart and efficient. For example, the Netherlands and Germany are currently in the process of updating their regulatory frameworks for district heating and heat planning, and are implementing support schemes. Many countries currently have limited policy and regulation on district heating,[39] however, and will need to start developing enabling frameworks to support (further) district heating development.

Moreover, across Europe – and especially in countries with currently lower deployment of district heating (see Figure 3) – challenges remain, such as developing value chains, raising awareness among end-users on the benefits of clean district heating, and finding business and governance models with the best cultural and legislative 'fit' in each country.

With the state of the sector varying significantly between countries, enabling frameworks are likely best designed at the national or subnational level. A fundamental goal of such frameworks would be to find ways to ensure their attractiveness to both developers and end-users while safeguarding the boundary conditions of decarbonisation, cost-effectiveness and affordability of heat, and consumer rights and protections. In addition, national frameworks should provide guidance, support and legal backing to subnational governments, especially municipal governments, on heat

[39] Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

planning and zoning, and provide legal clarity on governance and business models for district heating.

For EU member states, EU-level legislation can be used to create minimum standards, set common decarbonisation and efficiency targets, and provide guidance on enabling frameworks. European legislation can also play a role in increasing standardisation between member states, for example on metering and billing, reporting and monitoring, and benchmarking on aspects such as decarbonisation, efficiency, affordability and service level indicators.

Principles for clean district heat deployment

Decarbonising the heating sector, including district heating, is a huge challenge – but when done right it can enhance the acceleration of the energy transition at large. The policy principles in this chapter support a systems approach to decarbonising existing and developing new district heating. It is only through the further integration of the heating and electricity sectors, and their alignment with the building sector, that we will be able to unlock the full potential that district heating has to offer. We propose five equally important, high-level policy principles for heat networks: these are expanded on in Table 1 below.

Table 1. Policy principles for clean district heat deployment

	Principle	Purpose	Policy examples
	**Put efficiency first**	Reduce unnecessary production of heat, distribution loss, and use of heat to ensure that supply of clean heat can cover demand cost-effectively	• Energy efficiency standards and obligations • Building and renovation standards and codes • District heat pricing • District heating system transformation plans
	**Use local heat planning**	Ensure deployment of clean heat solution with lowest societal cost	• Local area energy planning • Planning and zoning obligations
	**Give value to unavoidable waste heat**	Increase use of readily available heat, preventing overinvestment in new low-carbon heat supply	• Heat pricing • Require waste heat analysis/reporting • Local area energy planning
	**Ensure end-user protection and enable viable business models**	Ensure that 'captive' customers are protected from effects of lack of competition (price and quality) while ensuring viable district heating business models	• Price, ownership and operation regulation • Capital support • Monitoring and reporting • Benchmarking
	**Reward energy system integration**	Ensure potential of system benefits is realised, avoiding unnecessary overinvestment in other parts of the energy system	• Grant and loan support • Heat and energy pricing

Principle 1: Put efficiency first

The energy efficiency first principle is an important part of European energy and climate policy; it also applies to the heat sector. Improving energy efficiency in the district heating system and within connected buildings reduces unnecessary use of energy. In systems currently using fossil fuels, avoiding unnecessary demand reduces fuel use and thus emissions, and lowers investment needs in developing and operating clean heat sources. Moreover, as local availability of clean heat can be limited, improvement in district heating energy efficiency is a prerequisite for decarbonisation. It not only allows more of these clean sources to be integrated into the district heating system, but enables their more efficient use.[40]

District heating can offer efficiencies of scale, especially in areas with high density of heat use, by aggregating the heat needs of hundreds or thousands of buildings into a steadier and more predictable load. This means a district heating system can often deliver the heat demand with a lower total installed heat capacity than would be needed if each building had its own heating system. With heat storage available within the system's pipes or connected thermal storage, district heating systems can smooth out heat demand, reducing peak generation and increasing load factors leading to higher energy efficiency. This saves energy and reduces total investment needs.

Many existing district heating systems and their connected buildings will need to undergo improvements to reach high levels of energy efficiency. The efficiency of a district heating system depends on the operation of the production plant, energy used for pumping, and energy lost during distribution. Distribution losses in district heating can be significant; in 2022 average losses for systems in the Netherlands were 25%.[41] The widely accepted solution – part of the fourth generation district heating concept – is to improve energy efficiency by lowering flow temperatures (see box on page 15).

Lowering flow temperatures is not only beneficial from an efficiency perspective, but also brings important economic gains.[42] Investment needs for future plants are lowered, as a smaller plant operating at a lower temperature can produce the same heat output as a larger plant at a higher temperature. In existing systems, more users can be connected to the grid after flow temperatures are lowered, as the production plant is now oversized. Moreover, lowering flow temperatures reduces operational costs, as lower temperatures generally lead to better production efficiencies for both fossil-based and clean heat production.[43] Lowering flow temperatures will thus bring immediate benefits, even before having integrated additional clean heat sources.

Energy efficiency should also be improved on the demand side. Buildings should be made clean-heat-ready through a mix of insulation, airtightness and ventilation measures to reduce heat demand, and by adapting the heat emitters (and pipes if

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[40] Paardekooper et al., 2018.

[41] Teng, M. & Kruit, K. 2023. *Verduurzaming bronnen voor warmtenetten: opgave, onrendabele top en knelpunten richting 2030.* CE Delft. https://ce.nl/publicaties/verduurzaming-bronnen-voor-warmtenetten/

[42] Averfalk et al., 2021.

[43] 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.* ifeu & Regulatory Assistance Project. https://www.raponline.org/knowledge-center/lowering-flow-temperatures-key-switch-to-efficient-clean-heat

necessary) to work with lower flow temperatures.[44] Making the building stock ready for clean heat is a no-regret endeavour, as individual heat pumps, solar collectors and condensing boilers also benefit from lower flow temperatures, and these efforts will improve building comfort and indoor air quality.

Principle 2: Use local heat planning

Local heat planning is a vital policy tool in support of developing and decarbonising district heating as, among other things, it allows authorities to determine where district heating can be cost-effectively installed and which local clean heat sources are available.

Current EU policy, through the Energy Efficiency Directive, requires that all regional and local authorities overseeing at least 45,000 residents should prepare heating and cooling plans which include (among other things) consideration of district heating networks.[45] Requiring all local authorities – not just those in larger communities – to prepare heating plans would ensure the reach of such plans would increase, and could potentially lead to a much greater understanding of district heating. National policy and legislation could support heat plans along with national energy agencies and research bodies.

Heat networks offer most value in areas where heat demand and the availability of a clean heat supply justifies their development. Efforts need to be made to determine where new heat networks are required for cost-effective decarbonisation. Quite simply, local heat planning will help both private and public actors determine where new networks should be developed.

The use of local heat planning will support other elements of heating decarbonisation, highlighting where – and, potentially, when – existing infrastructure such as gas networks will need to be decommissioned. Heat planning can also provide information on other elements of heat decarbonisation, indicating, for example, where heat pumps would be most suitable and potentially providing insight into requirements for fabric energy efficiency measures.

For example, in the Netherlands, Amsterdam aims to be fossil gas-free by 2040. Following city-wide heat planning, neighbourhood-level plans ascertain where heat network development will be prioritised.[46]

There is no simple and thorough guide to heat planning. Technical analysis – which takes into account heat demands and the availability of waste and other heat sources – will be needed, alongside broader stakeholder and citizen engagement. There are technical guides which cover issues like calculating heat demand, generation requirements and pipe sizing, but these measures alone are not sufficient.[47]

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[44] Pehnt et al., 2023.

[45] European Parliament and Council of the European Union. 2023. Directive (EU) 2023/1791 of the European Parliament and of the council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2023.231.01.0001.01.ENG&toc=OJ%3AL%3A2023%3A231%3ATOC

[46] Local Authority Amsterdam. 2023. Neighborhood by neighborhood natural gas free. https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/aardgasvrij/aardgasvrije-buurten/

[47] EnergieSchweiz. 2020. *Handbook on Planning of District Heating Networks.* https://www.verenum.ch/index_QMDH.html

The governance structure of a country's energy system should determine the appropriate approach in each locality.[48] Care should be taken to ensure that such heat planning programmes do not simply become box-ticking exercises lacking engagement and proper buy-in from key parties like local authorities. Efforts should also be made to try and limit the extent to which planning exercises become influenced by industrial interests. To ensure the quality of heat planning, municipalities will need support and additional resources from national governments to build the knowledge and capacity needed.

Following the broad planning stages, more specific decisions need to be made about the location, operation, development, characteristics and ownership of new district heating networks; such decisions require the significant involvement of local authorities. Discussions should also consider the fabric efficiency of and the flow temperatures required in relevant buildings.[49] Ensuring wider building and spatial programmes are aligned with heat planning has clear benefits for coordination.

The authority that local governments hold over energy issues varies between countries and regions, but it is likely that they own a significant public estate. Public estates, social housing and public buildings in urban areas may also be suitable for heat networks and may indeed be important anchor loads.[50]

Principle 3: Give value to unavoidable waste heat

District heating can accommodate a wide range of heat sources, including waste heat that would otherwise escape into the atmosphere. Unavoidable waste heat is the residual waste heat after implementing appropriate energy efficiency measures.[51] The advantage of using waste heat is obvious: it circumvents the need to produce heat from other sources and potentially lowers the costs and carbon emissions of district heating. Waste heat sources include industrial facilities, data centres, metro stations, buildings, sewage and wastewater treatment plants, and freshwater plants.

There is 2,860 TWh per year of waste heat available in the EU (see some examples in Figure 6, below). This corresponds to almost the entire EU energy demand for heat and hot water in residential and commercial buildings,[52] and is six times greater than the current final energy demand served by district heating.[53] Not all of today's waste heat is unavoidable or located near areas suitable for heat networks, but the magnitude of

[48] Hawkey & Webb. 2014. District energy development in liberalised markets: situating UK heat network development in comparison with Dutch and Norwegian case studies, *Technology Analysis and Strategic Management*. https://www.tandfonline.com/doi/abs/10.1080/09537325.2014.971001

[49] Pehnt et al., 2023.

[50] Colmenar-Santos, A., Rosales-Asensio, E., Borge-Diez, D. & Mur-Pérez, F. 2015. Cogeneration and District Heating Networks: Measures to Remove Institutional and Financial Barriers That Restrict Their Joint Use in the EU-28. *Energy* 85: 403–14. https://doi.org/10.1016/j.energy.2015.03.088

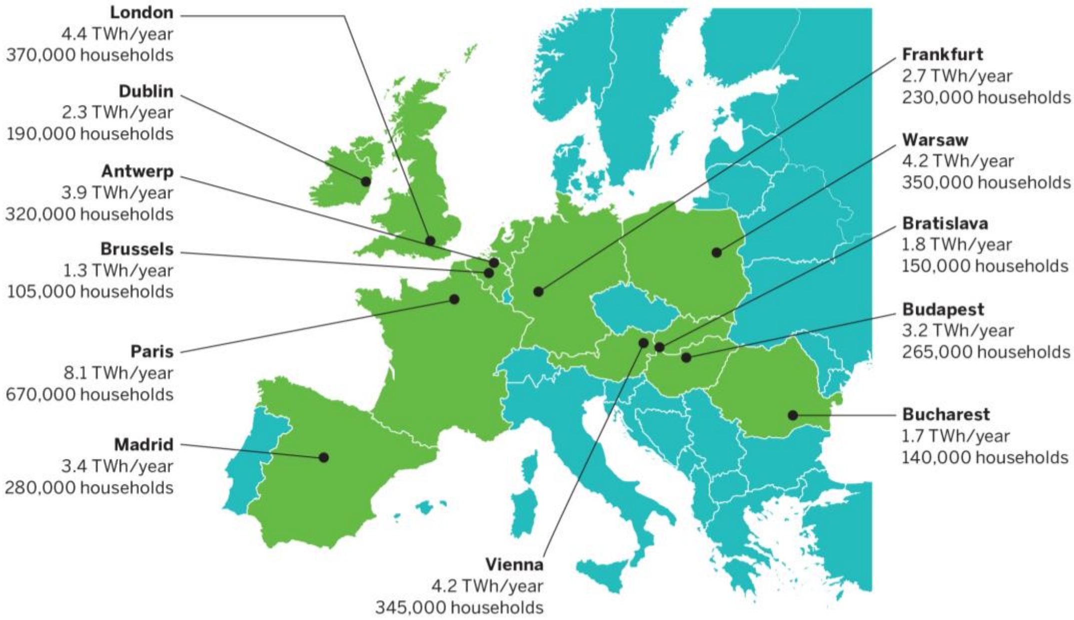
[51] Lyons, L., Kavvadias, K. & Carlsson, J. 2021. *Defining and accounting for waste heat and cold.* European Commission JRC. https://publications.jrc.ec.europa.eu/repository/handle/JRC126383

[52] Danfoss. 2022. *The world's largest untapped energy source: Excess heat.* https://www.danfoss.com/en/about-danfoss/news/cf/excess-heat-is-world-s-largest-untapped-source-of-energy/

[53] Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

available waste heat suggests it could make a significant contribution to district heating.

Figure 6. Examples of waste heat potentials in urban areas



Source: approximate selections from Moreno D., Nielsen S. & Persson U. (2022). The European Waste Heat Map. ReUseHeat project – Recovery of Urban Excess Heat. Last update: 31/05/2022.

Despite its potential, district heating systems across Europe currently use only a modest amount of waste heat. In 2018, 1.7% of district heat was from industrial waste heat,[54] less than 1% of the capacity identified above. Of all EU27 countries, Sweden uses the highest share of waste heat in district heating, with 8% of district heat coming from industrial waste heat.[55] In addition, Sweden's district heating networks utilise waste heat from sewage water, fed into the system by heat pumps.[56]

However, in individual district heating systems the share of waste heat can be much higher. For example, in HafenCity, a neighbourhood in Hamburg, Germany, waste heat from a copper smelter plant provides 67% of total heat production.[57]

In the long run, avoidable waste heat should be minimised by using enhanced technologies such as waste heat recovery systems, and district heating should only be served by unavoidable waste heat. The EU's Renewable Energy Directive recognises this, specifying that only unavoidable waste heat can be counted as waste heat. As

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[54] Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

[55] Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

[56] Averfalk, H., Ingvarsson, P., Persson, U., Gong, M. & Werner, S. 2017. Large heat pumps in Swedish district heating systems. *Renewable and Sustainable Energy Reviews* 79: 1275–84.

[57] Galindo Fernández, M., Bacquet, A., Bensadi, S. et al. 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.* European Commission, Joint Research Centre. https://op.europa.eu/en/publication-detail/-/publication/cc9516dc-7268-11eb-9ac9-01aa75ed71a1/language-en

industrial processes change (for example, through electrification), available waste heat will be reduced. District heat planners should take into account that waste heat availability from activities related to fossil fuels, such as oil refining or non-renewable waste incineration, is likely to decline as the phase-out of fossil fuels and implementation of circular economy goals advances.

The challenge is finding ways to exploit the significant potential of waste heat in district heating. There are several options available:

- **Waste heat sources can and need to be identified through local heat planning**, matching demand with supply. Low-temperature heat, in particular, needs to be used close to its source for maximum efficiency.[58]
- **Mandating waste heat reuse** can play an important role in ensuring that industrial facilities and data centres feed recoverable waste heat into district heating systems. Long-term contractual agreements are already being used to ensure the future delivery of waste heat and a stable pricing regime.[59]
- **Aligning energy and carbon taxation as well as financial incentives** to create economic encouragements for waste heat use in district heating – without incentivising unnecessary and avoidable production of waste heat.
- **Allowing third-party access to district heating systems can, under the right conditions, be an important lever to mobilise waste heat use**, as third parties providing waste heat cannot always feed that waste heat into district heating networks. Care must, however, be taken that third-party access does not lead to higher costs for end users.

Principle 4: Ensure end-user protection and enable viable business models

For a thriving district heat sector, policymakers and regulators need to protect end users, while ensuring viable business models can develop and operate. In countries with limited deployment of district heat, efforts are needed to foster public support for this clean heat solution and attract the investment necessary for district heating expansion and construction.

Protecting end users from network monopoly effects

District heating systems are natural monopolies. Once a user is connected, it is costly to switch. It is also not attractive for competitors to set up a rival network due to the high upfront investments required.[60] Moreover, in many cases district heating networks are vertically integrated: a single entity produces heat, operates the distribution network, and acts as a retailer to end users. This means that relying on

[58] Lygnerud, K. & Langer, S. 2022. Urban Sustainability: Recovering and Utilizing Urban Excess Heat. *Energies* 15, 9466. https://www.mdpi.com/1996-1073/15/24/9466

[59] Moser, S., & Jauschnik, G. (2023). *Using Industrial Waste Heat in District Heating: Insights on Effective Project Initiation and Business Models. Sustainability*, 15(13), 10559. https://www.mdpi.com/2071-1050/15/13/10559

[60] Wissner, M. 2014. Regulation of district-heating systems. *Utilities Policy* 31, 63–73. https://doi.org/10.1016/j.jup.2014.09.001

competition between providers to drive down prices and ensure quality of service, as is done in the EU electricity retail sector, does not work well in the district heating sector.

A recent study looking at European policy and regulatory frameworks for district heating identified several key elements that governments usually regulate to limit the effects of monopolistic behaviour: 1) ownership and operation, 2) heat retail prices, 3) consumption metering, 4) end-user grid connection and use, and 5) third-party access (see also Figure 7).[61]

District heating price regulation

Most price regulations used by governments fall into one of two categories: checks on companies by a regulatory authority before the prices are applied (ex-ante) or after the prices are applied (ex-post). Ex-post price control relies mainly on competition law, meaning that checks occur only if there are suspicions or complaints. In some cases, price rules such as caps or adjustment clauses, or specific methods for price calculation, are defined. Some countries also have the prices set directly by a regulatory authority.[62]

There seems to be limited evidence available, however, on the advantages and disadvantages of each method in assuring affordable heat for end users and best practices in price regulation. One comparison of district heating prices in the Netherlands, Germany, Sweden and Denmark found that prices in Denmark were significantly lower, likely due to stricter price regulation and the requirement that heat tariffs reflect the actual cost of production and transmission. Aside from the Danish case, there was no conclusive evidence on how pricing regulation (or the lack thereof) influenced heat prices. It is expected that other factors – such as production and transmission costs, market maturity or share of district heating deployment, and network size – influence heat prices.[63]

Protection mechanisms can also be used to improve equality between end users. For example, some district heating systems will have lower costs due to favourable geographic conditions and, consequently, could charge their end users lower prices than systems with less advantageous circumstances. Price regulation could be applied in this case. To support vulnerable households and energy poverty alleviation, however, more is needed than simply ensuring equality and fairness in heat tariffs. This might be achieved, for example, through cross-subsidy mechanisms between end users, such as solidarity mechanisms, or with social tariff structures.

District heating ownership regulation

In some countries, the ownership and operation of district heating systems is regulated, whether commercial, government, end-user ownership or a hybrid. Often this is done in combination with price regulation. For example, the Netherlands is

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[61] Billerbeck, A., Breitschopf, B., Winkler, J., Burger, V., Kohler, B., Bacquet, A., Popovski, E., Fallahnejad, M., Kranzl, L. & Ragwitz, M. 2023. Policy frameworks for district heating: A comprehensive overview and analysis of regulations and support measures across Europe. *Energy Policy* 173, 113377. https://doi.org/10.1016/j.enpol.2022.113377 and Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

[62] Billerbeck et al., 2023.

[63] Naess-Schmidt, S., Nikolaj Jensen, H. & Lutz, J. 2021. *District Heating Tariffs in Europe: Comparison of Tariffs and Regulation in Europe.* Copenhagen Economics. https://open.overheid.nl/documenten/ronl-ec66e0006b7e0acc22629091d63b448a4af5b0c3/pdf

currently in the process of requiring 51% public ownership in district heating systems as part of the redevelopment of the Heat Law.[64] There is also some evidence that ownership models can influence price levels. In Denmark and Sweden, local ownership of district heating – municipal or end-user – together with transparency and communication were found to lead to lower heat prices,[65] likely due to the acceptance of longer payback times by municipal and cooperative owners.

End-user and public ownership of district heating can be a means to drive equality in the switch to clean heat, improving the division of costs and benefits between commercial, public and consumer actors, and giving back some of the financial benefits gained from the use of local heat resources to those that experience the costs or have a local interest. In many countries, municipal participation in district heating systems is already common, while end-user participation has a long history among smaller heat networks in Denmark and is emerging in the Netherlands and Belgium.

End-user protection to enhance consumer trust

In areas that currently have lower levels of district heating deployment, such as northwestern and southern Europe, policy and regulation should serve to build trust among consumers who are usually wary of new solutions – even more so when it comes to such a significant investment decision as changing their heating system. In Denmark and Sweden, transparency and provision of information were found to be key elements in fostering end-user trust, facilitating monitoring and improving accountability in the district heating sector.[66]

Lessons can be drawn from current and historic policy[67] and industry efforts to increase deployment of heat pumps, which, in many countries, were also a new heating solution for end users. In frontrunner countries, for example, communication and end-user engagement, financial support and policy stability were key elements of developing a thriving heat pump sector and developing trust among producers, installers and end users.[68]

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[64] Ministry of Economic Affairs and Climate Policy. 2023. Voortgang voorstel Wet collectieve warmte. https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail

[65] 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

[66] Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

[67] Lowes, R., Gibb, D., Rosenow, J., Thomas, S., Malinowski, M., Ross, A. & Graham, P. 2022. *A policy toolkit for global mass heat pump deployment.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/policy-toolkit-global-mass-heat-pump-deployment/

[68] Lowes et al., 2022.

Figure 7. Regulation of district heating

District heating regulation			
Main goal: protecting end users from adverse effects of natural monopolies and vertical integration			
Secondary goals: incentivising investment in expansion, decarbonisation, efficiency and flexibility			
Examples of regulation frequently used			
Price	***Ownership and operation***	***Grid usage and access***	***Metering***
I. No price control II. Rules on price calculation with possible checks afterwards III. Prior control/approval	I. Registration and monitoring II. Licensing, concession, authorisation III. Permits and public approval IV. Regulated ownership	Voluntary, negotiated, or mandated: I. Access of heat suppliers to the grid ('third-party access') II. Connection of end users	E.g. quality requirements, obligations on metering methods and types

Source: Bacquet, A., Galindo Fernández, M., Oger, A. et al., 2022.

Supporting viable business models

Business models for district heating networks vary between countries, reflecting their different regulatory, cultural and geographic contexts. Finding business models that support expansion and decarbonisation and modernisation is key to realising the potential of district heating, especially for countries that currently have a smaller district heating sector, or that face a particularly large decarbonisation and modernisation challenge.

Finding a model that ensures district heating can be competitive with other clean heat solutions on both cost and speed of decarbonisation, such as direct electrification with heat pumps, while at the same time ensuring availability of capital and affordability of heat provision and quality of service is complex. It is vital to create clear development pathways and consistent policy, combined with enough end users who are willing to connect to the network, as upfront investments in district heating are high, payback times long, and a critical mass of heat demand is necessary for it to become viable.

Geographic conditions such as climate zone, urbanisation status or heat density, and the number of heating days influence the economic viability of installing a district heating network.[69] Moreover, the availability and cost of heat sources further impact the economics of a district heating system. Costs for a district heating system thus differ from location to location – and, consequently, the cost of heat could vary widely

[69] Naess-Schmidt et al., 2021.

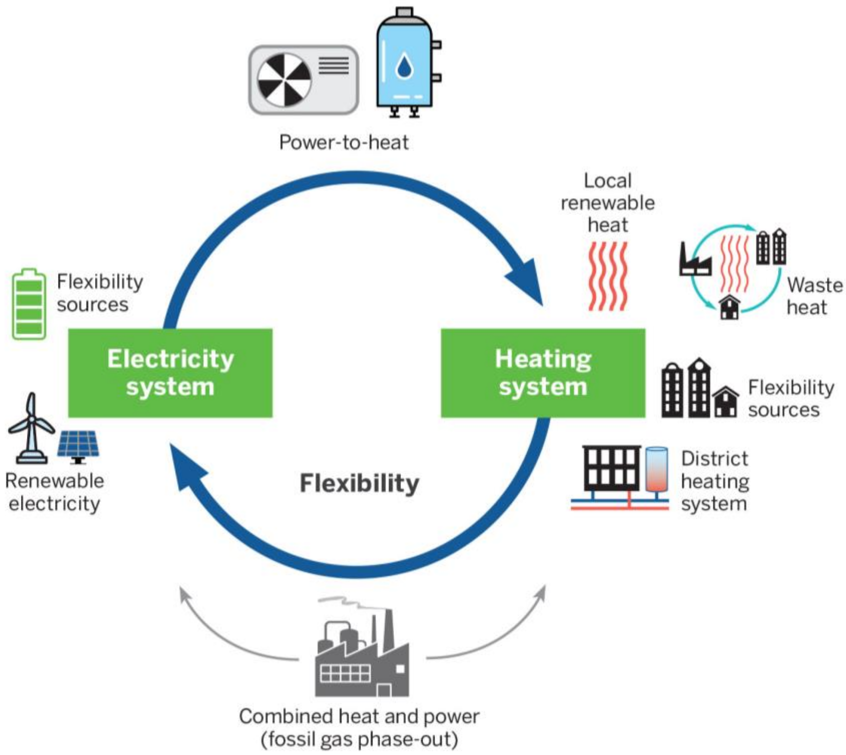
within a country or region. Local heat planning and zoning should be used to determine which areas are most suitable for the development or expansion of district heating. In addition, in line with the principle of end-user protection, policies need to be put in place that ensure security of heat supply, through district heating or other means, in less profitable areas.

Principle 5: Reward energy system integration

Energy system integration – linking the various energy infrastructures with carriers (see Figure 8) – increases overall system efficiency and should be promoted. Energy optimisation across the heat, electricity and gas sectors reduces total investment costs, leads to energy savings, and enables larger shares of renewable energy to be integrated into the system.[70]

Increased flexibility is the main driver behind the benefits from sector coupling. Currently district heating is connected to the gas and electricity sectors largely through fossil-based combined heat and power (CHP) generation plants which can switch between producing heat, electricity or both. Fuel-based CHP plants and peak boilers can produce heat on demand or are dispatchable, offering assurance that heat supply can meet consumer needs at every time of the day or season of the year. Moreover, CHP can generate electricity in times of lower heat demand.

Figure 8. Flexible energy system integration



As fossil fuels are phased out, however, the role of CHPs will diminish, as will their use of biogas, biomethane, biomass and e-fuels due to sustainability and availability issues,

70 Schmidt, R.-R., Böhm, H., Cronbach, D., Muschick, D., Lanakiev, A., Jentsch, A., Cadenbach, A., Kranzl, L., Reuter, S., Rossi, J., Sorknæs, P., Svensson, I.-L., Trier, D., Tunzi, M. & Widl, E. 2023. *IEA DHC Annex TS3 Guidebook, District Heating and Cooling in an Integrated Energy System Context.* https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts3

which will result in high prices for these fuels. The new dominant technology for coupling with the electricity sector will likely be heat pumps (see box, below), due to their high level of efficiency. Electric boilers, or e-boilers, can be used to provide additional peak load heat supply and provide short-term electricity grid balance by turning on and off when needed.[71] With this increased sector coupling, district heating can not only optimise its own operations, but also has significant potential to provide balancing services to the electricity grid.[72]

Policy and regulatory frameworks should aim to reward system integration and the flexible operation of district heating systems and connected buildings. In practice, this means facilitating – and, where necessary, supporting – the increased installation of storage and heat pumps, and the implementation of flexibility service models. This could be achieved through dedicated support mechanisms or, more importantly, by ensuring the feasibility of business models based on storage and flexibility, and aligning incentives coming from heat, electricity, fuel and grid prices. The goal should be sector integration. For example, to incentivise increased sector coupling and reduce biomass use, Denmark drastically reduced taxes on electricity when used to power a heat pump, driving strong growth in installations.[73]

Heat – electricity coupling with large heat pumps

An analysis of multiple scenarios for a climate-neutral district heating sector in 2050 shows sizeable potential for heat pumps to become the main provider of heat, with shares between 40-70%.[74] In these projections, large heat pumps replace fossil and bioenergy CHP plants almost entirely, with the latter comprising only 3-7% of the heating mix.

Heat pumps can make efficient use of the potential of lower-temperature waste, renewable and ambient heat available. In addition, when coupled with storage, they can provide flexibility to the electricity grid by ramping up production of heat when plenty of renewable electricity is available and storing the produced heat for later use, or reducing production when electricity demand is high and little renewable electricity is available. In this way, heat production uses electricity when it is cheapest, while at the same time more renewable electricity can be integrated into the grid, as less curtailing will be necessary.

Currently, there is an estimated 2.5GWth of installed capacity of large heat pumps in district heating networks, mainly in Sweden, Denmark, Finland, France and Norway, with significant growth expected over the coming years.[75]

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[71] Schmidt et al., 2023.

[72] Boldrini, A., Jiménez Navarro, J.P., Crijns-Graus, W.H.J. & van den Broek, M.A. 2022. The role of district heating systems to provide balancing services in the European Union. *Renewable and Sustainable Energy Reviews* 154, 111853. https://doi.org/10.1016/j.rser.2021.111853

[73] Skytte, K., Olsen, O. & Soysal, E. 2017. Barriers for District Heating as a Source of Flexibility for the Electricity System. *Journal of Energy Markets*. https://www.risk.net/journal-of-energy-markets/5283956/barriers-for-district-heating-as-a-source-of-flexibility-for-the-electricity-system

[74] Schmidt et al., 2023.

[75] Market Intelligence Unit, Euroheat & Power. 2022. For more examples see also: EHPA. 2020. Large Scale Heatpumps in Europe vol. 2. https://www.ehpa.org/2022/12/14/ehpa_news/large-scale-heat-pumps-in-europe/

Coordinating policies for clean district heating

Driving the development of clean, efficient and smart district heating requires a coordinated policy approach. Such an approach should integrate and align measures on the supply, distribution and demand sides. Ideally, it would bring heat planning, district heating modernisation planning, building renovation strategies, and updates to regulatory frameworks in line with decarbonisation and modernisation goals.

This section explores several policies that can contribute to putting the five principles into practice and can be part of a coordinated policy approach at both EU and national level. An in-depth discussion of each policy instrument and regulatory framework is beyond the scope of this paper, but references that provide further detail are included where possible.

Energy efficiency and emissions targets and standards

Energy efficiency and emissions targets and standards can be useful instruments to drive decarbonisation in district heating in a flexible way, leaving space to consider local specificities. Sector-wide renewable energy, emissions reductions and efficiency targets could be set at the EU level. When setting national-level policies, member states must keep in mind the interaction with EU emissions trading schemes, and in some cases national-level carbon taxes, to ensure that the district heating sector improves in line with EU-wide emissions reductions targets. For example, for EU member states, the RED III provides indicative targets for waste and renewable heat and cold in district heating, including from heat pumps (2.2% annual average increase between 2021- 2030).

A possible standard to support the achievement of the targets could take the form of a quantitative obligation on district heating system operators – also called a clean heat standard[76] – to increase the share of renewable energy in the heat provided to end users, achieve greenhouse gas emissions reduction targets, or achieve demand reduction targets through efficiency measures in production, distribution and among connected end users.

Building standards and codes

Improving the energy performance of buildings is an important element of decarbonising all heating, including district heating. This can be relatively easily implemented in new construction through ensuring building codes are up to date with the latest technological developments and enforced. The EU supports energy efficiency compliance through the concepts of nearly zero energy buildings and zero emission buildings. For member states, renovation standards are increasingly used to drive

[76] Santini, M., Cowart, R., Thomas, S., Gibb, D., Lowes R., & Rosenow, J. 2023. *Clean Heat Standards: new tools for the fossil heat phaseout in Europe.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/clean-heat-standards-new-tools-for-fossil-fuel-phaseout-in-europe

energy performance improvements in, for example, the form of clean-heat readiness, low-flow readiness,[77] or a mandatory energy performance standard.[78]

Heat planning and zoning

To promote adoption of heat planning and zoning, it is important that national governments create enabling frameworks. This includes, for example, giving local governments clarity on their legal powers, offering support to build planning capacity, developing and delivering standardized templates for planning and mapping, setting templates and methodologies for processes such as decision-making on societal costs and benefits of different solutions, and providing clarity on how to organise stakeholder and citizen participation, align heat and renovation policy, and perform cross-network planning. Ensuring standardisation in the way heat planning is performed can facilitate upscaling through simplification and cost reductions.

EU policy and regulation

As part of the Fit for 55 package, European legislation has been updated to address the increased 2030 emissions reduction target of 55%. Several of the updated directives include new or revised provisions on district heating.

In the Energy Efficiency Directive (EED), the most important provisions regarding district heating are on heat planning and the definition of 'efficient district heating'.[79] For the first time, the EED introduces an EU-wide obligation for regional and local authorities with more than 45,000 inhabitants to make heating and cooling plans (Art. 25). As described in the five principles, such planning is an essential tool for both new and existing district heating.

The definition for efficient district heating (Art. 26) sets out the requirements district heating systems need to meet to fall into the category of 'efficient district heating' and provides a gradual decarbonisation pathway to 2050. Although the definition now provides a decarbonisation pathway (the previous EED did not), it will still allow the use of fossil gas in the period 2040-2050, even though a phase-out by 2040, as proposed by the European Commission as part of the Energy Performance of Buildings Directive (EPBD),[80] is both necessary and possible.[81] The biggest benefit for owners and/or operators of district heating systems in being classified as 'efficient' under the EED definition is that they are eligible for state aid under EU guidelines.[82]

The RED III, moreover, allows member states to count waste heat and cold coming from efficient district heating systems towards the renewable heating and cooling goals set by that directive (Art. 23).[83] In addition, several EU programmes provide funding for the transformation of existing

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[77] Pehnt et al., 2023.

[78] Sunderland, L. & Santini, M. 2020. *Filling the policy gap: Minimum energy performance standards for European buildings.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/filling-the-policy-gap-minimum-energy-performance-standards-for-european-buildings

[79] European Parliament and Council of the European Union, 2023.

[80] Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the energy performance of buildings (recast). https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52021PC0802

[81] Graf, A. & Buck, M. 2023. *Breaking free from fossil gas A new path to a climate-neutral Europe.* Agora Energiewende. https://www.agora-energiewende.org/publications/breaking-free-from-fossil-gas

[82] 2022/C 80/01. COMMUNICATION FROM THE COMMISSION. Guidelines on State aid for climate, environmental protection and energy 2022. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52022XC0218(03)

[83] Directive of the European Parliament and of the Council of amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. https://www.consilium.europa.eu/media/65109/st10794-en23.pdf

district heating systems into 'efficient' district heating systems, and some member states have connected other privileges to systems falling within this category.

Beyond setting binding targets on the share of renewable energy in the heating sector and indicative targets on renewable and waste heat in district heating, the RED III includes several provisions relevant to district heating. It requires member states to assess their renewable and waste heating and cooling potentials (Art. 23) and includes provisions (Art. 24) on information provision to end users, (dis)connection rights, third-party access and coordination of waste heat providers, and coordination on coupling with the electricity sector.

District heating systems with a production capacity larger than 25MW are regulated under the EU ETS[84] (Emissions Trading System), which caps the GHG emissions of a number of installations in the EU. Heating in buildings will be submitted to a similar system, the 'ETS-2', from 2027 onwards. Fossil fuel suppliers will pass on the costs of this separate ETS to smaller district heating systems.

District heating policy and regulation

It is not within the scope of this paper to provide a full set of recommendations on designing district heating policies and regulations, but below we outline some elements to consider when aiming for clean, efficient and smart district heating systems.

District heating reporting, monitoring and benchmarking

For policymaking and regulation on district heating decarbonisation, availability of timely data is crucial to measure effectiveness and build an evidence base of best practices. In many countries, this is not currently the case. For example, several of the studies used in this report mentioned that it was difficult to determine the effect of different regulatory approaches on heat prices due to a lack of data availability. At the national level, governments might have better insight into district heating performance, but Europe-wide data on district heat sources, GHG and pollutant emissions, system efficiency, heat prices, and service quality is limited or not available at all.

Increased transparency and reporting would facilitate better monitoring of developments in the district heating sector and enable benchmarking to drive system improvements. A mix of factors including efficiency, emissions, environmental cost, and energy source and production type could be used to develop a climate index for district heating companies, linked to pricing policies.[85] For example, Sweden and Denmark use collective benchmarking of district heating system performance on heat prices to provide incentives for cost reductions.[86] Although the RED III will strengthen some reporting requirements and information provision to end users, system and national-level monitoring and reporting is needed to enable evidence-based policy and regulation. Increasing transparency in the district heating sector is key in this regard.

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[84] European Commission. 2023. EU Emissions Trading System (ETS). https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en

[85] Pakere, I., Blumberga, D., Kamenders, A. & Vītoliņš, V. 2021. Does District Heating Tariff Motivate Energy Efficiency Improvement? *Energy Reports, The 17th International Symposium on District Heating and Cooling* 7: 410–18. https://doi.org/10.1016/j.egyr.2021.08.087

[86] Galindo Fernández, M., Bacquet, A., Bensadi, S., Morisot, P. & Oger, A. 2021. *Integrating renewable and waste heat and cold sources into district heating and cooling systems.* Publications Office of the European Union, Luxembourg. https://publications.jrc.ec.europa.eu/repository/handle/JRC123771

EU-wide standardisation in monitoring and reporting is preferred, as it supports the exchange of best practices between countries and district heating systems. EU and member state-wide performance benchmarking of district heating performance could be a good way to drive continuous improvement in the sector.

District heat pricing

Heat pricing can, and should, be used to promote energy efficiency and flexibility on both the producer and end-user sides.[87] Some emerging pricing models include seasonal and time-of-use pricing, making heat more expensive during peak times in order to reduce peak demand. Capacity tariffs also incentivise reducing overall heat demand, as do tariffs that stimulate lower return temperatures from end users, which can drive increased energy efficiency.[88]

District heating connection regulation

Grid connection regulations are an important element of district heating business models in many locations, assuring a critical mass of end users connect to the network. In several countries, municipalities can use heat zoning to mandate connections to district heating systems.[89] In France, for example, connection can be required by the local authorities if a system is 'economically balanced' and more than 50% waste or renewable heat is used.

Obligations on end users to connect to district heating systems should not, however, delay decarbonisation or only be implemented when end-user protection frameworks are in place. Such stipulations could cause end users to be worse off than when using other available clean heat solutions. In practice, this will likely be a difficult balance to strike. Potentially, heat pump leasing schemes – similar to fossil gas boiler leasing schemes – could play a role in giving end users access to clean heat while they wait for their anticipated district heating system to arrive.

Energy communities in the heating sector

In the electricity sector, energy communities are a proven way to drive public acceptance of and trust in renewable energy generation. They can support a fair division of costs and benefits in the energy transition and are in line with the growing number of prosumers. The EU is transposing the definitions for Citizen and Renewable Energy Communities into member state law, and in several member states the first heating sector energy communities have emerged. To support this development, governments are advised to specifically include and enable energy communities in heat.

Energy taxation and grid tariffs

Taxes and levies on fuels, heat, and electricity and grid tariffs need to be brought in line with decarbonisation goals, to ensure clean options are more attractive and incentivise and facilitate flexibility in the energy system. In many countries, electricity is taxed

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[87] Selvakkumaran, S., Eriksson, L., Ottosson, J., Lygnerud, K. & Svensson, I.-L. 2021. How are business models capturing flexibility in the District Energy (DE) grid? *Energy Reports* 7, 263–272. https://doi.org/10.1016/j.egyr.2021.08.146

[88] Gunneberg, T., Selvakkumaran, S., Eriksson, L. & Yang, Y. 2022. D5.1 ANALYSIS OF PRICE MODELS. Flexy-Sync.

[89] Billerbeck et al., 2023.

more heavily than gas,[90] which can hinder heat electrification, including in district heating systems. Moreover, the way in which electricity wholesale markets and transmission and distribution charges are organised can incentivise or hamper flexibility. In countries such as the UK, the use of estimated instead of actual electricity use disincentivises flexibility for smaller end users;[91] in Denmark, static grid tariffs discourage the flexible use of heat pumps, where switching to time-of-use tariffs[92] or dynamic tariffs[93] could increase incentives for flexible use; and in the Netherlands, high grid tariffs reduce the financial viability of e-boilers.[94] In addition, a study for Finland found that moving to smaller settlement periods (e.g. 15 minutes) in the electricity market could provide district heating operators increased revenue from flexibility services delivery.[95]

As the coupling of district heating with the electricity sector grows, it will become increasingly viable to use the flexibility potential of the system and connected end user. This will only make financial sense, however, if end users, operators, and potential aggregators or other service providers are remunerated and can recoup investment and operating costs.

Conclusions

District heating can play a major role in decarbonising Europe's energy system and in reaching EU climate targets. To take up this role, however, the sector needs to accelerate its growth while at the same time becoming clean, efficient and smart. This tough challenge can be achieved with a coordinated policy approach cutting across heat supply, buildings, and the electricity and gas networks. The five principles developed in this paper provide guidance to policymakers and regulators on the dual goal of decarbonising existing district heating and developing new systems.

The put efficiency first principle underlines that improving energy efficiency is critical, as it is a prerequisite for ensuring the supply of clean heat can meet demand and prevents overinvestment in heat generation capacity. Moreover, without significant efficiency increases in district heat production, distribution and connected buildings, providing effective flexibility and storage services to the energy system through coupling with the electricity sector will be less valuable, as fewer possibilities to shift supply and demand will be available and storage will be less efficient. Increasing digitisation and automation in the sector, making it 'smart', supports both efficiency improvements and the delivery of flexibility services. In conjunction with increased

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90 Rosenow, J., Thomas, S., Gibb, D., Baetens, R., De Brouwer, A. & Cornillie, J. 2022. *Levelling the playing field: aligning heating energy taxes and levies in Europe with climate goals.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/aligning-heating-energy-taxes-levies-europe-climate-goals

91 Yule-Bennett & Sunderland, 2022.

92 Østergaard, P.A., & Andersen, A.N. 2021. Variable taxes promoting district heating heat pump flexibility. *Energy* 221, 119839. https://doi.org/10.1016/j.energy.2021.119839

93 Johannsen, R., Arberg, E. & Sorknæs, P. 2021. Incentivising Flexible Power-to-Heat Operation in District Heating by Redesigning Electricity Grid Tariffs. *Smart Energy* 2: 100013. https://doi.org/10.1016/j.segy.2021.100013

94 Teng & Kruit, 2023.

95 Javanshir, N., Syri, S., Tervo, S. & Rosin, A. 2023. Operation of district heat network in electricity and balancing markets with the power-to-heat sector coupling. *Energy* 266, 126423. https://doi.org/10.1016/j.energy.2022.126423

efficiency, we will need dedicated policies to enhance coupling between the heat and electricity sectors, including finding ways to reward system integration.

Lowering flow temperatures in district heating, and heating systems in general, is key to achieving high energy efficiency levels. In addition, yield from renewable and waste heat sources will increase. Flow temperature depends in large part on the needs of the connected buildings; preparing buildings for lower-temperature heat will likely require a combination of envelope improvements and pipe and emitter upgrades. Achieving success in decarbonising district heating is thus closely bound to the renovation of European buildings. Using heat planning is instrumental in ensuring developments in heat production, distribution and demand align. In conjunction, we will need to value waste heat to ensure we make the most out of locally available sources of heat.

At the same time, growing and decarbonising the district heating sector across Europe will necessitate an expansion of enabling regulatory frameworks. The exploration of policy areas and instruments in this paper shows that countries deploy very different regulatory strategies. Although several frontrunner countries in Europe have achieved high(er) levels of decarbonisation, they have done so with very different regulatory models. Further research will thus be needed on regulatory best practices for decarbonisation, including exploring their application to diverse cultural and economic contexts – and district heating sectors with different technology generations and connected building stocks. As they do so, governments should strike a balance between protecting end users and fostering viable business models.

As clean heat is inherently local, policies and regulations should align with common goals in line with decarbonisation targets while accommodating individual system differences; the policy principles outlined in this paper can support this endeavour. Implementing heat planning at the local level, for example, can be encouraged by the creation of a national-level framework to provide the necessary legal, planning and capacity support. Increasing standardisation in reporting and monitoring on district heating performance across European countries would bolster the tracking of progress on policy targets and benchmark performance.

The Fit for 55 package – which mandates heat planning and the setting of a decarbonisation pathway for district heating – is just the beginning. Over the coming years, EU institutions and national governments will both need to focus on careful implementation and execution of these provisions, and put in place a coordinated policy approach for heat planning, district heating decarbonisation and expansion, and building renovation. Only then will we be able to reach our emissions and renewable energy targets and unlock the benefits of clean, efficient and smart district heating.

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Rue de la Science 23
B – 1040 Brussels
Belgium

+32 2-789-3012
info@raponline.org
raponline.org