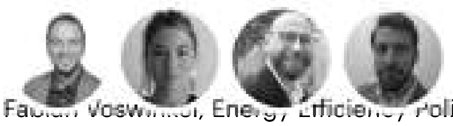
Opportunities for district heating in the changing energy landscape



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District heating can enhance resilience, efficiency and flexibility of the energy system

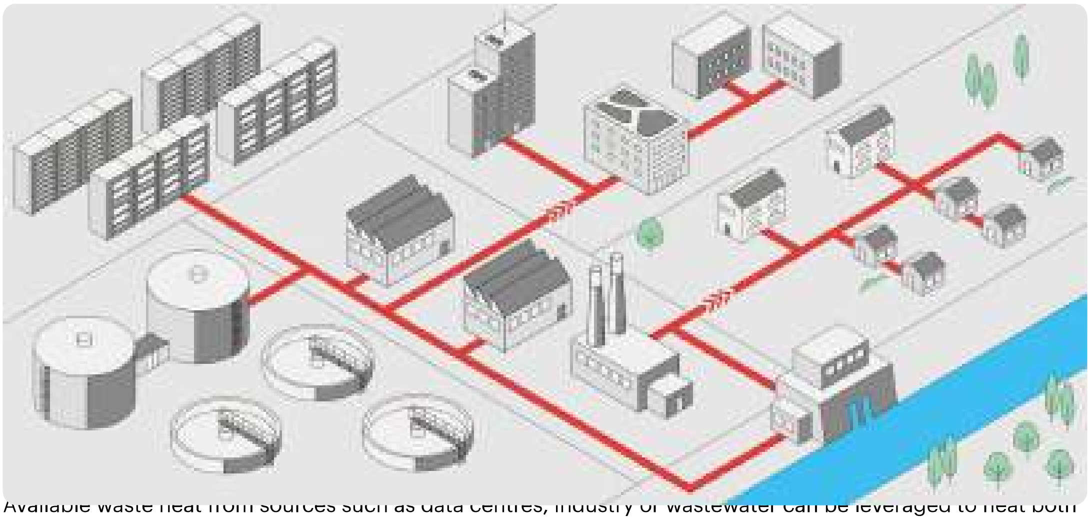
District heating has been around for almost 150 years. Since the first commercial system *(https://www.asme.org/topics-resources/content/birdsill-holly-jr)* was installed in New York in 1877, district heating systems have used insulated supply and return pipes to distribute heat to multiple buildings. While the first generation used steam produced by a central fossil fuel boiler, modern systems have evolved into a flexible infrastructure that can connect multiple energy and storage solutions and supply both heating and cooling. This way, they keep up with and actively sustain the rapidly changing global energy system, marked by rising electricity demand and a growing share of renewables.

Today, district heating supplies around 10% of global building heat demand, with much higher shares in Northern and Eastern Europe and China, and growing deployment in newer markets such as Canada and Ireland. Around 90% of global district heating supply is produced from fossil fuels today. The infrastructure can enable large-scale integration of renewable and other low-emissions sources, such as bioenergy, solar thermal *(https://www.iea-shc.org/solar-heat-worldwide)* and geothermal energy *(https://www.iea.org/reports/the-future-of-geothermal-energy)*, and nuclear energy. While only a small part of networks already operates at low-temperature levels that make renewable integration straightforward, ongoing upgrades to pipes, substations, and controls will be critical to unlocking greater flexibility and efficiency.

Particularly valuable in dense urban areas, district heating networks offer benefits beyond renewable and storage integration, including easier infrastructure management, efficient use of space, recovery of waste heat, and lower local air pollution.

This commentary examines key emerging opportunities that could strengthen the role of district heating in the changing energy landscape, expanding heat recovery and enabling system flexibility.

Illustration of selected heat sources available to a district heating system



Available waste heat from sources such as data centres, industry or wastewater can be leveraged to heat both residential and commercial buildings using district heating networks

Recovering more waste heat streams from new and untapped heat sources unlocks efficiency gains

District heating is the most efficient – and sometimes only – technology available to recover heat streams that otherwise would go to waste. As such, they can play an important role in enhancing energy efficiency in a system. While high-temperature waste heat is often already recovered in industries or utilised for power generation, a large volume of waste heat below 100 °C is still discharged into the environment. Modern district heating networks can operate at lower temperatures and integrate a wide range of heat sources while minimising distribution losses. Growing electricity consumers in the future energy system, such as data centres or hydrogen electrolysers, generate low-temperature waste heat and increase opportunities for recovery if located close enough to urban areas. The use of heat pumps *(https://heatpumpingtechnologies.org/heat-pumps-in-district-heating-and-cooling-systems/)* to upgrade low-temperature waste heat to higher temperatures suitable for district heat distribution further enables the effective use of otherwise unusable heat sources, such as wastewater or mine water *(https://www.sdi.co.uk/news/harnessing-the-geothermal-potential-of-scottish-mine-water#:~:text=In%20Scotland%2C%20the%20Midland%20Valley,the%20total%20demand%20across%20Scotland.)* from decommissioned coal mines.

Waste heat sources for district heating and cooling with temperature ranges

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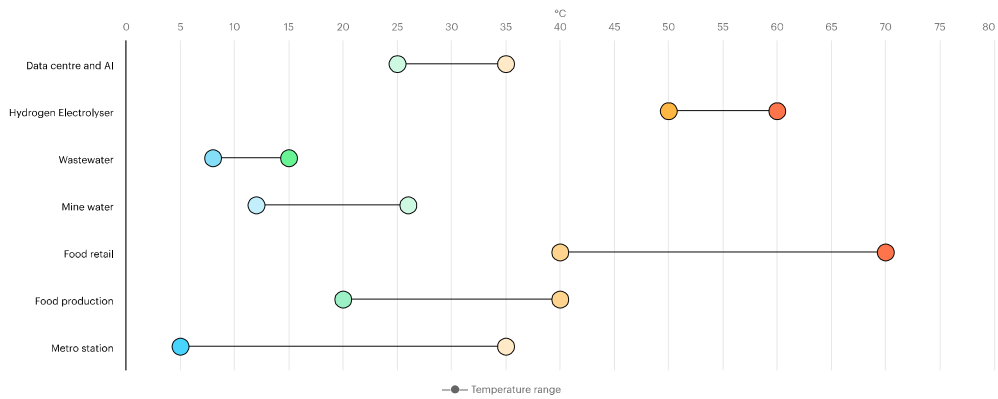

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The development and increasing usage of artificial intelligence give rise to strong growth in electricity demand for data centres. While they currently account for around 1.5% of global electricity demand, their demand is set to double by 2030 *(https://www.iea.org/reports/energy-and-ai)*. Nearly all electricity consumption in data centres becomes usable heat, *(https://www.sciencedirect.com/science/article/pii/S1364032123006342)* of which around 70-80% is recoverable using heat pumps. Data centres are also often located close to urban centres *(https://www.iea.org/data-and-statistics/data-tools/energy-and-ai-observatory?tab=Energy+for+AI)*, an ideal opportunity for the use of waste heat in district heating networks. For example, in Stockholm, more than 20 data centres already provide 1.5% of district heating needs, and in Espoo, Finland, a cluster of new data centres will provide enough waste heat for around 100 000 homes *(https://www.bloomberg.com/news/features/2025-05-14/finland-s-data-centers-are-heating-cities-too)*. In Europe in particular, there is great potential for future heat recovery. If fully integrated into district heating networks, reused heat from data centres could provide up to 300 TWh of space heating *(https://www.iea.org/reports/energy-and-ai)* to buildings located within 5 km by 2030. That would be enough for around 10% of European homes. While technology for waste heat recovery from data centres is available, incorporating it into already existing networks poses challenges, such as the need for clear business models and tariff structures.

In their vicinity, data centres offer relatively high waste heat temperatures with strong potential for highly efficient use for district heating. in contrast, wastewater from sewage systems has a lower temperature, which is an advantage in temperate regions as it can also be used for district cooling in warmer months, enabling a higher level of utilisation of the equipment and infrastructure throughout the year. Wastewater is available everywhere and sewage systems and wastewater treatment plants are typically located where people live, i.e. exactly coinciding with where space heating and cooling are needed. The heat can be recovered using heat pumps, either in a decentralised way directly from the network located in urban areas, or centrally from wastewater treatment plants. The key to the efficient use of wastewater as a heating and cooling source is therefore the geographical mapping of temperature and volume streams to identify the highest potentials. For example, a mapping study by Applied Energy Planning *(https://maps.appliedenergyplanning.com/)* in Christchurch, New Zealand, found that for the city of about 400 000 inhabitants, about 80 MW of recoverable heat is available from wastewater, enough to heat around 10 000 houses in the city. Heat recycling in wastewater treatment plants is increasingly leveraged. For example, the city of Qingdao in China is expanding and retrofitting its district heating system. Wastewater heat pumps are expected to provide 49 MW of heating and 45 MW of cooling *(https://www.adb.org/sites/default/files/project-documents/48003/48003-002-iee-en.pdf)* capacity to the city. And in Germany, the city of Hamburg is constructing four large heat pumps at a wastewater treatment plant that can produce 60 MW of heat *(https://www-hamburgwasser-de.translate.goog/umwelt/energiegewinnung/abwasserwaerme?_x_tr_sl=auto&_x_tr_tl=en&_x_tr_hl=en-GB)*, enough for almost 40 000 households.

Through sector integration, district heating can provide more flexibility to the electricity system

New electricity consumers such as data centres, electric vehicles, heat pumps, air conditioners, hydrogen electrolysers and electrified industrial processes drive a strong growth in electricity demand. Much of the increased demand is met by new variable renewable sources, which require more flexibility in the system. District heating can use low-cost renewable electricity from wind and solar generation at times of high generation to produce heat in electric boilers and large heat pumps. In Aarhus, Denmark, the district heating system uses large electric boilers *(https://danskfjernvarme.dk/media/w1ghiibk/faktaark_heat_generation_in_denmark-v2.pdf)* to absorb surplus wind electricity during low-price periods, contributing to both the emissions reduction in heat and the stability of the power grid.

District heating can support electrification by easing the burden on the electricity grid. Already today, cogeneration plants, which produce both electricity and heat, play a particularly important role in maintaining the balance in local electricity grids, as these plants are often feeding heat into district heating networks and are therefore located closer to population centres than other electricity sources. Furthermore, district heating can help free up grid capacity to electrify other end-use sectors if deployed in a flexible manner to manage periods of peak electricity demand or by absorbing surplus renewable energy when abundant. By using thermal storage, district heating systems can absorb more of this surplus electricity and produce heat for later use. In Helsinki, Finland, one of the world's largest underground thermal storage *(https://www.hel.fi/static/kanslia/energy-challenge/the-hot-heart-final-entry-public.pdf)* facilities is being developed to store heat produced during the summer or surplus electricity-derived heat for use during winter heating demand, supporting seasonal balancing. Similarly, in Hamburg, Germany, a 2 million litre water tank inside an energy bunker *(https://www.kfw.de/stories/environment/renewable-energy/energiebunker-wilhelmsburg/)* acts as a thermal storage unit, balancing supply and demand into district heat and helping reduce grid congestion.

Digitalisation enhances the responsiveness and flexibility of district heating systems. Smart heat meters and advanced controls enable district heating networks to adjust demand and supply more precisely to optimise operations, using real-time data, including weather, consumption patterns, and electricity market signals. In the Greater Copenhagen area, widespread deployment of smart heat metering *(https://dbdh.org/wp-content/uploads/2023/06/SoG_case_catalogue_DIGI_spreads_compressed.pdf)* enables improved load forecasting, demand response, and operational efficiency. In the Netherlands, a heating network digital twin *(https://knowledge.gradyent.ai/hubfs/Eneco%20Case%20Study.pdf)* is used to optimise district heating operations, displaying temperatures, water flows, and pressures based on real-time weather forecasts, smart meter data, and heating system sensors.

Tailored and well-designed policy support is crucial for emerging district heating opportunities

No heating and cooling system is a "silver bullet" for integration into and support of the changing energy landscape. It is the understanding of current and future heating and cooling demand, their spatial and temporal dynamics, and local resource availability, that enables cities and governments to design coherent strategies that maximise efficiency and minimise emissions and cost.

Three key considerations can guide the way.

1. **Heat mapping and integrated planning** are key enablers for identifying the most cost-effective and sustainable solutions – from individual technologies such as heat pumps to shared infrastructure like modern district heating and cooling networks. Initiatives like Heat Roadmap Europe *(https://heatroadmap.eu/)*, ReUseHeat *(https://www.euroheat.org/dhc/eu-projects/re-use-heat)* and the UNEP Copenhagen Climate Centre's *(https://unepccc.org/project/district-energy-in-cities-initiative/)* work on district energy support cities and governments in advancing this system-level approach. Germany's Heat Planning Act provides a strong policy example of coordinated national heat mapping and planning, as highlighted in the IEA Energy Policy Review of Germany 2025 *(https://www.iea.org/reports/germany-2025)*. Similarly, the revised EU Energy Efficiency Directive *(http://data.europa.eu/eli/dir/2023/1791/oj)* requires Member States to map future demand and assess waste heat potential based on factors such as location, temperature, and time of availability. Embedding such system-wide planning into policy frameworks helps overcome barriers to infrastructure-based solutions like district energy and ensures that cost-benefit analyses prioritise using existing waste heat and renewable resources before investing in new capacity.

2. **Framework conditions,** such as prices of electricity and fossil fuels, play an important role in decision-making. Reducing electricity taxes for heat production, as has been done in Finland *(https://www.iea.org/policies/21053-lowering-electricity-tax-level-of-class-ii)*, can make electric solutions more competitive and support a well-integrated energy system.

3. **Targeted support policies** that include clear zoning frameworks can leverage results from the comprehensive heat planning and mapping to incentivise investment in district-heating infrastructure in regions where it is most suitable.

District heating infrastructure implementation requires careful planning, but with the right conditions in place, the technology can play a more important role in enhancing efficiency, reducing emissions, and strengthening the resilience of the energy system. Making it a success requires coordinated efforts from governments and industry, along with an enabling policy framework. The IEA can help by providing platforms for sharing of knowledge and best practices, including the Technology Collaboration Programme on District Heating and Cooling *(https://www.iea-dhc.org/home)*, the Digital Demand-Driven Electricity Networks (3DEN) *(https://www.iea.org/programmes/digital-demand-driven-electricity-networks-initiative)* Initiative, national Energy Policy Reviews *(https://www.iea.org/search?q=energy%20policy%20review)*, and specific conferences, such as the IEA's annual Global Conference on Energy Efficiency *(https://www.iea.org/events/10th-annual-global-conference-on-energy-efficiency)*.