Renewables in District Energy

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Abstract

This report examines how renewables can play a larger role in district energy systems, helping to deliver cleaner, more secure and more efficient heating and cooling. District energy networks already supply heat to around 600 million people worldwide, but many systems remain heavily dependent on fossil fuels, exposing consumers and utilities to price volatility, supply risks and high emissions.

The report provides a global overview of district energy systems, their fuel mixes, market conditions, governance models and affordability implications. It explores the growing opportunities offered by renewable and recovered heat sources, including bioenergy, geothermal, solar thermal, waste heat, large-scale heat pumps and thermal energy storage. It also sets out policy priorities for three types of markets: established systems with high renewable shares, fossil fuel-intensive networks, and emerging or untapped district energy markets.

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Questions or comments?

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Executive summary

District energy is a strategic lever for energy security and emissions reduction

District energy supplies around 10% of global final energy consumption for heat. As heating and cooling account for more than half of global end-use energy consumption today, this corresponds to around 5% of total energy consumption. District heating and cooling systems offer an efficient, large-scale solution for energy diversification in areas with sufficiently dense demand. By producing heat or cold centrally and distributing it through insulated networks, district energy systems can integrate diverse energy sources - including renewables - optimise demand management at scale, and support coordinated infrastructure planning in urban and industrial settings**.**

District heating serves more than 600 million people worldwide and global networks extend over more than one million kilometres. The amount of heat delivered through district heating has increased by about 35% since 2010. These systems are embedded in national energy systems across Europe, China, Russia and parts of Central Asia. District cooling is less developed than district heating but is expanding beyond the Middle East into multiple regions. With rising cooling demand and urban density, it can improve efficiency, reduce peak electricity demand and support system integration.

To date, district heating remains largely fossil fuel-based, with around two-thirds of consumption in energy-importing countries, exposing consumers to price volatility and geopolitical supply risks. While efficiency improvements – including the shift to combined heat and power – have reduced emissions intensity, overall fossil fuel use remains high. Coal accounts for around half of global district heat production, with natural gas contributing close to one-third, reflecting continued reliance on legacy infrastructure and established supply chains, particularly in China and Eastern Europe. Existing networks provide a platform for fuel switching and the integration of renewables and waste heat, making district energy a key lever to advance, energy security and system efficiency and emission reductions.

Renewables and waste heat can scale district energy, but challenges remain for faster deployment

Renewables currently supply just 7% of global district heat, concentrated in a small number of countries with strong policy support, favourable

resources and coordinated planning. This contrasts sharply with the rapid scale-up of other clean energy technologies. Over the past five years, global solar PV capacity has more than quadrupled, wind capacity has nearly doubled, and electric car sales have surged – all while renewables use in district heating has remained stable.

Without policy changes, renewable district heat is projected to grow by only around 10% to 2030. This highlights a major untapped opportunity to expand renewables in both existing and new district energy systems, supporting diversification and decarbonisation of heat supply. In existing networks alone, renewable and waste heat could increase up to tenfold without major infrastructure investment. Under existing policies, the number of district heating consumers is set to increase by around 8% by 2030, reaching approximately 650 million worldwide. Yet the expansion potential remains significant, particularly in dense urban areas: over 600 million people live in cities with substantial heating demand but no access to district heating. Experience in countries such as Denmark shows that, in some cases, district heating can be viable beyond the densest urban areas.

Several technologies needed to decarbonise district energy are commercially available and increasingly cost-competitive. District energy systems can leverage economies of scale that are not viable at the individual building level. Large-scale high-efficient heat pumps are competitive where suitable low-temperature sources are available, networks can operate at lower supply temperatures, and electricity-to-gas price ratios are favourable. Solar thermal and geothermal can provide low-cost heat where land, resources, financing and risk-sharing frameworks align; and sustainable bioenergy continues to underpin most systems that already operate at high renewable shares.

Thermal storage in district energy systems enables cost-effective system integration, offering capabilities few other technologies can match. By shifting heat across hours, days or even seasons, storage facilitate the integration of variable renewables. This is evident in solar district heating: Denmark pairs large solar thermal fields with seasonal storage, while projects in Germany and the Netherlands combine solar thermal, storage and waste heat to extend supply beyond summer. Waste heat offers significant but underutilised potential as well: large volumes of low-temperature heat are released from urban and industrial sources including data centres. While capture is technically straightforward, deployment depends on local conditions, including proximity to demand, temperature compatibility and connection costs.

The main challenges are not technological, but economic and regulatory, and can be addressed through targeted policy action. High upfront capital requirements and long payback periods constrain investment, while high operating temperatures and ageing network infrastructure limit the integration of low-temperature renewable sources. Price signals, including unfavourable electricity-to-gas price ratios, can discourage electrification. In addition, frameworks to value and integrate third-party heat remain underdeveloped, and insufficient planning allows individual heating choices to undermine network efficiency. Addressing these challenges requires coordinated policy and system-level approaches alongside technical solutions.

Energy security gains are largest where renewables and waste heat displace imported fuels and add system flexibility

Across key district heating regions, renewables and waste heat already displace over 190 million barrels of oil equivalent of imported fossil fuels each year, largely driven by Europe. In Northern Europe, import dependence in district heating is currently around 14%, and about 25% in the Baltic region. Without renewables, it would be more than fourfold and fivefold higher, respectively.

Strategic implications vary across systems. Networks reliant on imported natural gas, notably in parts of Central and Western Europe, are most exposed to supply shocks, while systems based on domestic fossil fuels have lower import dependence but higher emissions. In contrast, several Northern European countries have diversified towards bioenergy, waste heat and heat pumps, reducing both import dependence and emissions and showing that energy security and decarbonisation can advance together.

Electrification can enhance energy security in district energy systems. As power systems decarbonise, heat pumps and electric boilers reduce reliance on fossil fuels and, with thermal storage, enable integration of variable renewables and peak load shifting. However, benefits depend on system design: electricity tariffs can raise cost exposure, waste heat use is location-specific, and fossil capacity is likely to remain for peak and backup supply during the transition.

Policy priorities: plan, modernise and finance district heating and cooling for the next phase

Closing the gap between district energy's potential and its current trajectory requires a more coordinated and comprehensive policy approach than is in most jurisdictions today. In jurisdictions where untapped potential exists, policy makers need to move district energy systems up the energy policy agenda by making the role of renewables and efficiency more prominent in national energy planning while focusing in four main priorities:

Plan. Heating and cooling planning should be a statutory element of urban and energy strategy, not an optional exercise. Demand mapping, zoning and clear designation of network areas align utilities, municipalities, building owners and investors around long-horizon commitments. In established systems, planning supports temperature reduction and renewable integration; in emerging markets, it helps identify where district energy is viable and where decentralised solutions are more appropriate.

Modernise. Most existing networks need investment to lower supply temperatures, reduce losses, deploy digital controls and support building renovations that enable low-temperature operation. Lower temperatures facilitate the integration of heat pumps, waste heat and solar thermal while improved building performance ensures system compatibility. Tariff and metering reform are also critical: consumption-based pricing strengthens efficiency incentives, provided that affordability measures protect vulnerable consumers.

Electrify and integrate. Electricity price structures, capacity market rules and waste heat valuation frameworks should reflect the services district energy can provide. Recognising thermal storage and large-scale heat pumps as flexibility assets in electricity markets, with appropriate remuneration, represents a high-impact policy opportunity.

Finance. District energy systems are capital-intensive and long-lived, yet often lack access to suitable financing frameworks. Financing mechanisms such as concession models, regulated returns, blended finance and dedicated funds for network rehabilitation can help mobilise capital, while public support for feasibility studies and project preparation is critical in markets with limited project pipelines.

Policy priorities vary by market maturity. Advanced renewable district heating markets should focus on optimisation, temperature reduction and supply diversification; fossil-dominated systems on efficiency, fuel switching and regulatory reform; and emerging markets on planning, institutional capacity and bankable project pipelines. Across all contexts, stronger policy action is needed to unlock district energy’s full contribution to energy security, emissions reduction and system flexibility.

Summary of policy recommendations

Challenge	Policy priority
For district heating markets with high renewable shares	
Fragmented governance and inconsistent investment frameworks	Make heat mapping and planning a legal obligation
	Further reform district heating financing and business models to support further emissions reductions in systems
High operating network temperatures	Accelerate building renovations
	Incentivise waste-heat recovery by introducing standardised connection and contract frameworks
	Introduce low-temperature connection standards for new buildings and major renovations
	Use tariff structures that reward lower return temperatures and building-side efficiency
	Align renovation waves with temperature-reduction pathways
Limited diversification in the renewable energy supply portfolio	Further incentivise renewable heat deployment with integrated thermal energy storage
	Reform electricity taxes and network charges to reach favourable electricity-to-gas price ratios, a critical enabler for improving the competitiveness of large-scale heat pumps
	Encourage capacity building for municipalities to plan, procure, and finance multi-source renewable systems
	Support innovation in seasonal thermal storage, smart controls, and low-temperature networks
Siloed energy markets limit district energy's potential as a flexible system asset	Enable district heating to respond to flexibility, balancing, and price signals across connected energy systems
Imbalanced prioritisation between affordability, energy security, and resilience	Target support for low-income households during renovation-driven transitions or temperature-reduction phases

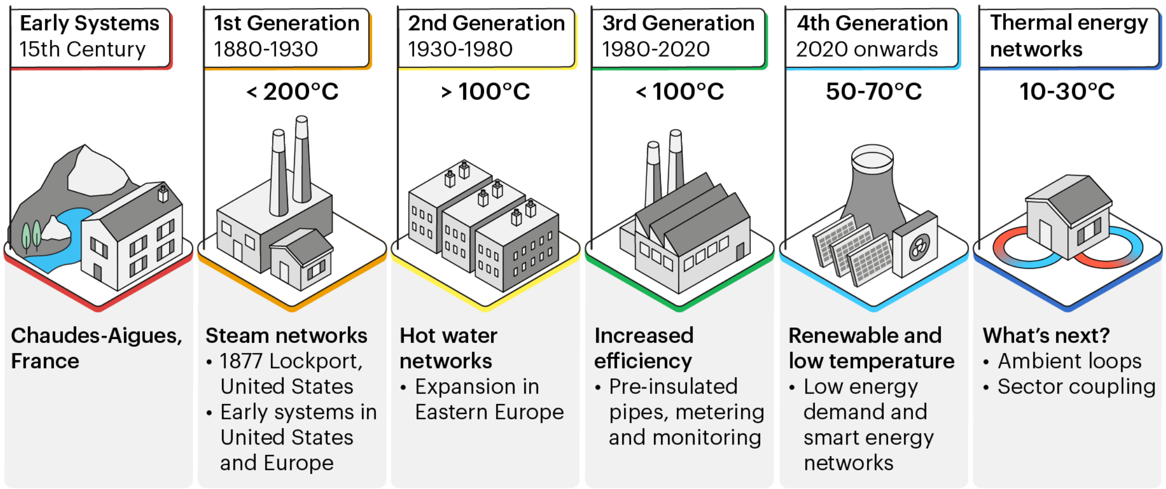
Challenge	Policy priority
For district heating markets with high fossil fuel shares	
Well-established reliance on fossil fuels	Incentivise the transition away from fossil fuels
	Strengthen municipal heat mapping and planning and subsequent implementation
	Improve the viability of integrated renewable sources
District heating systems characterised by ageing infrastructure, low efficiency, and high operating temperature requirements	Target public funding for modern energy-efficient pipe replacement and return-temperature reduction measures
	Introduce mandatory metering and consumption-based billing to incentivise efficiency
	Modernisation requirements tied to utility licences or concession renewals
	Introduce digitalisation support: SCADA systems, predictive maintenance, real-time optimisation, and smart controls
Structural investment barriers and misaligned business models	Heat-planning obligations that give long-term visibility to investors
	Concession models and Regulated Asset Base (RAB) approaches to derisk investments
	Access to low-cost finance through development banks, climate funds, or green bonds
	Tariff reform with clear social protections for vulnerable consumers

Challenge	Policy priority
For untapped and emerging district energy markets	
Limited long-term policy and regulatory support	Develop Long-term Heating and Cooling Targets and Strategies
	Implement Heating and Cooling Mapping
	Create measures to improve competitiveness of renewable energy
Inadequate infrastructure development	Conduct feasibility studies and pilot projects and ensure broad dissemination of resulting lessons learned
	Provide public infrastructure funding
	Implement regulatory support for sustainable community energy planning
	Advance sector coupling, including integration of heat pumps, waste heat recovery and flexible thermal storage, to improve system flexibility, optimise energy use and enable higher shares of renewables
Undeveloped or underdeveloped labour markets	Develop academic and skilled-labour training programmes
	Provide financial aid for education, training, and hiring skilled labour
	Strengthen international collaboration

District energy: Why it matters now

Heating and cooling account for more than half of end-user energy consumption worldwide and play a central role in global energy security, efficiency, and sustainability. District heating and cooling play a central role in this energy provision, by offering a centralised system where heating and cooling are produced before being distributed via insulated pipes to multiple buildings – residential, commercial, and/or industrial – in a neighbourhood or city. District heating and cooling is especially common in urban centres because it is an efficient way to distribute heating and cooling in densely populated milieus. Over time, heating networks have evolved from high-temperature steam systems to lower-temperature, more efficient and flexible configurations capable of integrating renewable energy, waste heat and ambient heat sources.

Illustration of the concept of historical district heating generations



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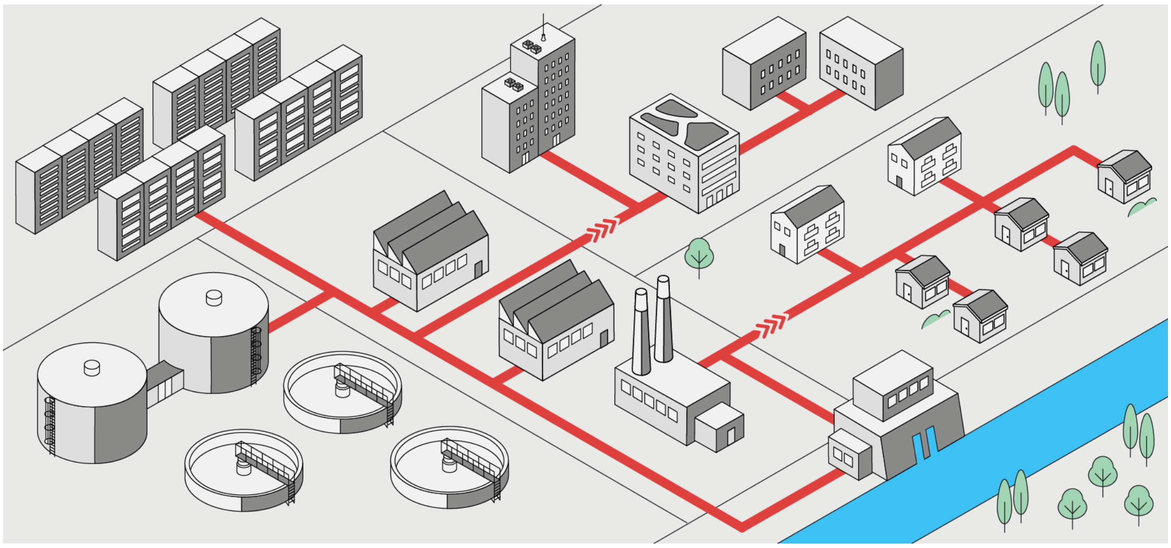
Sources: IEA analysis based on Lund et al. (2014) 4th Generation District Heating (4GDH): Integrating smart thermal grids into future sustainable energy systems. IEA DHC (2024) District heating network generation definitions.

Today, district heating supplies around 10% of the global total final energy consumption for heat in buildings and industry and serves some 600 million people worldwide. Incredibly, global district heating networks span over 1 million kilometres, enough to encircle the Earth roughly 25 times. While district heating's share of total supply remains modest at the global level, final energy consumption delivered through district heating has increased by around 35% since 2010 and it remains a crucial part of many national energy systems.

In Denmark, Finland, and Sweden, for example, district heating meets around half of heat demand in buildings. District heating also plays a major role across Central and Eastern Europe, the Russian Federation (hereafter, "Russia"), and Central Asia, where extensive network infrastructure serves a large share of urban heat demand. Although many of these systems were developed decades ago, recent expansions in parts of Europe and rapid, large-scale development in People's Republic of China (hereafter, "China") demonstrate strong and sustained momentum. China's district heating network length has increased tenfold since 2000, from nearly 50 000 kilometres to more than 500 000 kilometres, mainly in northern provinces, underpinned by urban growth and centralised planning.

Illustration of selected users and heat sources available to a district heating system



Source: IEA (2025), Opportunities for district heating in the changing energy landscape.

But challenges remain globally. Many district energy systems use outdated infrastructure, rely on imported fossil fuels, and face exposure to price and supply shocks, laid bare by global energy crises over the decades. Modernising district energy networks and integrating renewable energy sources, namely through targeted policies and long-term planning, can help to address these challenges, contributing to cleaner, more secure, and more affordable energy systems.

This report focuses on such efforts and recommendations, while also providing a comprehensive global overview of district energy systems today. Chapter 1 covers that overview, examining different energy sources for district energy systems and offering a detailed snapshot of systems in place in Northern Europe, the Baltics, Central and Western Europe, China, Eastern Europe, and Central Asia and the Caucasus, including specific energy security risks faced in each. Chapter 2 examines different market conditions and regulatory systems, including implications of efficiency and pricing, and looks ahead at trends to watch in district energy, notably on innovative storage technologies and the implications and opportunities that data centres offer for heat generation. Finally, Chapter 3 examines the key barriers and opportunities for scaling up renewable energy in existing and emerging district energy networks and sets out policy priorities tailored to different regional contexts.

District energy in this report

The term “district energy” is used in this report as an umbrella term covering district heating, district cooling, and integrated networked systems that supply thermal energy at district scale, while creating synergies across heat, cooling, hot water, and where relevant electricity. Today, district heating is by far the most widespread application globally, while district cooling and combined district heating and cooling networks remain less developed and are concentrated in a limited number of markets.

Accordingly, this report places a stronger emphasis on district heating, reflecting its larger role today, its greater near-term potential for renewables integration, and its more immediate relevance for energy security in many regions. At the same time, the report recognises the increasingly important role that district cooling already plays in some markets, particularly in the Middle East, as well as its growing potential in the European Union, Latin America, North Africa, and Southeast Asia. It also acknowledges the increasing momentum behind integrated networks that can deliver both heating and cooling.

While our examination of district cooling is therefore less extensive than that of district heating, it is included throughout the report to highlight the main challenges, opportunities, and policy considerations relevant to scaling up these systems in the near term.

District energy: Progress and opportunities

District energy networks have made significant progress in recent decades, driven by growing renewable energy deployment and a progressive transition from inefficient fossil fuel-based heat-only boilers to more efficient combined heat and power (CHP) systems. This shift has reduced the emissions intensity of district heating, which in many cases is lower than that of individual fossil fuel-based heating solutions.

Two recent structural shifts have helped to reduce the carbon intensity of district energy at a quicker rate than in previous decades.

- **Significant technological improvements, cost reductions, and increased policy attention have helped large-scale heat pumps to become accessible across a broader range of climates.** When combined with thermal storage, supplementary renewable sources (including geothermal and waste heat) allow district energy networks to electrify substantial portions of the heat supply while maintaining reliability. This creates a direct link between heating and reducing the carbon intensity of power systems, enabling urban areas to benefit from cleaner electricity and greater system efficiency.
- **Cities are concentrating a growing volume of recoverable low-temperature waste heat from data centres, metro systems, hospitals, wastewater treatment facilities, and industry.** Modernised low-temperature networks are uniquely equipped to capture this otherwise unused resource. Individual buildings, by contrast, cannot typically access or integrate these heat streams efficiently. District energy networks therefore serve as infrastructure that unlocks a new category of local, low-cost, and low-carbon heat supply.

Recent geopolitical crises have reinforced the central role of energy security and the importance of reducing reliance on imported fossil fuels for heating. District energy networks contribute to stronger energy security by facilitating the integration of waste heat and locally available renewable heat sources. That allows for flexible fuel switching, enabling sector coupling between the heating and electricity sectors and ensuring a reliable heat source during supply interruptions.

In many markets, well planned district energy networks also enhance system resilience by reducing exposure to fuel price volatility and enabling co-ordinated infrastructure planning at the municipal and regional levels. These drivers, combined with falling renewable and waste-heat recovery costs, urban climate ambitions, heightened attention to energy security and system efficiency, and increasing pressure to improve urban air quality, make district energy networks among the few solutions capable of reducing emissions rapidly, affordably, and at a scalable rate in the near term in dense urban and industrial areas.

By offering supply-source flexibility, district energy networks function as multi-vector energy hubs. They can balance variable power generation, provide long-duration storage, and support electrification while avoiding excessive strain on electricity grids during peak heating or cooling periods. Modern district energy networks can also integrate a broad range of renewable and low-carbon heat sources, often more efficiently and at a larger scale than individual technologies can achieve alone. These include bioenergy, geothermal heat, large-scale solar thermal, and large-scale heat pumps using ambient, wastewater, or waste heat from sources such as industry and data centres.

Despite growing momentum, several structural challenges prevent district energy networks from reaching their full potential. Many existing networks, particularly in parts of Eastern Europe and Central Asia, are characterised by high heat losses, ageing pipes, and fossil fuel-intensive generation. Even in advanced economies, integrating large shares of renewables into district heating systems requires regulatory reforms, modernised network temperature regimes, and investment in thermal storage to optimise operations. The economics of new network development also vary widely with urban density, building efficiency, local skills and workforce capacity, and consumer acceptance. In areas without long-term planning frameworks or predictable tariff structures, expanding networks can be risky and slow. Moreover, new networks require substantial upfront capital investment, and the economics can be difficult to estimate due to energy price fluctuations and policy uncertainty. Clear governance models, heat zoning, and transparent consumer protection frameworks are increasingly important for mobilising investment. This combination of structural opportunity and persistent barriers gives rise to a simple but decisive conclusion - accelerating renewable district energy requires both system modernisation and strong policy support.

Unlocking the full potential of renewables and waste-heat recovery within district energy networks requires targeted policies, long-term planning, and modernisation of existing assets. As multi-vector energy systems, district networks have the potential to integrate renewable energy sources at scale, complement electrification efforts, harvest heat that would otherwise be wasted, and contribute to resilient and cost-effective urban energy systems.

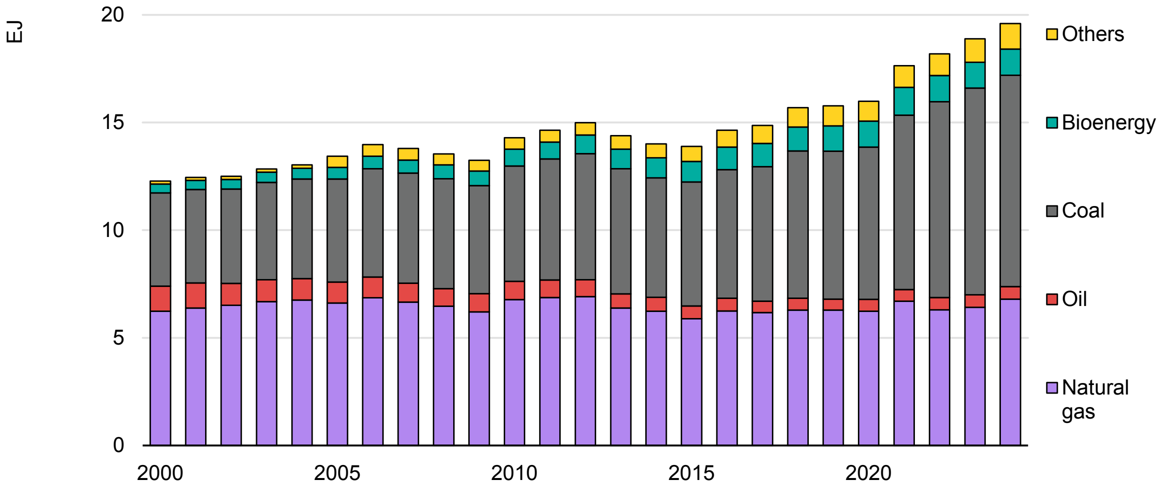
Chapter 1. District energy today

Global trends in district energy

District heat supply remains dominated by fossil fuels

In 2024, global heat production for district heating networks reached around 20 EJ[1], an increase of around 35% compared with 2010 and 60% compared with 2000. District heating reached around 10% of global final consumption for heat in 2024. Despite efficiency improvements over the past two decades, including a broad shift from heat-only boilers to CHP plants, the district heating fuel mix remains overwhelmingly fossil fuel-based. Most fossil fuel-based district heat is now produced in CHP plants, which make more efficient use of fuels by cogenerating heat and electricity.

Heat production for district heating networks, 2000-2024



Note: "Others" includes heat recovery, waste-to-energy, geothermal, solar thermal, electricity, and ambient heat harnessed by heat pumps.
Source: IEA (2025), World Energy Balances.

Coal still accounts for roughly half of all district heat production globally, while natural gas contributes close to one-third. Over the past two decades, coal has met the largest share of growth in district heat production, making it the single

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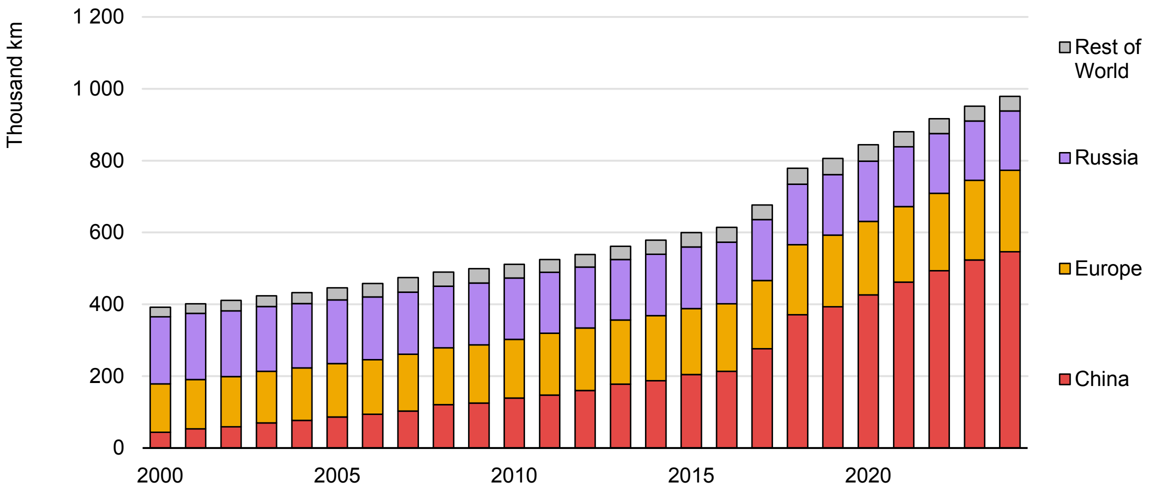
[1] Heat in IEA statistics refers to derived heat that is produced and sold, i.e. heat supplied to a distribution system or delivered under contract to third parties (persons or entities unrelated to the producer). It covers heat sold for use in buildings (residential and non-residential) and industry, including heat sold from CHP plants and heat-only plants, as well as recovered waste heat sold to third parties.

largest contributor to the expansion of district heating over this period. Although the overall fossil fuel share in district heat output has fallen by about three percentage points since 2010, the absolute use of coal has nearly doubled over this period.

Global district heat production is driven overwhelmingly by China, Russia, and Europe, which together account for over 90% of total output. China now produces five times more district heat than it did 20 years ago, a trajectory underpinned by strong central planning and large-scale network deployment across northern provinces. This expansion has been predominantly coal based, with the district heating networks shifting over time from heat-only coal boilers to more efficient centralised coal-fired CHP plants, while alternative sources, including renewables and waste heat, have so far remained relatively limited.

Length of district heating networks in China, Europe, Russia, and other countries, 2000-2024



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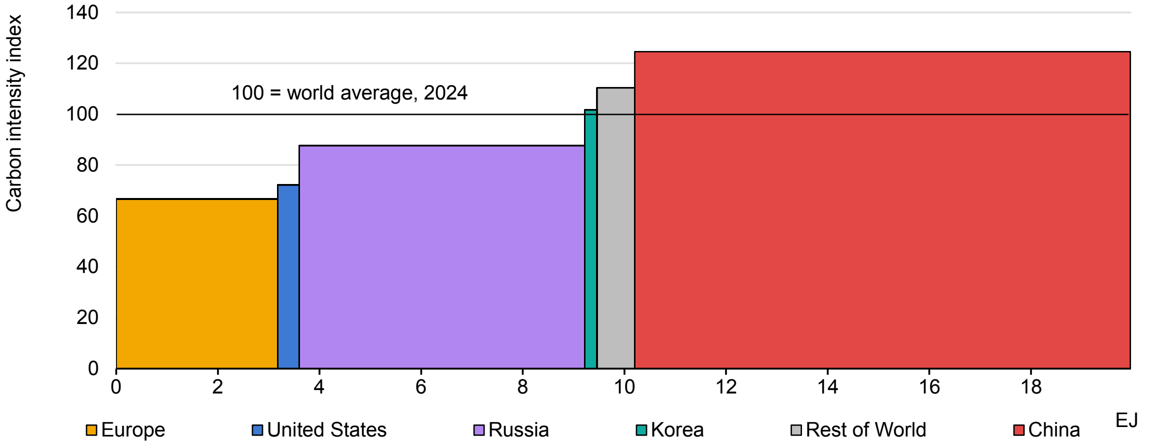
Notes: Network length refers to trench length (route length). China's network length data is derived from China's Statistical Yearbook, which excludes district heat supplies provided by small-scale heating enterprises.

Sources: IEA analysis based on China's Statistical Yearbooks, compiled by the National Bureau of Statistics; EuroHeat and Power Market Outlooks; and IEA estimates.

In contrast, Russia's district heating sector has been comparatively stable in scale, but highly concentrated in terms of fuel use as it continues to rely primarily on domestic natural gas, reflecting large-scale availability. The European Union presents a more diversified picture, depending on the availability of domestic resources, policy frameworks, and infrastructure legacies. Overall heat production has declined in the European Union as building-level efficiency improvements reduced demand, but fuel mixes vary significantly by region. Nordic countries have undergone a sustained transition towards bioenergy-based renewable district heating, combined with increased electrification via heat pumps and electric boilers. Many systems in Central and Eastern Europe, by comparison, still depend heavily on imported fossil fuels, particularly gas and coal.

Coal is the predominant heat source for China's district heating, and as such, the rapid expansion of the system has had a substantial impact on global emissions. China now has the highest carbon intensity of district heat production worldwide, around 20% above the global average and nearly twice the level in Europe. This reflects both the scale of China's network and its continued reliance on coal-based generation. District heating has become more efficient in recent decades due to policy changes, including a shift from small, inefficient coal boilers to larger coal-fired CHP plants, as well as targeted programmes to upgrade existing CHP units and modernise network operations.

CO_2 emissions intensity index for district heat production by country and region, 2024



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Note: A carbon intensity index of 100 corresponds to the global average emission intensity of district heat production in 2024.
Source: IEA (2025), World Energy Balances.

Waste heat: A largely untapped local resource for district heating

Waste heat is another potentially important source for district heating, as it can be recovered from a wide range of urban and industrial sources, including data centres, metro systems, supermarkets, and wastewater treatment plants. Today, however, large volumes of waste heat are simply released into the atmosphere or water bodies, thus rendering it unusable. The temperature ranges of available waste heat vary considerably by source. Some waste heat streams can be fed directly into existing district heating networks, while others require a temperature increase. In these cases, large-scale heat pumps offer a highly effective solution in efficiently elevating low-temperature waste heat to higher temperatures that can be more readily used, thereby improving system efficiency and reducing operating costs.

Modern, low-temperature district energy networks are especially well suited to integrating diverse waste-heat sources. By lowering return and supply temperatures, networks can capture a broader range of low-grade heat, reduce losses, and make more efficient use of local resources.

In China, waste heat currently plays a limited role in district heat supply despite the country having substantial theoretical waste heat potential, estimated at around 10 EJ when including the combined waste heat available from industry, wastewater, and data centres. In practice, however, only part of this potential is economically recoverable. Deployment is often constrained by the geographic distance between heat sources and demand, temperature requirements, and the cost of connecting and adapting infrastructure.

By comparison, in Nordic countries, the integration of waste heat is already standard practice. In Finland, for example, waste heat contributed to 18% of total district heat production in 2024.

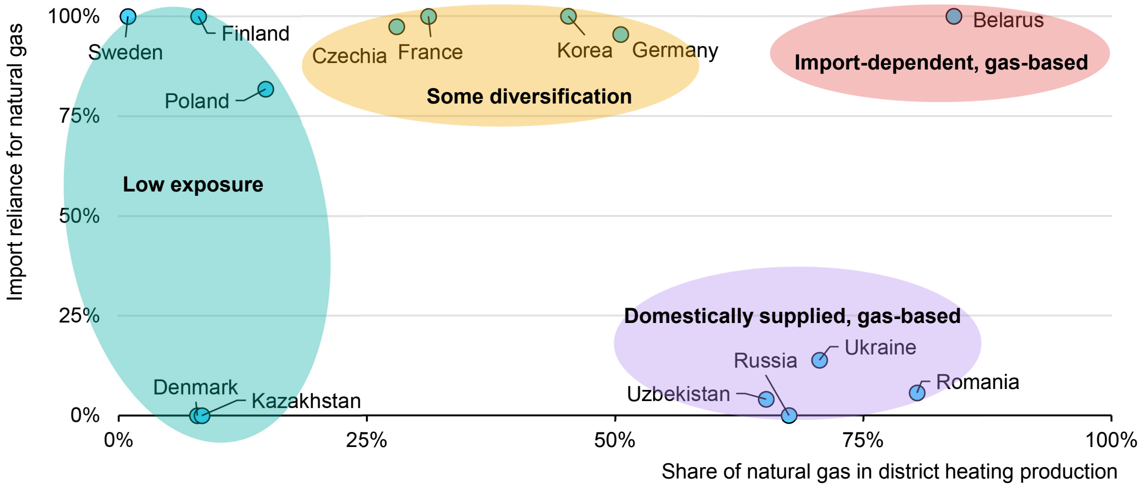
Energy security risks: Gas-intensive district heating and high import dependence

A heavy reliance on fossil fuels in district heating systems may lead to energy security vulnerabilities for fossil fuel-importing countries. Historically, district heating networks often enabled more efficient use of fossil fuels than decentralised fossil-based alternatives. Over the past two decades, cogeneration-based district heating has more than doubled, in many cases replacing less efficient heat-only boilers, while recovering heat that would otherwise have been wasted in electricity generation. Although these systems can raise overall efficiency, they can also lead to fossil fuel-dependence, exposing import-dependent markets to global price volatility, impacting overall energy security.

Some major district heating markets, such as Russia, depend heavily on natural gas for heat supply and produce most of the gas they consume. In these cases, import reliance is low, meaning supply disruptions are relatively limited. The situation is markedly different in other countries. Czechia, France, Germany, and South Korea also rely substantially on natural gas for district heating but depend on imports for most of their demand; even with recent diversification efforts, natural gas still accounts for 30-50% of the gross district heating production in those countries.

By contrast, countries such as Estonia, Finland, Latvia, Lithuania, and Sweden have little to no domestic natural gas production and therefore would be highly exposed to import dependence if their systems were gas-based. Yet these countries have largely avoided this vulnerability by building highly diversified district heating portfolios, drawing on bioenergy, waste heat, heat pumps, and other renewables.

Natural gas-based district heating and exposure to import reliance, 2024



Note: The import reliance is calculated as the ratio between the net imports and the total energy supply of natural gas for a given country.
Source: IEA (2025), World Energy Balances.

Overall, renewables that are locally or regionally sourced play a central role in improving the energy security of district heating systems. By reducing or eliminating the need for imported fossil fuels, renewable heat sources, along with waste heat and electrification through heat pumps, help create more resilient, self-sufficient, and predictable heat supply systems. This makes district heating a key lever for reducing emissions and achieving strategic energy independence.

Renewables: A modest but growing role

Renewable district heat production[2] has nearly doubled over the past decade, yet its overall share within systems globally remains modest. Today, only about 7% of district heat production is sourced from renewables, yet there is ample opportunity to accelerate their efficient and cost-competitive deployment within existing and emerging networks.

The European Union is a global leader in renewable district heating, accounting for roughly half of global renewable energy in district heating. The region also

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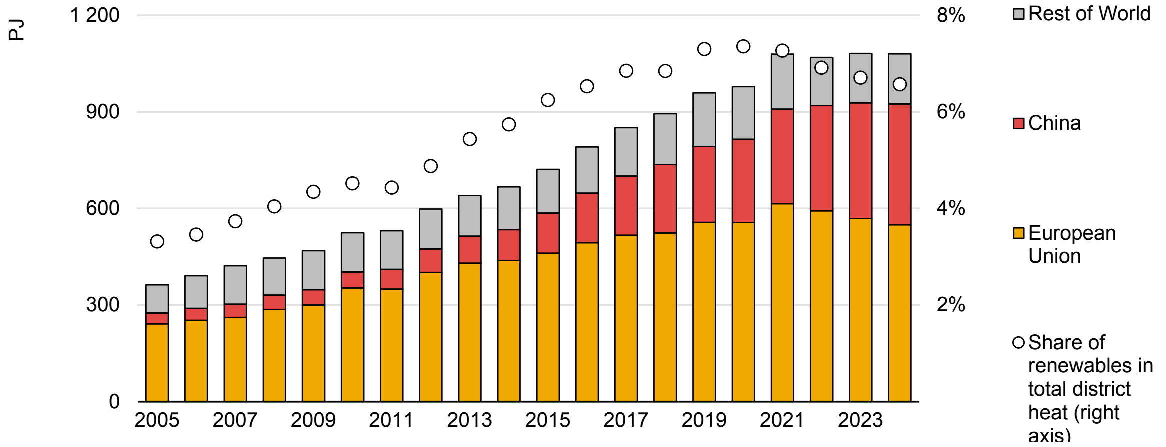
[2] Renewable district heat includes direct use of renewables (bioenergy, solar thermal, geothermal, renewable waste), indirect use of renewables (renewable electricity), and ambient heat harnessed by heat pumps.

hosts the world's most advanced portfolio of renewable-based district heating. Nordic and Baltic countries rely heavily on bioenergy, primarily solid biofuels, complemented by growing electrification through large-scale heat pumps and increasing levels of large-scale thermal energy storage. Elsewhere, the scattered deployment of solar thermal and geothermal helps to boost the European Union's overall share of renewables in district heating. The European Union's leading role reflects several structural advantages, including higher network efficiency, lower supply temperatures, a markedly reduced reliance on coal, and a greater contribution from renewable energy and waste heat.

Renewable district heat production per region and share of total district heat production, 2005-2024



IEA. CC BY 4.0.

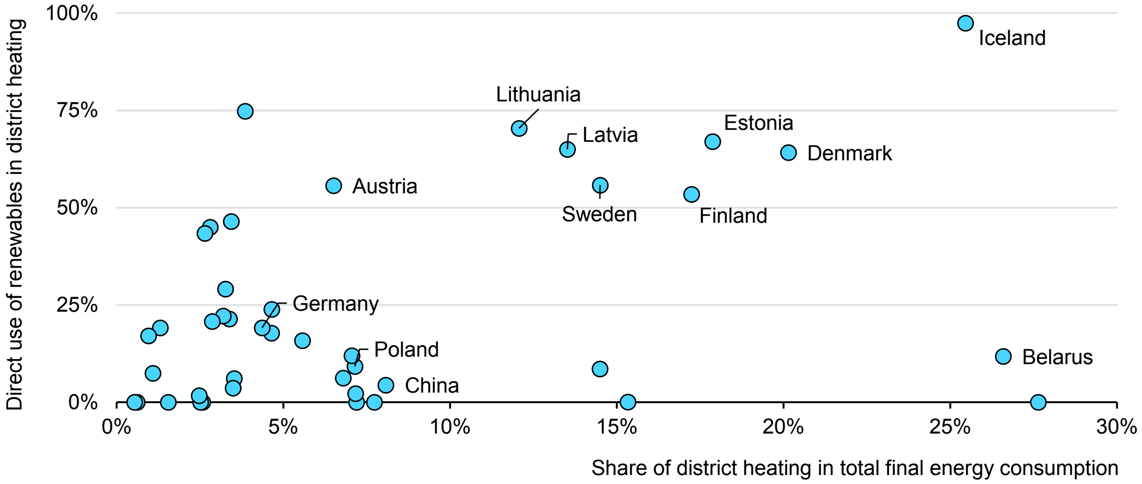
Source: IEA (2025), World Energy Balances. IEA (2025), World Energy Outlook.

In China, renewables-based district heating has expanded significantly in recent years, primarily driven by geothermal, although the share remains small relative to the country's total district heat output. Growth has been driven primarily by the increasing use of renewable electricity and bioenergy, bringing China's share to around one-third of global renewable district heat production.

The global deployment of renewable energy in district heating remains highly concentrated geographically. Only nine countries worldwide supply more than 50% of their district heat from renewable sources. Of these, eight are European Union members, and Iceland is the ninth.

An abundance of geothermal resources in Iceland, developed over several decades, has become the backbone of the country's district heating system. Similarly, the high share of renewables observed in other Nordic countries, such as Denmark, Finland, and Sweden, is the result of strong structural conditions and sustained policy support introduced starting in the 1980s. Following the 1970s energy crisis, many of these countries had strong domestic forest sectors, with well-developed inventory data and robust supply chains, allowing them to easily source abundant, low-cost, and drop-in ready solid biofuels from harvesting and forest product manufacturing residues. Carbon and energy taxes, renewable energy incentives, and district heating regulations that progressively displaced oil and coal, helped to quickly reshape the fuel mix of district heating networks in the region resulting in the high level of renewable sources today.

Share of direct use of renewable energy in district heating networks, 2024



IEA. CC BY 4.0.

Note: Direct use of renewables includes bioenergy, solar thermal, geothermal and renewable waste.
Source: IEA (2025), World Energy Balances.

Electrification via heat pumps: A key flexibility and emissions reduction option

Large-scale heat pumps are becoming a central pillar of modern district heating systems. They are not a new technology, but stronger policy support and growing pressure to reduce fossil fuel-dependence are making them increasingly attractive across a wider range of markets. Continued improvements in compressor efficiency, the deployment of natural and low global-warming-potential refrigerants, and economies of scale in manufacturing and project development have further strengthened their competitiveness. Today's utility-scale heat pumps can deliver supply temperatures in the 60-90°C range, making them compatible with many existing third- and fourth-generation networks, although higher output temperatures generally come with lower efficiency. Their performance and value depend strongly on source temperatures, network temperature requirements, electricity price structures, and the availability of thermal storage.

Nordic nations remain the most established markets for large-scale heat pumps in district heating, with long-standing deployment in systems supplied by wastewater, seawater, industrial waste heat, geothermal resources, and, increasingly, data centres. Their experience shows that heat pumps can supply a substantial share of annual heat demand while reducing reliance on imported fuels and improving temperature management across the network. At the same time, new momentum is emerging in other markets. In Europe, stronger policy support and renewed efforts to move away from natural gas have accelerated project development, particularly in Germany. China has also begun scaling large heat pumps, particularly in northern provinces, where they are increasingly used to integrate renewable electricity and tap into substantial wastewater and industrial waste-heat resources.

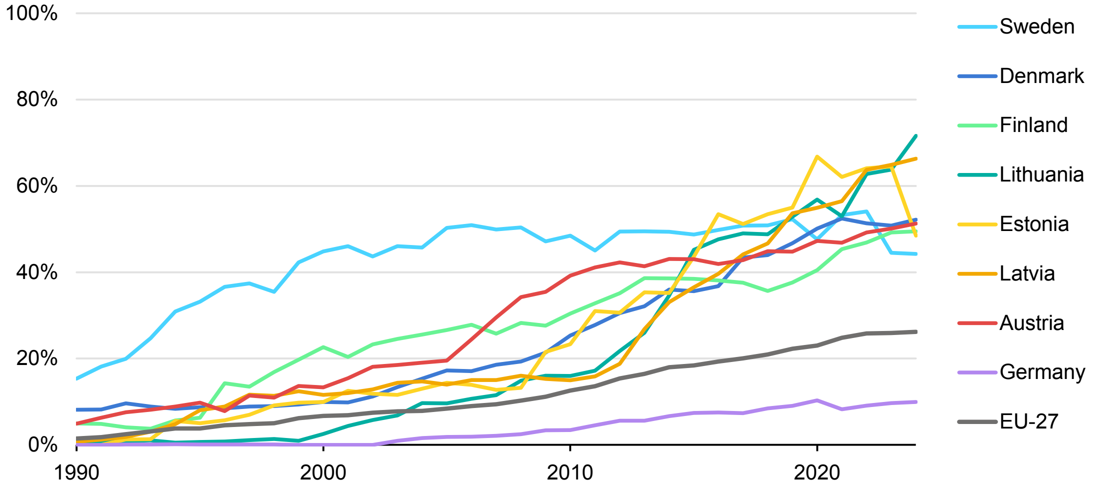
When combined with thermal storage, supplementary renewable sources, and waste heat, large-scale heat pumps can electrify a growing share of district heat supply while also increasing system flexibility. Rather than simply replacing one heat source with another, they strengthen sector coupling between the heating and electricity systems by allowing district energy networks to absorb electricity when it is low cost, convert it into heat efficiently, and shift part of that supply over time through storage. This improves the ability of urban energy systems to integrate variable renewable generation while avoiding unnecessary strain on electricity grids during peak heating periods.

Where heat pumps operate alongside electric boilers and thermal storage, utilities can combine efficient bulk heat production with very fast flexibility. Heat pumps are typically best suited to high-efficiency operation over longer periods, often providing a large share of baseload heat when source and network conditions are favourable. Electric boilers, by contrast, are far less capital-intensive and can respond within seconds or minutes, making them well suited to converting very low-cost or surplus electricity into heat for storage. In practice, their economics are often driven less by efficiency than by timing as they can operate during hours of low, or even negative, electricity prices storing heat for later use. This makes electric boilers particularly valuable as a flexibility and sector-coupling asset, especially when paired with thermal storage, rather than as the primary solution for prolonged peak demand during periods of very high electricity system stress. As electricity markets evolve, tariff structures, taxation, and grid-connection rules that reward flexible operation will be essential to fully realise the benefits of both heat pumps and electric boilers in district energy systems.

Bioenergy: The backbone of renewable district heating

Bioenergy, primarily from solid biofuels such as wood chips, has become the largest source of renewable energy in district energy today, particularly in Northern Europe and increasingly in Eastern Europe. This is due to readily available and cost-competitive biomass feedstocks sourced as residues and byproducts from existing forest and agricultural supply chains or through strong aggregation business models. Supportive regulations, policies, and heating targets over several decades to reduce reliance on fossil fuel imports, lower emissions, and create economic development opportunities by leveraging local resources are also contributing factors.

Share of bioenergy in district heat production of selected countries, 1990-2024



IEA. CC BY 4.0.

Note: Shares of heat production by fuel are calculated on a heat-output basis, i.e. as the share of total heat produced and supplied to the network by each fuel.
Source: IEA (2025), World Energy Balances.

Fossil fuels such as coal, oil, and natural gas were previously used in many district heating systems in regions that are now primarily reliant on renewables, such as in the Nordics and the Baltics. For example, between 1980 and 1990, fossil fuels made up 70-90% of the heat supply in Denmark's, Finland's and Sweden's networks. This reliance on imported fuels left countries exposed to significant price volatility due to geopolitical conflicts of the era.

To reduce exposure to price and supply volatility, countries introduced policies to move away from these fuels in favour of renewable energy. For many, bioenergy, primarily from agricultural sources (e.g. straw) and forest sector residues (e.g. wood chips from manufacturing), became a readily available source of renewable energy. As networks were already well developed, utilities could transition from fossil fuels to bioenergy relatively quickly, affordably, and at scale, often by retrofitting CHP plants rather than undertaking full system rebuilds. In addition, the use of bioenergy provided new economic development opportunities by generating new sources of revenue for domestic agriculture and forest sectors from byproducts traditionally left unused or burned without energy capture.

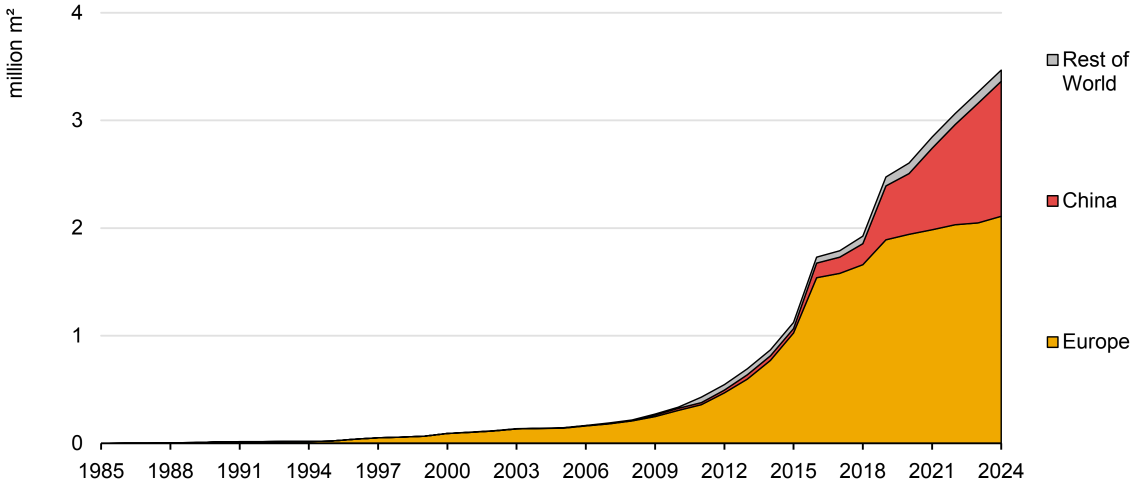
In Finland and Sweden, fossil fuel taxes and municipal energy planning, the introduction of carbon taxes, and increased public infrastructure funding and subsidies for renewable energy between the 1970s and 1990s helped the rapid deployment of bioenergy. Similarly in Denmark, the implementation of the Heat Supply Act in the late 1970s – which mandated heat planning, the development of subsidies for renewable energy, and tax exemption for renewable energy including bioenergy – as well as government infrastructure funding helped drive fuel switching in existing systems.

These examples suggest how strong policy frameworks, adaptable infrastructure, and accessible sustainable local resources have allowed the European Union, and particularly Northern Europe, to become a global leader in renewable district energy.

Solar thermal can achieve high penetration under favourable policy and system design conditions

Globally, solar thermal for district heating remains a relatively small but established segment. In 2024, the commissioning of 24 new large-scale solar heating systems (over 350 kilowatts thermal [kWth], 500 m²) was reported globally, totalling 93 MWth of added capacity. This brought the global stock to 622 systems, with a combined capacity of 2 378 MWth, corresponding to 3.4 million m² of collector area. Under favourable conditions, particularly in mature markets, solar thermal-driven systems can operate at costs as low as EUR 20-50/MWh.

Large-scale systems for solar district heating and large buildings worldwide – cumulated area in operation, 1985-2024



Note: Other countries include Australia, Brazil, Canada, Cambodia, Colombia, India, Japan, Jordan, Kuwait, Kyrgyzstan, Mexico, Morocco, Russia, Saudi Arabia, South Africa, Korea, Thailand, Tunisia, Turkey, United Arab Emirates, and the United States.
Source: Reproduced from Solar Heat Worldwide (2025).

Over the past decade, Denmark has demonstrated the highest achieved penetration levels when enabling conditions are in place. A combination of stable policy support, low operating temperatures, widespread deployment of thermal storage, and strong municipal heat planning enabled Danish utilities to install solar collector fields that routinely covered up to 30% of annual heat demand in participating networks. Performance of existing systems remains strong, especially where they are integrated with large hot-water tanks or seasonal storage that shifts summer heat into winter. However, despite proven performance of the solar thermal fields, the sharp slowdown in new installations since 2020, linked to a policy pivot towards electrification and changing economic incentives, highlights the policy sensitivity of the market.

China represents a second major cluster of activity. Although unit sizes, system configurations and integration strategies vary widely, deployment of large solar thermal fields continues, driven by municipal interest in diversifying away from coal in parts of northern China. These projects illustrate how solar thermal can complement electrification and waste-heat strategies, particularly where land availability is less constrained or where local governments prioritise low-carbon heat sources that reduce fuel-price exposure and improve air quality.

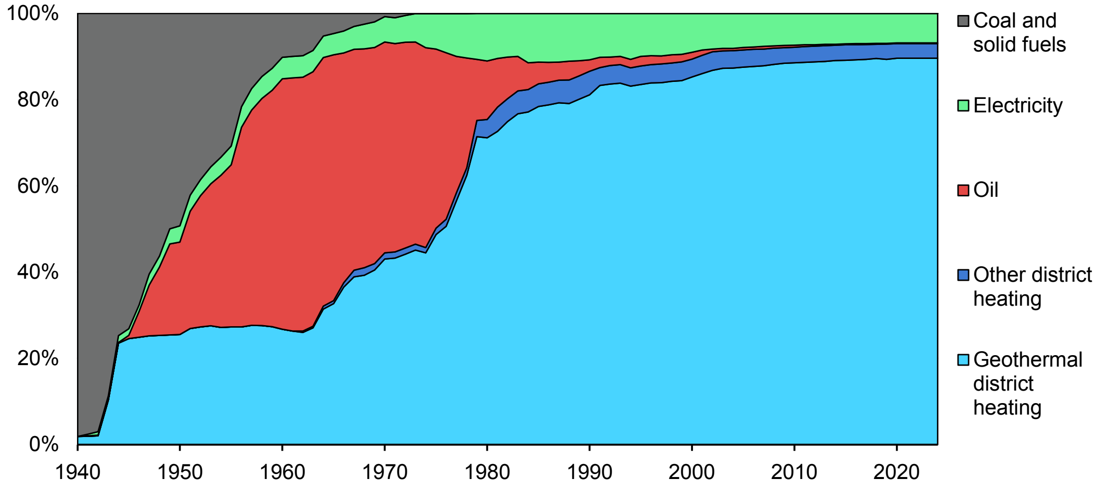
Geothermal district heating scales where strong planning and risk-sharing overcome financing rather than resource constraints

Globally, around one-third of geothermal heat is currently delivered through district heating systems. Deployment is accelerating with advances in drilling and material technologies, stronger policy frameworks, and innovative risk-mitigation instruments that reduce upfront investment risks and costs. The experience also shows that central planning, co-ordinated infrastructure development, and effective allocation of subsurface and market risks are critical to scaling deployment.

Country experiences illustrate different pathways to expansion. Iceland represents the most mature model, where geothermal supplies heat nearly the entire urban population via district heat and accounts for roughly 10% of global geothermal district heating consumption. Its success reflects a unique combination of abundant high-temperature geothermal resources, early government support, centralised planning, and risk-sharing mechanisms that enabled large-scale network development and long-term investment certainty.

China, the world’s largest user by volume, has rapidly scaled geothermal district heating in its coal-dominated system, driven primarily by air quality policies and centrally co-ordinated clean-heating programmes. As a result, its consumption has grown 2.5 times in the past five years, now serving more than 70 cities across 11 provinces.

Total final consumption for residential space heating in Iceland, 1952-2024



Source: Reproduced from Odinn Melsted (2021) Eliminating fossil fuels: Iceland's transition from coal and oil to geothermal district heating, 1930–1980.

France shows how publicly backed risk mitigation can unlock geothermal even in more moderate resource conditions. Around 75 systems are in operation, supported by the modernised Fonds Chaleur, which combines upfront financing for heat projects with dedicated derisking guarantee schemes that socialise a significant share of exploration and development risk, and thus enables a broader range of developers to participate.

Germany is emerging as a key growth market, with more than 150 systems under development. Expansion is driven by a hybrid model, combining a dedicated public derisking instrument, upfront financing, and a risk-sharing mechanism, with emerging private insurance solutions that absorb part of the drilling risk.

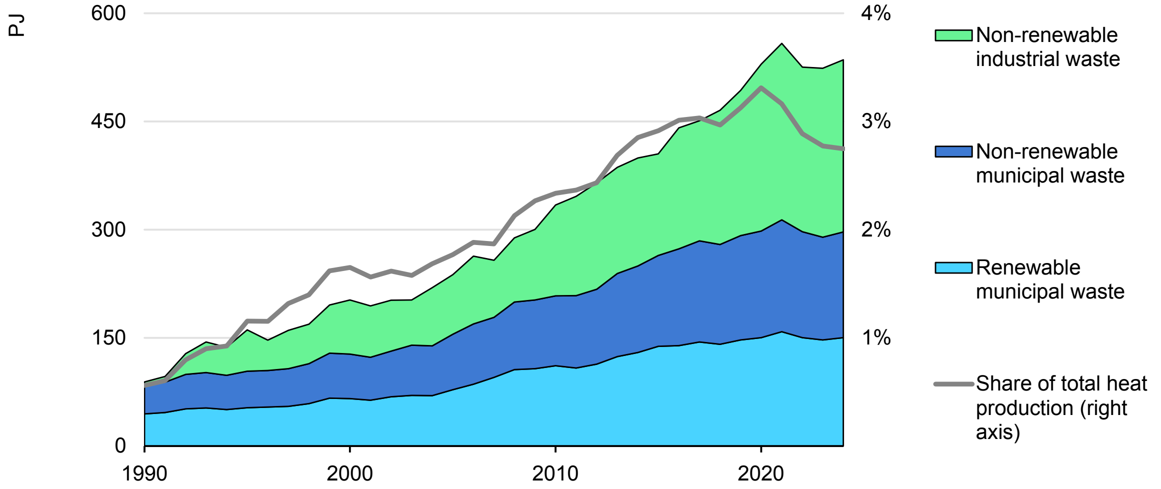
Denmark illustrates a more market-embedded approach to derisking. Large, capitalised developers absorb exploration risk on their balance sheets with long-term district heating offtake contracts and regulated heat markets. The risk is thus not explicitly insured by the state but internalised within vertically co-ordinated developer-utility structures, enabling geothermal to compete without dedicated public risk guarantees.

Waste-to-energy supports waste management while providing a source of dispatchable heating

Waste-to-energy systems have been used for several decades to support waste management and generate dispatchable heat for local district heating systems. Since 1990, the share of waste-to-energy in district heating production globally has increased gradually from roughly 1% to just under 3% in 2024. Nearly half of this comes from non-renewable industrial waste, such as old tyres burned to produce low-cost heat and electricity for manufacturing. Renewable municipal waste, such as residential wood waste and food waste, and non-renewable municipal waste, such as unrecycled plastics, make up the remaining amount.

While a small share of the overall district heating supply, waste-to-energy systems have been deployed widely to leverage readily available waste and support district heating networks, especially in urban settings. For example, Copenhagen's Amager Bakke waste-to-energy plant uses non-recyclable waste from roughly 650 000 people and provides electricity to 80 000 households and district heating to 90 000 apartments. Amsterdam's AEB waste-to-energy plants use renewable and non-renewable waste collected from the city and the surrounding region for its waste-to-energy facility, which produces heat for roughly 30 000 homes via local district heating systems, as well as electricity which it supplies to the local electricity grid. Outside of Oslo, the Slemmestad's Veas wastewater treatment plant treats wastewater from the region to provide 118 GWh of heat to the city's district heating systems while producing over 10 million cubic metres of biogas and 45 000 tonnes of soil enhancement byproducts.

Heat production using renewable and non-renewable waste, 1990-2024



IEA. CC BY 4.0.

Notes: Industrial waste of non-renewable origin consists of solid and liquid products (e.g. tyres) combusted directly, usually in specialised plants, to produce heat and/or power. Municipal waste consists of products that are combusted directly to produce heat and/or power and comprises waste produced by households, industry, hospitals, and the tertiary sector that is collected by local authorities for incineration at specific sites.

Source: IEA (2025), World Energy Balances.

Advances in waste-to-energy plants used to support district heating are also being made, specifically in adding carbon capture utilisation and storage technologies (CCUS). Captured carbon from these facilities can be stored in appropriate geological formations or sold as a byproduct for other end uses (e.g. chemicals, materials, or production of synthetic fuels). For example, Veas has partnered with Norway's Northern Lights CCS project, which aims to sequester captured carbon in saline aquifers off Norway's shore by capturing carbon using CCUS technology.

The plant is also seeking to liquify biogas for emerging sustainable fuel markets in industries such as shipping. Similarly, facilities such as Amager Bakke and AEB are also exploring adding CCUS technology and partnering with the Northern Lights project to store captured carbon in the Norwegian offshore.

The potential for district cooling remains largely untapped

Though district cooling has existed for decades, it remains far less prevalent than district heating. However, this is changing as cooling demand rises with urbanisation, higher peak temperatures, and growing purchasing power, namely in emerging and middle-income economies. In dense districts, this demand growth creates three main challenges: limited space for rooftop chillers and cooling towers, sharp electricity peaks during heatwaves, and affordability concerns for consumers and utilities. Modern district cooling systems address all three by centralising cold production, aggregating loads, and leveraging storage, delivering higher efficiency at lower energy use, lowering peak demand, and creating more predictable lifecycle costs than an equivalent stock of standalone air-conditioning units.

In some hot and densely urbanised markets, district cooling is already a major operating reality rather than a future option. The Middle East is home to some of the world’s largest district cooling systems, particularly in cities such as Dubai, where high cooling loads, dense commercial districts, and large real-estate developments have supported large-scale deployment. Singapore and several East Asian cities also illustrate how district cooling can serve dense urban districts, business zones, and major public or commercial facilities. These examples show that district cooling is most competitive where demand is concentrated, anchor loads are large and stable, and urban planning can support the development of shared cooling infrastructure.

Beyond efficiency, district cooling provides system-level flexibility that individual equipment cannot. With thermal energy storage (TES), district cooling plants operate as “thermal batteries,” meaning they can ‘charge’ when electricity is abundant or cheap (e.g. windy nights or sunny days) and discharge during peak hours, reducing stress on the electricity grid and enabling higher shares of variable renewables. Proven networks (e.g. Dubai, Paris, Toronto) show substantial peak shaving and avoided generation capacity, illustrating how district cooling supports power-system resilience during extreme heat events.

Overview of selected district cooling networks and technologies

City	Year	Size of network	Main technologies
Barcelona	2004	26 km, 1.8 million m^2, 49 MW of cooling capacity	Waste-to-energy driving absorption chillers, seawater cooling, electric compression chillers, thermal storage
Copenhagen	2010	30 km, 100 MW cooling capacity	Seawater free cooling, absorption chillers using surplus district heat in summer, compression chillers
Dubai	2004	90 cooling plants and over 1 700 buildings served	Centralised chilled-water district cooling using large electric chiller plants, distribution via insulated pipelines
Helsinki	2000	Around 550 buildings connected	Centralised production in cooling plants via heat pumps, wastewater heat recovery, free cooling, and underground chilled-water reserves
Marseille	2016	5 km, 26 GWh of heating and cooling sales, 50 delivery points	Seawater-sourced chilled water (and heat) distributed via an urban network; 82% of the supplies come from renewables
Munich	2011	40 km of district cooling connected to more than 100 buildings	Groundwater and combined generation of cold and heat, together with thermal storage
Paris	1991	103 km, 438 MW of installed capacity and four storage sites	River-water cooling plants, cooling-tower based plants, and storage
Singapore	2006	23 buildings, 246 MW	Centralised chilled-water district cooling using large electric chiller plants, distribution via insulated pipelines
Stockholm	1994	250 km, 600 buildings connected	Free cooling from the lake water in Ropsten, heat pumps connected to district heating and cooling, chillers, and cold storage
Tallinn	2019	5 MW of cooling capacity in two district cooling plants	Centralised chilled water using free cooling, heat pumps, and chillers
Tartu	2015	3 km, 18 MW in two cooling plants	River-water based cooling and solar electricity supporting the system
Toronto	2004	40 km, 200 buildings and 40 million ft^2	Deep lake-water cooling complemented by chiller plants and thermal storage
Vienna	2007	30 km, 200 buildings supplied, around 230 MW of capacity	Absorption chillers driven by waste heat, high-efficiency chillers, and ice storage

District cooling also yields additional benefits in urban centres. It can integrate waste heat – from CHP plants, industry, waste-to-energy plants, or data centres – via absorption chillers. Replacing hundreds of building-level towers and rooftop units improves aesthetics, reduces noise pollution and frees valuable surface area in commercial buildings. Several European and Middle Eastern networks have reported meaningful water and chemical savings as well, especially where free-cooling (e.g. via water from a lake, sea, or river) can substitute for compressor work.

In the right urban conditions (i.e. with high density, concentrated loads, and tight grid margins) district cooling can be a strategic enabler, cutting energy use, flattening peaks, absorbing renewables, and delivering tangible urban benefits from waste-heat reuse to quieter, cleaner streets and more leasable space.

THE STATE OF DISTRICT HEATING TODAY

Northern Europe

Fuel mix

RENEWABLES DOMINATE DISTRICT HEATING ACROSS THE REGION

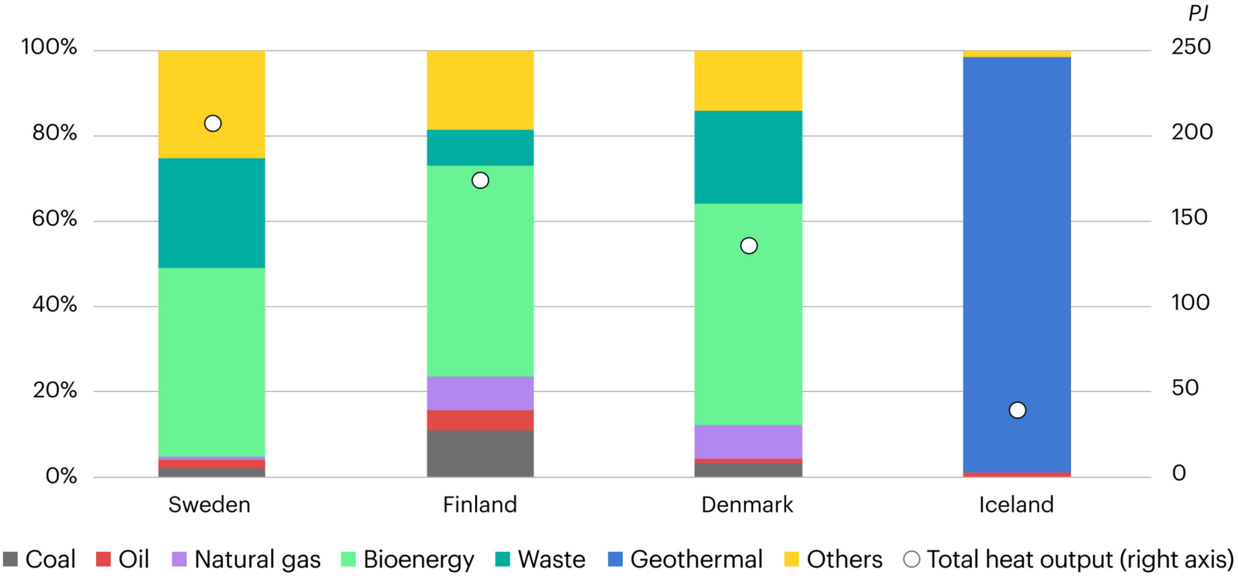
Iceland leverages the widespread availability of geothermal to provide nearly all its heat supply, and it is a global leader in deployment of renewable energy in district heating, with nearly 100% of supply coming from geothermal. Similarly, in Denmark, Finland, and Sweden, solid biofuels provide nearly 50% of heat in district heating systems. In Denmark, domestic agricultural residues are supplemented by a significant share of imported biomass feedstocks, while Finland and Sweden utilise strong biomass feedstock supply chains from domestic forest industries, in addition to wind and solar. Electrification through large-scale heat pumps is also used in district heating in the region, particularly in Sweden, and their deployment has accelerated in recent years, gaining momentum as systems expand the use of waste heat, wastewater, and ambient sources.

Key drivers and constraints

ENERGY SECURITY DRIVES RENEWABLE ENERGY DEPLOYMENT

Over the past several decades, reducing reliance on imported fossil fuels has driven the rapid deployment of renewable energy across the region. Strong policy frameworks, including government support for system development, strategic heat planning, clear renewable energy targets, carbon pricing, and other financial incentives have played a central role in accelerating this transition. As a result, countries have harnessed domestically available resources to strengthen energy security, while creating new economic opportunities. In Iceland this has meant capitalising on abundant geothermal availability. Denmark has utilised agricultural and forest residues sourced regionally, while Finland and Sweden use forest residues from large domestic forest sectors.

Energy supplies to district heating networks, 2024



Note: Bioenergy includes solid, liquid, and gaseous bioenergy. Waste includes industrial waste, as well as renewable and non-renewable municipal waste.
Source: IEA (2025), World Energy Balances (database).

ENERGY SECURITY IMPLICATIONS

Northern Europe

SECURITY

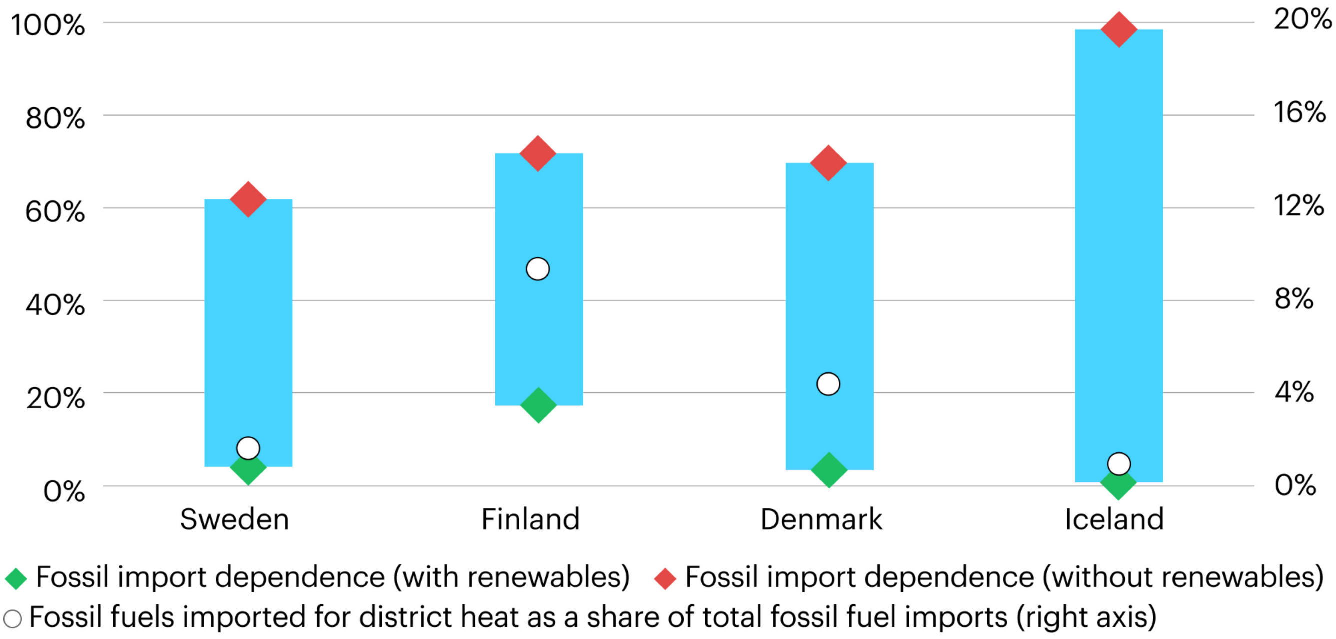
Deployment of renewables in district heating networks across Nordic countries has reduced dependence on imported fuels

Though 86% of the region's fossil fuel supply is imported, a high share of its district heat supply comes from domestically produced renewable energy, reducing its exposure to international price dynamics for heating. An estimated 14% of district heat supply in the region relies on imports. Bioenergy and waste accounts for 60% of energy used in district heating across the region (87% of which is sourced domestically). Deployment of renewables in district energy across the region has ultimately reduced overall dependence on imported fossil fuels by 8 percentage points, (displacing over 8 Mtoe of imported fossil fuels), ultimately improving energy security in the region.

14%

of district heat supply in the region relies on imported fuels

Share of imported fossil fuels in energy supplies to district heating networks, and share of total fossil fuel imports in selected countries, 2024



Note: Fossil import dependence in energy supplies to district heating networks is calculated as the average import dependence by product, weighted by share of heat output. Import dependence by product is calculated as net imports of fossil fuel products (natural gas, coal, peat and peat products, oil shale and oil sands, and primary and secondary oil) divided by the total energy supply (excluding bunkers and stock changes). The counterfactual scenario (without renewables) assumes that for net fossil fuel importing countries, all heat output from renewable sources in the given year is directly replaced with imported fossil fuels. In this scenario, renewables include solid, liquid, and gaseous bioenergy, geothermal, solar thermal, and the renewable portion of municipal waste.
Source: IEA (2025), World Energy Balances (database).

Baltic countries

Fuel mix

SOLID BIOFUELS SUPPLY MOST RENEWABLE ENERGY ACROSS THE REGION

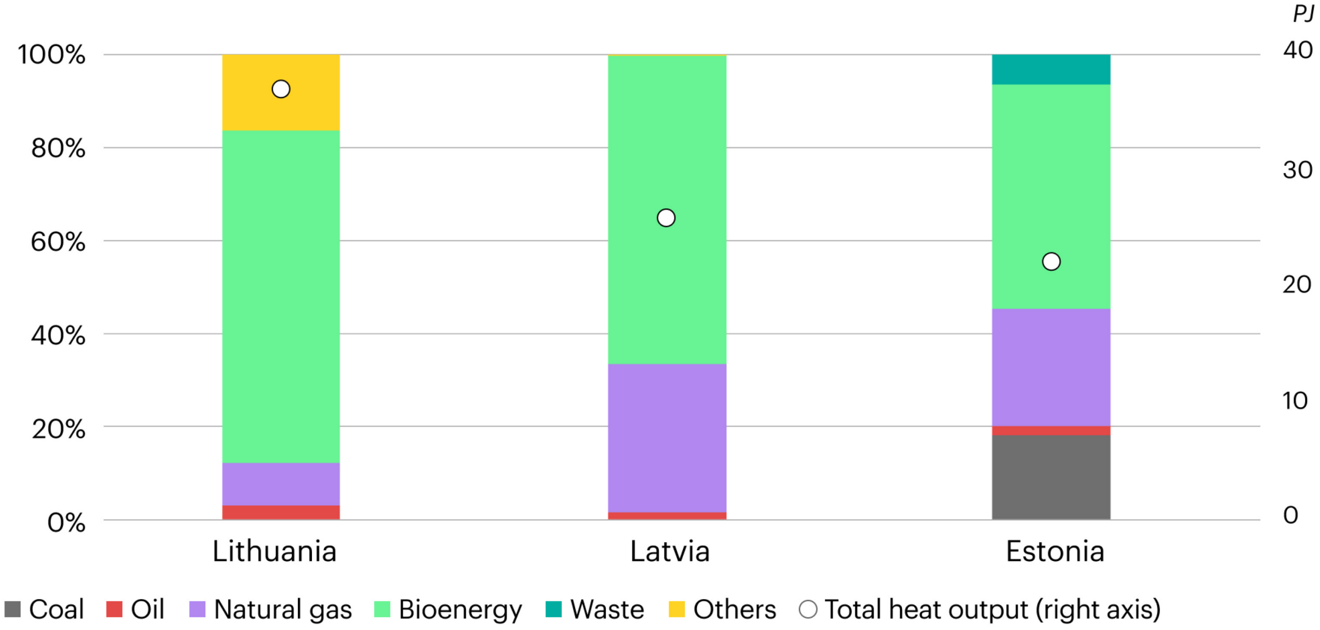
Regional countries utilise strong biomass feedstock supply chains from domestic forest industries, sourcing, for example, wood chips to supply district heating. In Lithuania, solid biofuels make up most renewable energy supply, followed by wind and solar. In Estonia and Latvia, these fuels are the only source of renewable energy, with additional heat supplied primarily by natural gas.

Key drivers and constraints

LARGE, MODERNISED NETWORKS AND ENERGY SECURITY SHAPE REGIONAL NETWORKS

Over the past two decades, the region has updated many systems, supported through EU and national funding, to replace ageing infrastructure and improve energy efficiency. This has included efforts to improve energy security and reduce natural gas imports, previously sourced from Russia, with policies such as carbon taxes, feed-in-tariffs, tax reductions, and national strategies implemented to leverage abundant biomass feedstock supplies. While some gas-fired plants remain – they are important for some systems during peak demand periods – renewable energy in district heating remains a central component of urban heat supply across the Baltics, serving a large share of apartment buildings in major cities.

Energy supplies to district heating networks, 2024



Note: Bioenergy includes solid, liquid, and gaseous bioenergy. Waste includes industrial waste, as well as renewable and non-renewable municipal waste.
Source: IEA (2025), World Energy Balances (database).

ENERGY SECURITY IMPLICATIONS

Baltic countries

SECURITY

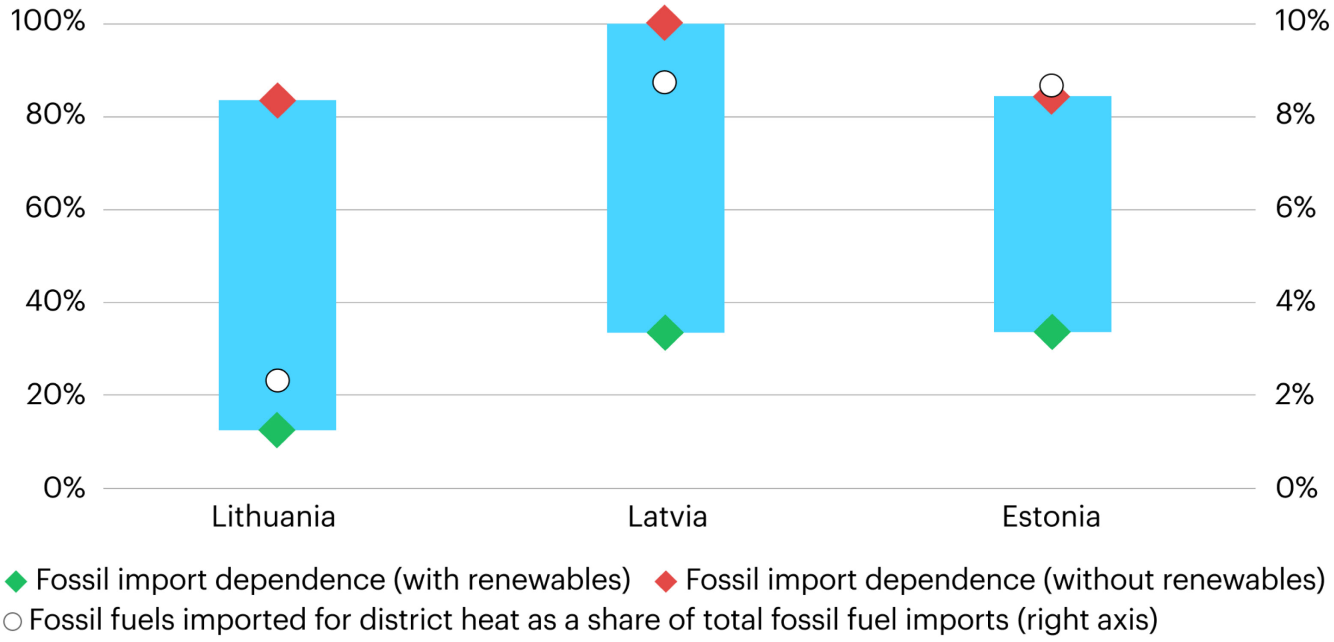
Domestic solid biofuels have reduced reliance on imported natural gas in district heating systems across the Baltic region

Baltic countries are reliant on imports for 78% of fossil fuel supply, however a high share of domestically produced renewable energy in district heat supply has reduced the region's exposure to international price dynamics and geopolitical events. An estimated 25% of district heat supply in the region relies on imported fuels. Solid biofuels and waste account for 66% of energy used in district heating across the region (64% of that is from solid biofuels), of which 100% is sourced domestically. Imported natural gas accounts for an additional 20% of district heat supply. Deployment of renewables in district energy across the region has ultimately reduced overall dependence on imported fossil fuels by 8 percentage points, improving energy security in the region. Replacing the remaining use of natural gas in district heating with renewables could reduce total natural gas imports to the region by 16%.

25%

of district heat supply in the region ultimately relies on imported fuels

Share of imported fossil fuels in energy supplies to district heating networks, and share of total fossil fuel imports in selected countries, 2024



Note: Fossil import dependence in energy supplies to district heating networks is calculated as the average import dependence by product, weighted by share of heat output. Import dependence by product is calculated as net imports of fossil fuel products (natural gas, coal, peat and peat products, oil shale and oil sands, and primary and secondary oil) divided by the total energy supply (excluding bunkers and stock changes). The counterfactual scenario (without renewables) assumes that for net fossil fuel importing countries, all heat output from renewable sources in the given year is directly replaced with imported fossil fuels. In this scenario, renewables include solid, liquid, and gaseous bioenergy, geothermal, solar thermal, and the renewable portion of municipal waste.
Source: IEA (2025), World Energy Balances (database).

Central and Western Europe

Fuel mix

FOSSIL FUELS STILL DOMINATE THE FUEL MIX, BUT SOME DIVERSIFICATION IS EMERGING

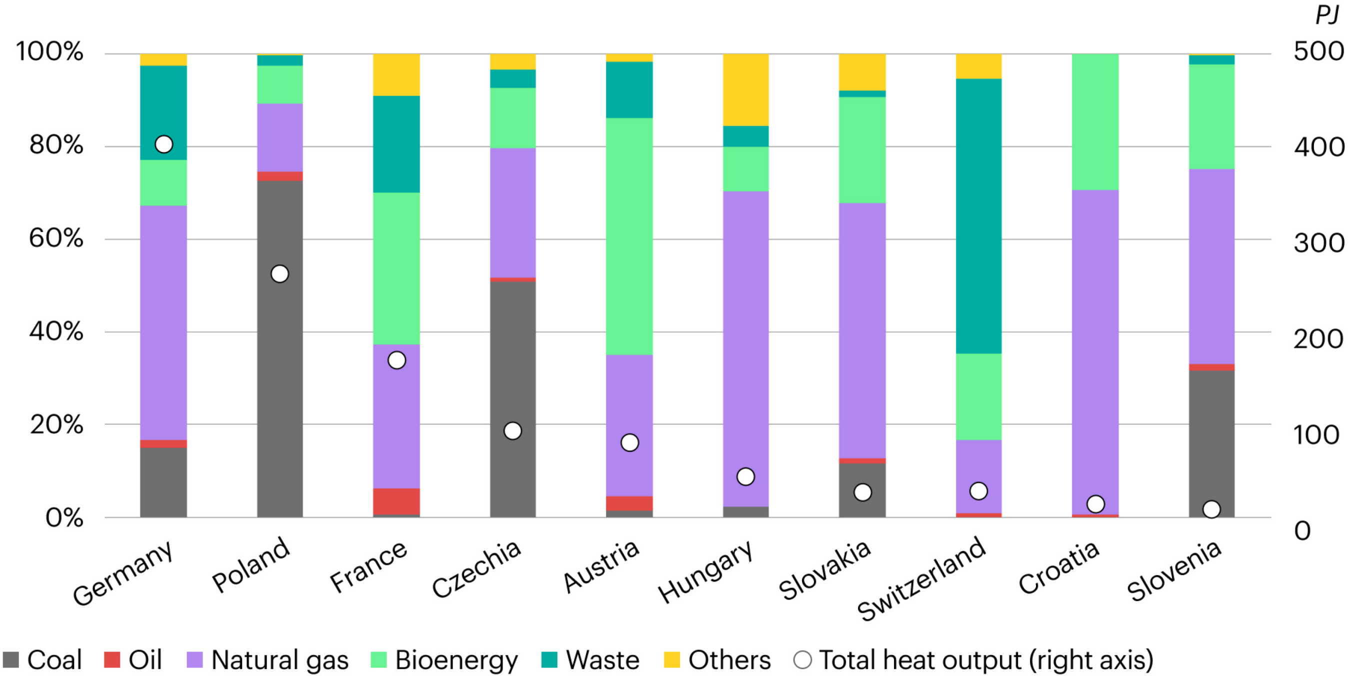
While fossil fuels dominate district heating in the region, fuel mixes vary sharply. Coal remains central in Czechia and Poland, while gas is prominent in Croatia, Germany, Hungary, and Slovakia, exposing those countries to import risks. In contrast, France and Switzerland have demonstrated more rapid diversification, as solid and gaseous biofuel sources have increased, along with waste incineration heat and other recovered sources. Across the region, renewables and waste heat are rising quickly in district heating and cooling, signalling a shift toward cleaner baseload supply and electrification-ready networks.

Key drivers and constraints

REGULATION IS RESHAPING HEAT ACROSS THE REGION, WITH RENEWABLES TARGETS, EFFICIENT DISTRICT HEATING AND COOLING RULES, AND THE ENERGY PERFORMANCE OF BUILDINGS DIRECTIVE (EPBD) DRIVING SYSTEM MODERNISATION

EU policy is increasingly steering district heating toward lower-carbon, lower-temperature systems. The Renewable Energy Directive III strengthens binding renewables growth in heating and cooling, while the revised Energy Efficiency Directive updates the “efficient district heating and cooling” framework to drive integration of renewables and waste heat. The updated EPBD tightens building performance requirements, reinforcing renovation and system-side efficiency (metering, lower losses, and temperature reduction).

Energy supplies to district heating networks, 2024



Note: Bioenergy includes solid, liquid, and gaseous bioenergy. Waste includes industrial waste, as well as renewable and non-renewable municipal waste.
Source: IEA (2025), World Energy Balances (database).

ENERGY SECURITY IMPLICATIONS

Central and Western Europe

SECURITY

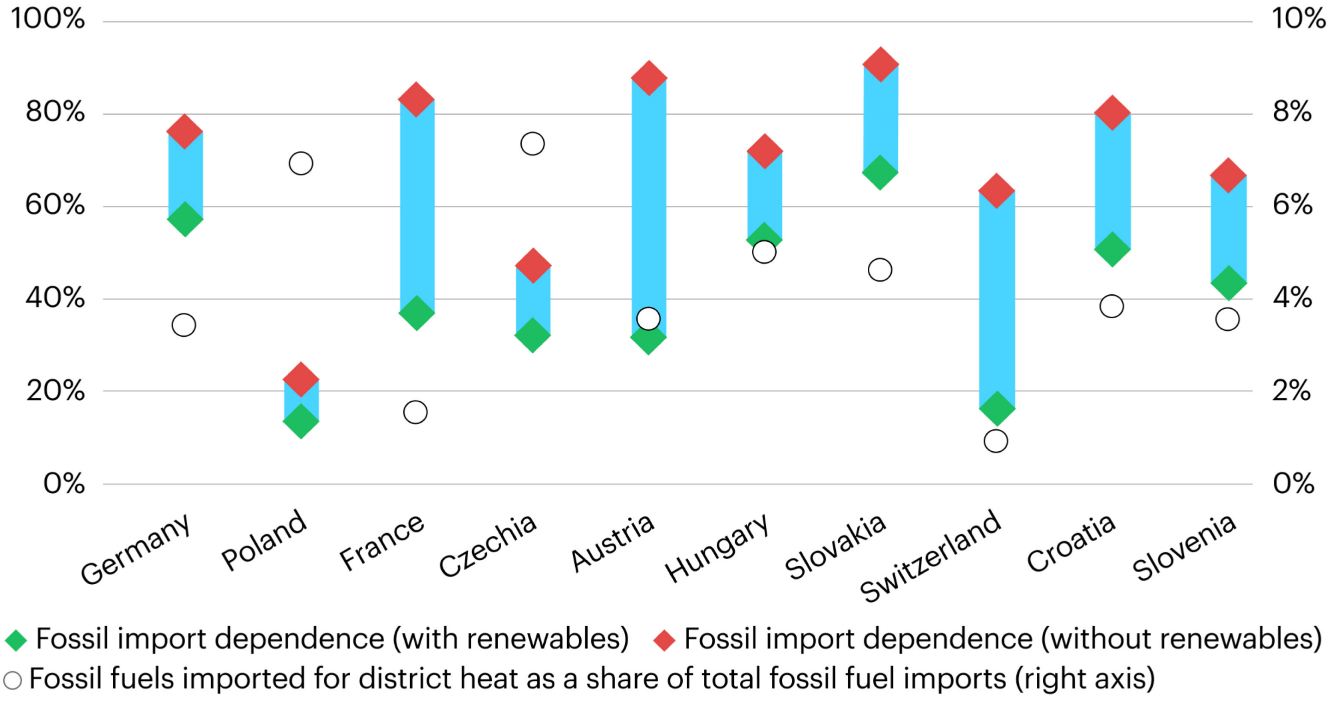
Imported fossil fuels still underpin district heating in much of Central and Western Europe

44%

of district heat supply in the region ultimately relies on imported fuels

District heating networks in Central and Western Europe remain closely linked to global fuel markets because a large share of the energy they use is imported. An estimated 44% of district heat supply in the region ultimately relies on imported fuels, tying heating costs to international price dynamics and geopolitical developments. Natural gas plays a particularly prominent role: Around 93% of the gas used in district heating across the region (accounting for 34% of district heat supply) is imported, exposing networks to supply disruptions and price volatility. Reducing import dependence is therefore becoming a key energy security priority. Expanding domestic renewable and recovered heat can strengthen system resilience while limiting exposure to external shocks.

Share of imported fossil fuels in energy supplies to district heating networks, and share of total fossil fuel imports in selected countries, 2024



Note: Fossil import dependence in energy supplies to district heating networks is calculated as the average import dependence by product, weighted by share of heat output. Import dependence by product is calculated as net imports of fossil fuel products (natural gas, coal, peat and peat products, oil shale and oil sands, and primary and secondary oil) divided by the total energy supply (excluding bunkers and stock changes). The counterfactual scenario (without renewables) assumes that for net fossil fuel importing countries, all heat output from renewable sources in the given year is directly replaced with imported fossil fuels. In this scenario, renewables include solid, liquid, and gaseous bioenergy, geothermal, solar thermal, and the renewable portion of municipal waste.
Source: IEA (2025), World Energy Balances (database).

China

Fuel mix

CHINA IS HOME TO THE WORLD'S LARGEST DISTRICT HEATING SYSTEM, WHICH IS PREDOMINANTLY COAL BASED

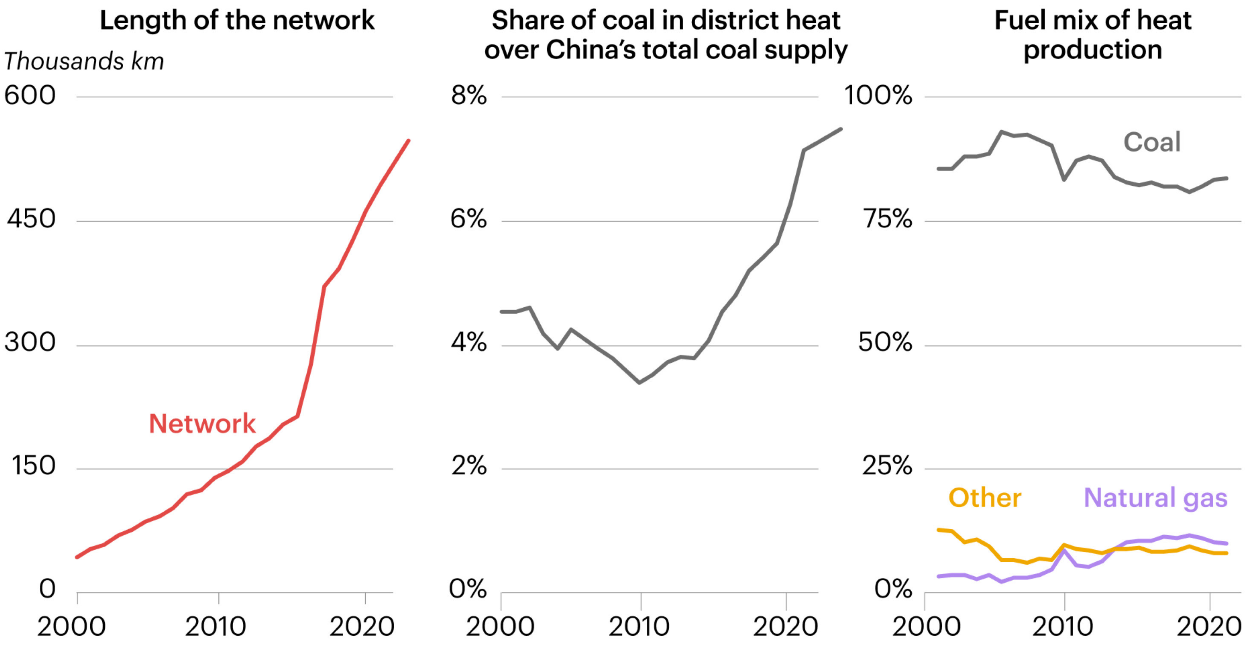
China's district heating network is concentrated in northern cities where heating seasons can last up to six months. China's district heating system already covers around 500 000 kilometres of networks, with coal supplying more than 80% of district heat energy. This scale makes district heating a major contributor to local air pollution and CO2 emissions. Over the past decade, policies aimed at reducing particulate pollution have supported a shift away from small, inefficient coal boilers toward larger, better-controlled plants and increased cogeneration.

Key drivers and constraints

A NORTHERN, STATE-REGULATED SYSTEM THAT PRIORITISES AFFORDABILITY AND COVERAGE

China's district heating network is concentrated in cold and severely cold regions in line with the country's historical heating divide. This reflects the legacy of China's so-called heating line, under which state-supported central heating was historically provided mainly north of the Qinling-Huai River line, while southern regions were generally not covered. Heat is widely treated as a public service, meaning the government is closely involved in planning and investment and regulates tariffs and pricing, which prioritises affordability and universal provision over cost-reflective signals. This model enables rapid expansion when mandated, but the absence of pricing and regulatory reforms weakens incentives for efficiency, metering, loss reduction, and low-carbon diversification.

District heating network length, fuel mix, and coal use as a share of China's primary coal supply, 2000-2024



Source: IEA (2025), World Energy Balances (database).

THE STATE OF DISTRICT HEATING TODAY

Eastern Europe

Fuel mix

NATURAL GAS DOMINATES DISTRICT HEATING, WITH OTHER FUELS VARYING BY COUNTRY

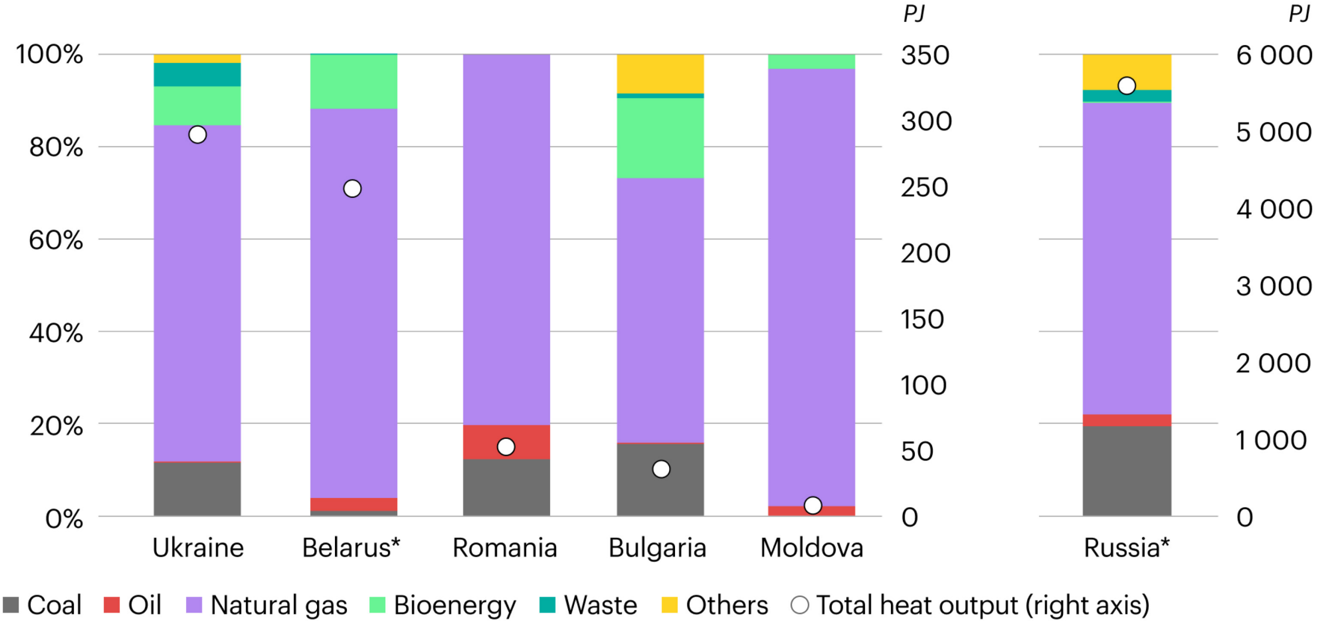
District heating systems across Eastern Europe reflect Soviet-era infrastructure, concentrated in urban areas and characterised by CHP-based heat production and strong public sector regulation. Apart from Russia, district heating energy consumption has declined in regional countries over the past decade due to network losses – which have amounted to up to 30% percent in some areas – low efficiency, ageing infrastructure, rising operating costs, and consumer disconnections. Natural gas dominates the fuel mix, supplying 60-90% of heat. Most countries excluding Russia rely on imports, exposing systems to price volatility and prompting a growing interest in diversification toward solid and gaseous biofuels, waste heat, and electrification.

Key drivers and constraints

STRUCTURAL BARRIERS PERSIST IN THE REGION, NAMELY DUE TO LEGACY INFRASTRUCTURE, HIGH LOSSES, LOW TARIFFS, AND UNEVEN, FUNDING-DEPENDENT MODERNISATION

District heating utilities operate as regulated local monopolies, with tariffs often set below full cost recovery to protect households, creating persistent financial pressure and limiting investment capacity. Modernisation has therefore progressed unevenly and remains heavily dependent on external financing, including the EU Cohesion and Modernisation funds and support from the EBRD, the European Investment Bank, the United Nations Development Programme, and the World Bank. Policy priorities focus on improving efficiency, reducing gas dependence, enhancing system resilience, and gradually integrating renewables and low-carbon heat, particularly solid biofuels, rather than large-scale expansion.

Energy supplies to district heating networks, 2024



* For Belarus and Russia, where 2024 data were unavailable, the most recent available data (2023) were used.
Note: Bioenergy includes solid, liquid, and gaseous bioenergy. Waste includes industrial waste, as well as renewable and non-renewable municipal waste.
Source: IEA (2025), World Energy Balances (database).

ENERGY SECURITY IMPLICATIONS

Eastern Europe

SECURITY

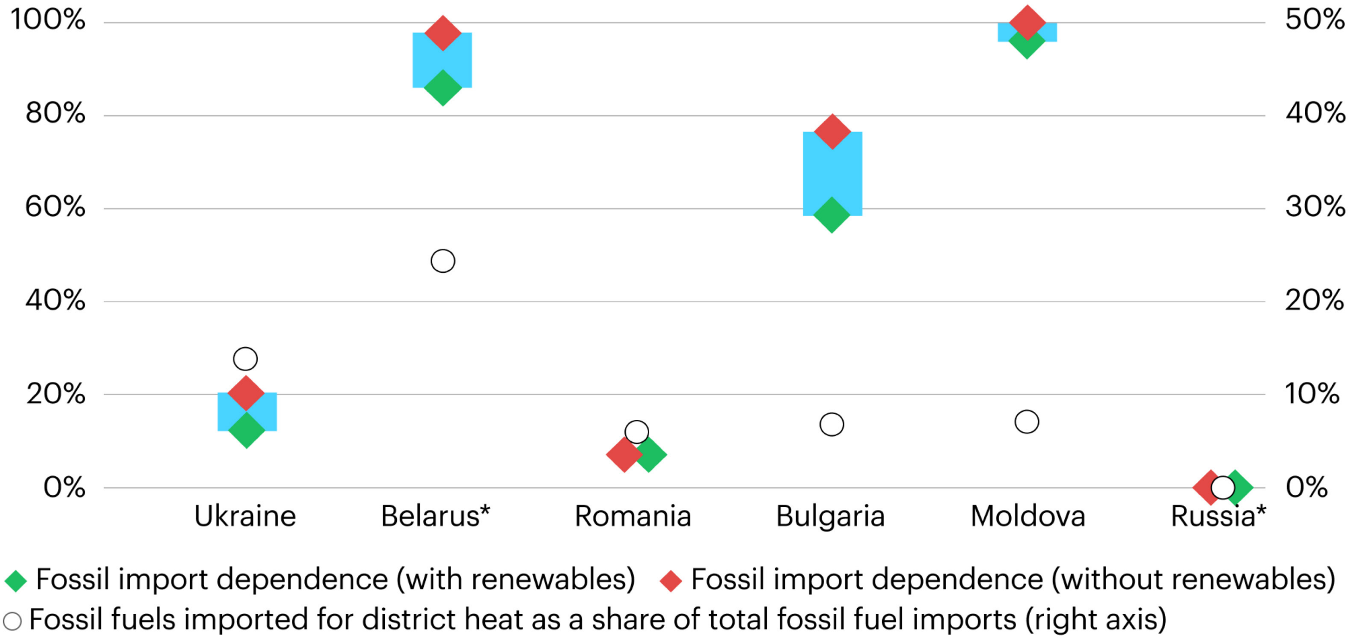
Diversification is very low in the region and imported natural gas accounts for 36% of district heating supplies

38%

of district heat supply in the region ultimately relies on imported fuels

Fossil fuels remain dominant in district heating networks across Eastern Europe. Excluding Russia, fossil fuels account for 86% of heat supply, with 38% of heat supply coming from imported fuels. Despite some deployment of renewables in district heat networks, almost exclusively from solid biofuels, diversification remains low across the region. Natural gas dominates, supplying 76% of the regions heat, nearly half of which is imported, while solid biofuels accounts for an additional 10% of regional heat supply. Deployment of renewables in district energy across the region has ultimately reduced overall dependence on imported fossil fuels by 1 percentage point. Replacing the current use of natural gas in district heating with renewables has the potential to further reduce total natural gas imports to the region by 25%.

Share of imported fossil fuels in energy supplies to district heating networks, and share of total fossil fuel imports in selected countries, 2024



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Source: IEA (2025), World Energy Balances (database).

THE STATE OF DISTRICT HEATING TODAY

Central Asia and Caucasus region

Fuel mix

FOSSIL FUELS DOMINATE DISTRICT HEATING, WITH COAL AND GAS SPLIT ACROSS COUNTRIES

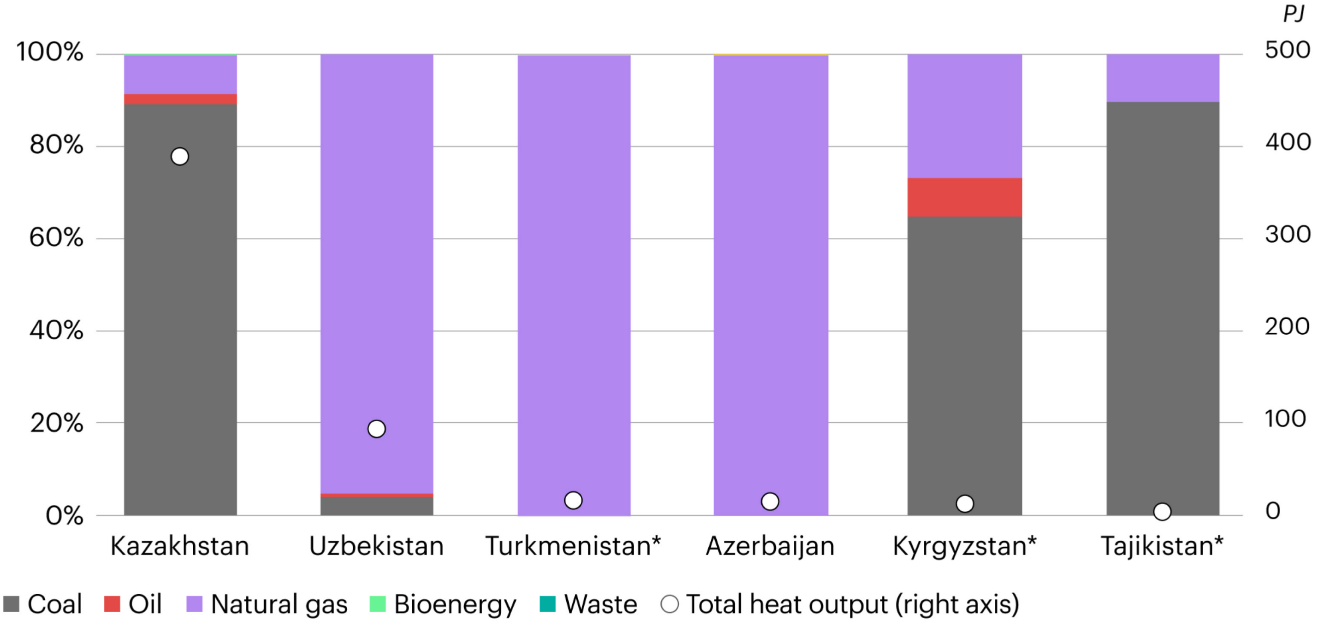
Coal dominates heat production in Kazakhstan, Kyrgyzstan, and Tajikistan, owing to legacy coal-fired CHPs fleets and domestic coal availability. In contrast, natural gas provides nearly all district heat in Azerbaijan, Turkmenistan, and Uzbekistan. Coverage is uneven: Systems are most developed in Kazakhstan, but in most countries, district heating is largely confined to selected urban centres, coexisting with widespread individual heating elsewhere.

Key drivers and constraints

LEGACY INFRASTRUCTURE, HIGH LOSSES, AND LOW TARIFFS HINDER SYSTEM EFFICIENCY

Most district heating networks in the region were built during the Soviet period. A significant number of pipelines have exceeded their design lifetime and suffer from insulation degradation, corrosion, and leakages. Technical losses in transmission and distribution often exceed 30%, substantially above levels observed in modernised European systems. Underinvestment in maintenance, low cost-recovery tariffs in some countries, and limited metering have contributed to persistent inefficiencies.

Energy supplies to district heating networks, 2024



* For Kyrgyzstan, Tajikistan, and Turkmenistan, where 2024 data were unavailable, the most recent available data (2023) were used.
Note: Bioenergy includes solid, liquid, and gaseous bioenergy. Waste includes industrial waste, as well as renewable and non-renewable municipal waste.
Source: IEA (2025), World Energy Balances (database).

ENERGY SECURITY IMPLICATIONS

Central Asia and Caucasus region

SECURITY

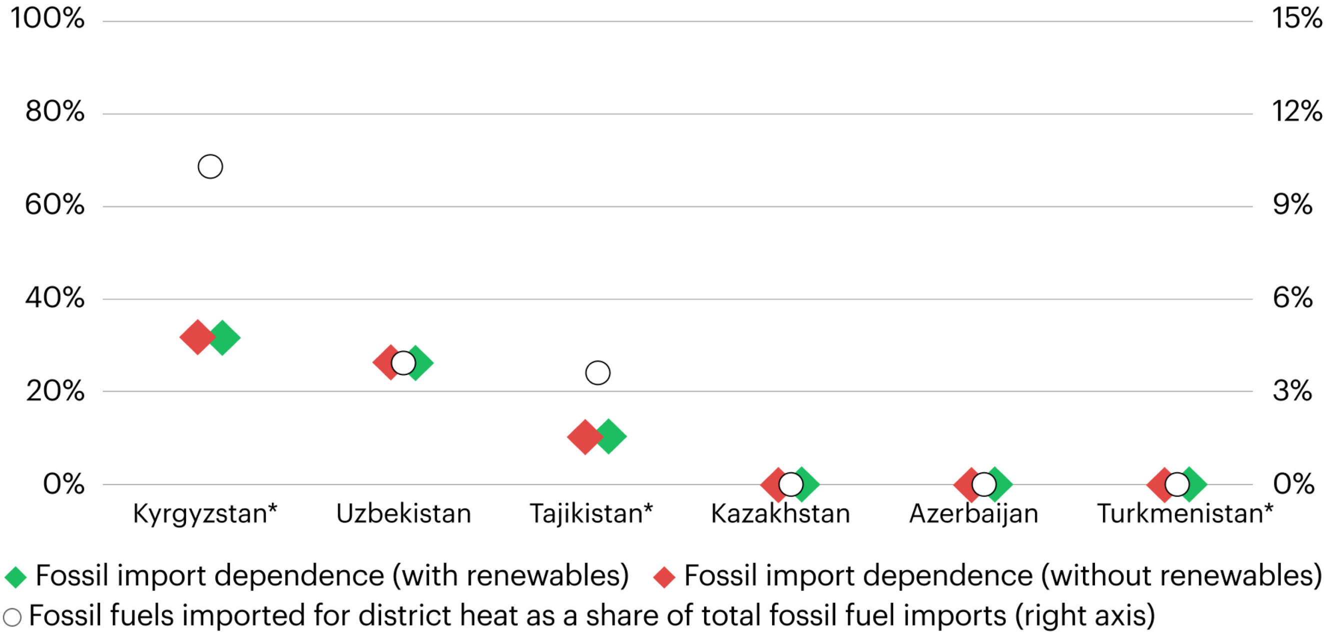
Energy security considerations differ, as the region is split between net fuel exporters and importers

Domestic supplies are more than sufficient to meet energy needs in Azerbaijan, Kazakhstan, and Turkmenistan, which collectively account for 78% of the region's district heat networks on an energy basis. Whereas Kyrgyzstan, Tajikistan, and Uzbekistan rely on imports for 10-30% of district heat output. Overall, less than 1% of district heat supply in the region relies on imported fuels. While current district heat supply is almost entirely fossil fuel-based, for net importers, replacing fossil fuels in district heat networks with renewables has the potential to reduce national fossil fuel imports by between 4% and 10%.

<1%

of district heat supply in the region ultimately relies on imported fuels

Share of imported fossil fuels in energy supplies to district heating networks, and share of total fossil fuel imports in selected countries, 2024



* For Kyrgyzstan, Tajikistan, and Turkmenistan, where 2024 data were unavailable, the most recent available data (2023) were used.
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Source: IEA (2025), World Energy Balances (database).

Chapter 2. Market conditions and enabling factors for district energy

Competitiveness of renewables in district heating

The cost-competitiveness of renewable district heating is shaped by local conditions

District heating tariffs vary widely across countries, reflecting differences in fuel prices, market design, regulation, and subsidy regimes. However, large price differences also exist within countries, even where systems operate under similar regulatory and market frameworks. This highlights that the cost-competitiveness of district heating, including renewable and low-carbon systems, is shaped not only by fuel choice, but also by a broad set of local conditions.

District heating is a capital-intensive infrastructure service. Tariffs reflect a combination of factors, for example network size and heat density, infrastructure design, age, amortisation of assets, financing structures, and the availability of local energy resources. Demand-side characteristics, such as building energy performance, customer density, and load profiles, also play a critical role in shaping system costs. In addition, cost-competitiveness depends not only on current input prices, but also on their predictability over time. This can be particularly relevant for long-term investment decisions, as systems that rely heavily on fuel purchases may be more exposed to input price volatility than systems based on stable, local renewable resources. In ageing networks, maintenance, refurbishment, and reinvestment needs can also become a significant cost burden, particularly where legacy assets require replacement or upgrading. These costs may be more difficult to recover where heat demand growth is weak, or where efficiency improvements reduce delivered heat volumes over time. As a result, systems using similar fuels can exhibit very different cost structures, while networks with very different fuel mixes can deliver heat at comparable prices.

These dynamics are particularly visible in countries where district heating tariffs are broadly cost reflective rather than centrally capped. For instance, in Germany, district heating prices are largely determined by cost-based tariff formulas that allow for the pass-through of fuel costs and infrastructure investments. Within this framework, multi-family residential district heating prices vary widely across individual heat networks. In German sub-networks, shares of renewables and waste heat range from low to high levels of integration. Yet there is no systematic relationship between renewable shares and final consumer prices. Networks with high renewable shares are observed across the full price spectrum, as are fossil-dominated systems. The wide dispersion in prices likely reflects differences in network age and refurbishment needs, heat density, customer mix and load profiles, financing conditions, and the scale and timing of infrastructure investments across individual systems. This dispersion reflects the structural characteristics of district heating systems rather than fuel mix alone.

The German case illustrates that the economics of renewable district heating cannot be generalised based solely on energy sources. Cost-competitiveness emerges from the interaction between local infrastructure, demand patterns, asset configurations, resource endowments, the stability of input costs over time, and the maintenance and reinvestment needs of existing networks. Fuel mix is one component of system economics, but it does not on its own determine tariffs.

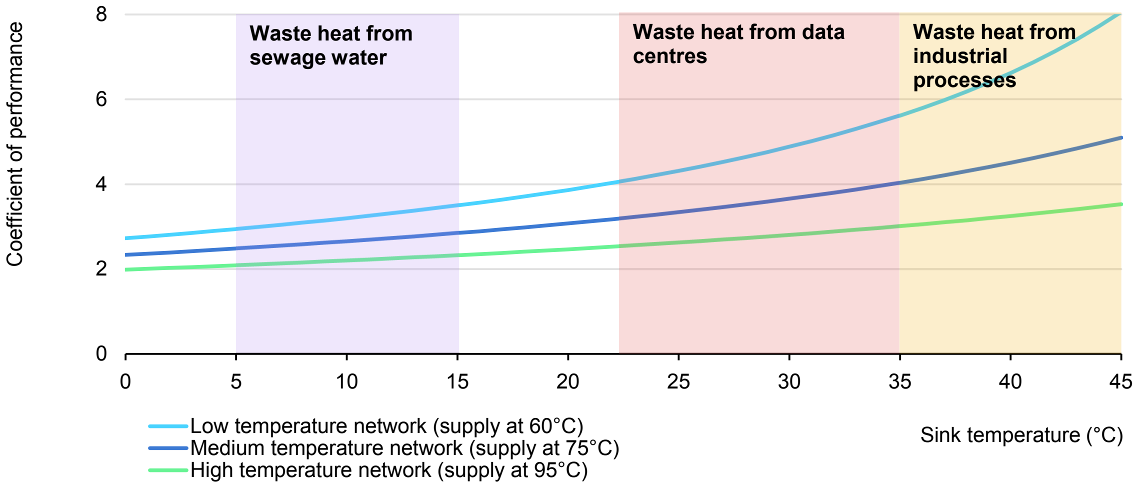
Price signals, waste-heat availability, and network temperatures define heat pump competitiveness

The performance and competitiveness of heat pumps in district heating systems depend strongly on the temperature lift between the heat source and the heat delivered to the network. Two factors are therefore particularly important, the temperature and availability of heat sources, including waste heat, and the temperature levels required in district heating networks. Higher source temperatures and lower network supply temperatures reduce the temperature lift required from the heat pump and can substantially increase efficiency.

Waste heat from industrial processes, data centres, wastewater treatment plants, or commercial refrigeration systems can provide relatively warm heat sources compared with ambient air, ground or surface water. When such heat can be captured and upgraded through heat pumps, the required temperature lift is significantly reduced, improving the coefficient of performance and lowering electricity consumption per unit of heat delivered. However, the cost-competitiveness of waste heat also depends on its proximity to existing or planned district heating networks, as longer connection distances can raise infrastructure costs and reduce economic viability. This makes early planning, appropriate permitting, and the co-ordination of network and industrial development important for the effective use of waste-heat resources.

District heating temperature levels also play a key role. Lower supply temperatures reduce the temperature lift required from the heat pump, increasing efficiency and reducing operating costs. Achieving lower temperature networks often requires improvements in building envelopes, more efficient heat emitters and substations, and reductions in distribution losses within the network. In addition to improving the efficiency of heat pumps, these measures also reduce overall heat demand and improve system flexibility.

Coefficient of performance of district heating heat pumps under different source and supply temperature conditions



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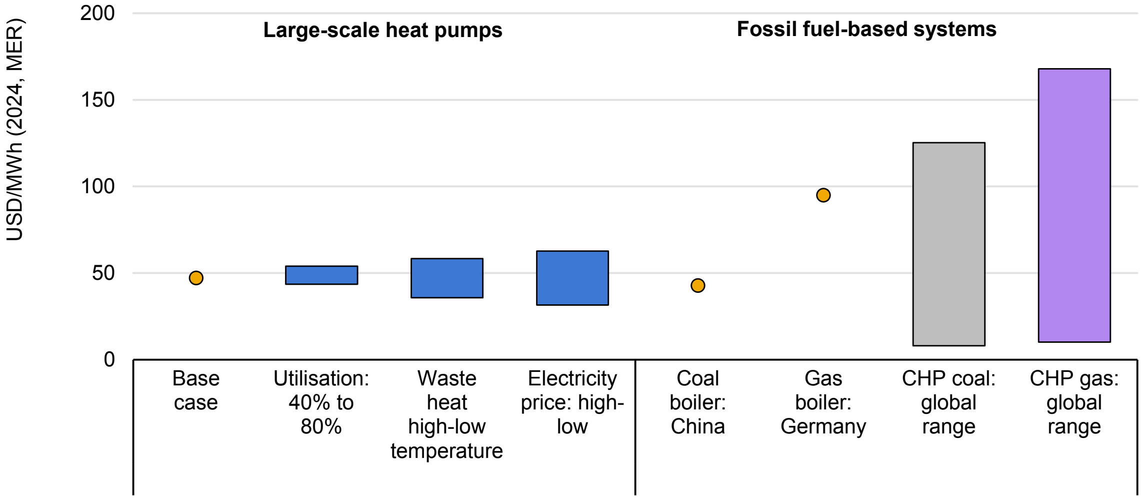
Notes: Coefficient of performance (COP) values are illustrative and represent instantaneous performance under nominal conditions. COP is estimated as 55% of the theoretical Carnot performance, based on the temperature difference between the heat source and the district heating supply. Approach temperature losses of 4 Kelvin are assumed on both the source and sink sides to represent heat exchanger pinch temperatures. Temperatures shown for selected waste heat streams are indicative; the temperature available to the heat pump is typically lower due to heat exchanger and system losses. Actual performance depends on system design, operating conditions, and auxiliary energy consumption.

The combined effect of higher-temperature waste-heat sources and lower district heating supply temperatures can be substantial. For example, a heat pump upgrading industrial waste heat at around 40°C to supply a low-temperature district heating network (e.g. 55°C) may achieve a performance several times higher than a heat pump extracting heat from ambient sources (e.g. 10°C) and supplying a high-temperature network (e.g. 85°C). Under such conditions, the same heat pump installation could require three times less electricity per unit of heat delivered, significantly improving operating costs and reducing pressure on electricity systems. In practice, however, realised performance will also depend on how well the heat pump is designed and optimised for the expected operating conditions, including the required temperature lift. Heat pumps designed for higher-temperature applications may not achieve the same efficiency when operating under lower-temperature conditions as systems specifically configured for those conditions. In addition, where waste heat is sourced from industrial facilities, the economic case depends not only on temperature levels but also on the expected availability and duration of the heat source over time, as uncertainty can affect asset utilisation and investment payback periods.

Indicative levelised cost of heat (LCOH) supplied to district heating networks for heat pumps versus natural gas and coal systems, 2024



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Notes: LCOH estimates are shown for heat pumps, coal boilers, gas boilers, and combined heat and power (CHP) plants. The reference case for heat pumps assumes a 60% annual utilisation rate, a coefficient of performance (COP) of 3.2 and an electricity price of USD 100/MWh. Sensitivity ranges cover utilisation rates of 40-80%, COP values of 2.4-5.0, representing lower-temperature sources, such as sewage water through to higher-performance industrial waste heat applications, and electricity prices of USD 50-150/MWh. Coal boiler efficiency is assumed at 75% and gas boiler efficiency at 85%. CHP plants are assumed to produce 70% heat and 30% electricity, with sensitivity ranges based on coal prices of USD 25-125/tonne, gas prices of USD 2-20/MBtu, and CO_2 prices of USD 0-100/tonne. For country comparisons, CO_2 prices of USD 100/tonne for Germany and USD 13/tonne for China are applied. Across all technologies, a 7% discount rate and a 25-year lifetime are assumed.

Source: Capex and performance assumptions are based on IEA analysis and the Danish Energy Agency technology catalogue for electricity and district heating.

Electricity-to-fossil-fuel price ratios also play a decisive role in determining whether large-scale heat pumps can compete with gas- and coal-based heat supply in district heating networks. Even where heat pump technologies are mature and suitable and low-temperature heat sources are available, unfavourable electricity-to-gas price ratios can prevent electrification from progressing beyond pilot scale. In markets where electricity prices remain two to four times higher per unit of useful heat than natural gas, heat pumps struggle to compete with existing boilers or CHP units, especially in high-temperature networks with limited flexibility. By contrast, when price ratios narrow, either through lower electricity levies, reduced grid fees for flexible loads, structurally low-cost electricity supply (e.g. in systems with abundant hydropower or favourable wind and solar resources), or rising fossil fuel prices, heat pumps rapidly become cost-competitive. This is particularly true when they can operate at high seasonal performance by tapping into wastewater, industrial waste heat, or ambient sources.

Well-designed electricity price structures are therefore a central enabler of renewable district heating, particularly in regions aiming to diversify away from fossil fuels. Time-of-use tariffs, wholesale-linked pricing, access to spot market power pricing, especially when combined with thermal storage, and dedicated network charges for flexible electrification can significantly improve the business case for heat pumps by aligning operation with periods of low-cost, low-carbon electricity.

Heat pumps, solar thermal, and seasonal storage in Serbia's district heating network

The district heating system in the Serbian city of Novi Sad has a significant reliance on imported natural gas to supply heat to their 300 000 consumers. To reduce this dependency, the European Bank for Reconstruction and Development (EBRD) has agreed to finance a project with city authorities to introduce a combination of seasonal pit thermal energy storage (roughly 870 000 m^3), a 17 MW large heat pump, 60 MW of power-to-heat electric boilers, and a 38 623 m^2 solar-thermal field.

The configuration is designed for reliable, year-round operation while strengthening sector coupling between the heat and power systems. One specific benefit of this project is the contribution to power system balancing. Today, automatic frequency restoration reserve in Serbia is largely covered by hydropower, causing suboptimal operation of hydro plants. Once the Novi Sad system is deployed, the power-to-heat units and seasonal storage would participate in grid balancing. This would bring expected annual benefits of around EUR 8 million just from the optimised hydro dispatch that the system would enable.

The total investment will be about EUR 108 million, and the system is expected to deliver up to 120 GWh of clean heat annually, cutting CO_2 emissions by 17 000 tonnes per year, lowering imported natural gas within the system by about 20%.

An increasing number of cities are exploring combinations of renewable technologies such as heat pumps, solar thermal, geothermal, bioenergy, and thermal energy storage to displace fossil fuels. The International Energy Agency's Coordination Group on Thermal Networks, under the lead of the District Heating and Cooling Technology Collaboration Programme, has compiled a set of case studies on thermal networks, highlighting successful examples of renewable integration in district energy.

Solar thermal can provide low-cost complementary district heat

Experience in Denmark, Germany, and the Netherlands demonstrates what is achievable when conditions are favourable. Danish utilities have installed some of the world's largest collector fields, typically integrated with seasonal pit thermal energy storage that shifts excess summer heat into winter demand. In these systems, solar thermal can effectively cover summer baseload as well as some of the demand during shoulder seasons.

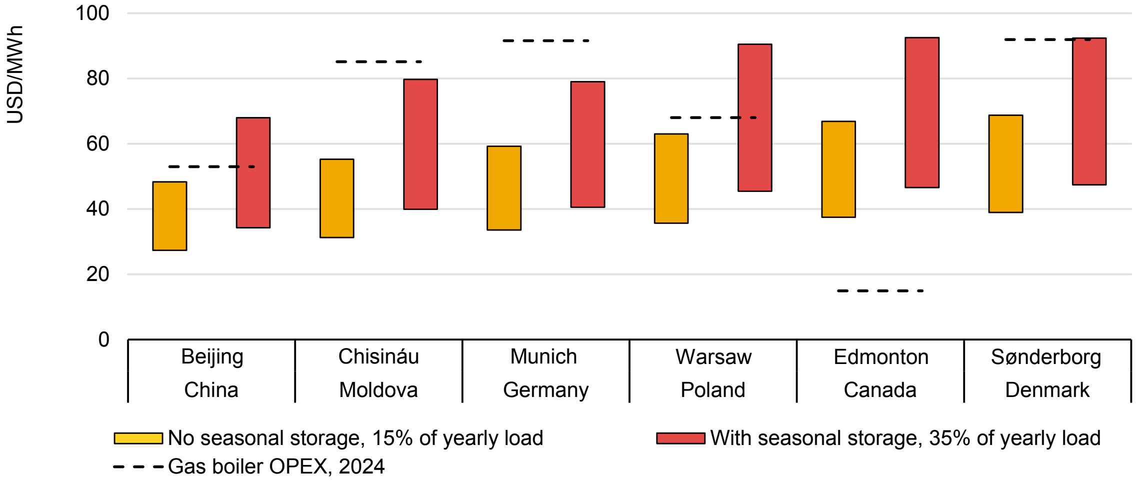
The economics of solar district heating are governed by a small number of structural variables. Land availability and cost are decisive. For example, the world's largest solar district heating system, located in the Danish town of Silkeborg, requires approximately 2 m^2 of collector area per annual MWh of heat delivered, which would amount to several hectares of land even for a medium-size town. In systems without seasonal thermal storage, this ratio can be significantly higher. Thus, in many dense European and Asian cities, the opportunity-cost of land renders large-scale solar thermal uneconomical. Conversely, in sub-urban areas or small municipalities where land is inexpensive or municipally owned, solar thermal is one of the most cost-effective renewable heat sources.

Network operating temperatures are also important for deploying solar thermal. Most flat-plate or evacuated-tube collector fields operate optimally when district heating supply temperatures are low. High-temperature networks limit performance and increase the levelised cost of heat (LCOH).

Finally, solar thermal is highly capital-intensive with extremely low operating costs. As a result, its competitiveness is sensitive to financing conditions. Low-cost municipal or green financing can substantially improve its LCOH, whereas high discount rates, typical in emerging markets, can push costs above competing technologies. This contrasts with heat pumps or bioenergy whose operational costs make up a larger share of lifetime costs.

Without seasonal storage, solar thermal penetration typically saturates at 10-20% of annual demand, which generally covers the summer baseload (mainly for domestic hot water and residual space heating), as well as smaller shares of heat demand during the shoulder seasons and winter. In these cases, solar thermal systems are highly competitive – the LCOH is typically lower than the operating cost of gas-based heat supply. This is particularly true in regions where gas prices are not very low, such as parts of China, Denmark, Germany, and Moldova. In such contexts, solar thermal can economically displace a portion of gas demand, with LCOH ranging between USD 30-70 per MWh.

LCOH from solar thermal district heating systems compared with large-scale gas boilers across selected regions, 2024



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Notes: LCOH for solar thermal district heating is presented as ranges reflecting different cost and performance assumptions. The estimates assume a capex of USD 350-500/kW, a 25-year lifetime, and a 5-7% discount rate, with operations and maintenance costs of 1.5% of capex per year. Two configurations are considered: (i) systems without seasonal storage, where solar collectors operate with diurnal thermal storage to balance daily supply and demand; and (ii) systems with seasonal storage, where a pit thermal energy storage (PTES) allows surplus summer heat to be shifted to winter. The analysis assumes a typical district heating demand profile, with space heating demand peaking in winter and domestic hot water plus residual space heating demand in summer. Solar yields vary by country to reflect differences in solar resources.

Source: IEA analysis based on solar radiation profiles extracted from Renewables ninja, and techno-economic data for solar thermal installations extracted from the Danish Energy Agency technology catalogue.

Pit thermal energy storage (PTES) systems – large, insulated earth basins used for seasonal heat storage – are currently the most cost-effective long-duration storage option for district heating (thermal energy storage section follows). When combined with PTES, large solar collector fields can economically deliver larger shares of annual district heat supply. However, the addition of seasonal storage further increases both the land requirements and the upfront capital costs of these systems, making access to suitable land and low-cost financing important enabling conditions for deployment. Under favourable conditions, such systems can deliver 40-50% of yearly heating load at levelised costs of USD 35-90 per MWh. At the same time, by displacing a large share of fossil fuel consumption, solar thermal systems, coupled with seasonal storage, can enhance the resilience of district heating systems by reducing their exposure to volatile fossil fuel prices.

Geological technical potential and derisking policies unlock geothermal opportunities

Geothermal district heating is becoming increasingly competitive as technology progresses and policies are developed to reduce project development and investment risks. Heat production costs typically range from USD 20-110 per MWh, depending on geological conditions, drilling depth, and regulatory frameworks.

The technical potential for expansion is significant. Globally, hot sedimentary aquifers exceeding 90°C and extending to depths of up to 5 kilometres could provide more than 250 000 EJ of heat at costs below USD 50/MWh, sufficient to sustain an average heat output of roughly 320 TW for 25 years. Real-world projects are already approaching this range, with heat prices of USD 55-60/MWh reported in Denmark, without subsidies. At lower temperatures (around 60°C), the technical resource potential rises to nearly 1 million EJ, with almost 90% of district heating potential located at depths shallower than 3 kilometres. Emerging technologies, particularly closed-loop designs, and integration with heat pumps or CHPs, could further expand accessible resources, although higher costs at greater depths currently favour hybrid heat and power applications.

Further bioenergy deployment will continue to require sustainable, integrated, and cost-competitive supply

Bioenergy remains a reliable solution for transitioning away from fossil fuels as a drop-in ready solution, as it can leverage existing infrastructure, reduce the need for expensive retrofits, and act as a source of dispatchable low-carbon high temperature heat, especially during periods of peak demand.

However, the availability of sustainable and cost-competitive bioenergy can vary significantly between, and within, countries. The sustainability of bioenergy remains the most important requirement for continued deployment, but also the most complex, as it is often context specific, relying on factors such as local land management practices, biodiversity, climate change adaptation and mitigation considerations, and supply chain characteristics. Continued development of consistent, transparent, and interoperable sustainability criteria will remain important.

Transportation and distribution of biomass can influence solid and gaseous biofuel prices. Seasonal fluctuations and market changes in the primary sectors (e.g. agriculture and forestry) where biomass is typically sourced to produce solid and gaseous biofuels can impact prices as well. Design of supply chains, specifically when integrated as part of other sectoral value chains and feedstock aggregation models (e.g. biohubs) can help to mitigate price fluctuations from transportation and seasonal variation and improve access to biomass feedstocks by ensuring consistent and reliable supplies. In addition, like any commodity, competing demand for biomass in the growing bioeconomy (e.g. bioenergy, biochemicals, and biomaterials in transport, buildings, and industry) can also impact availability and prices.

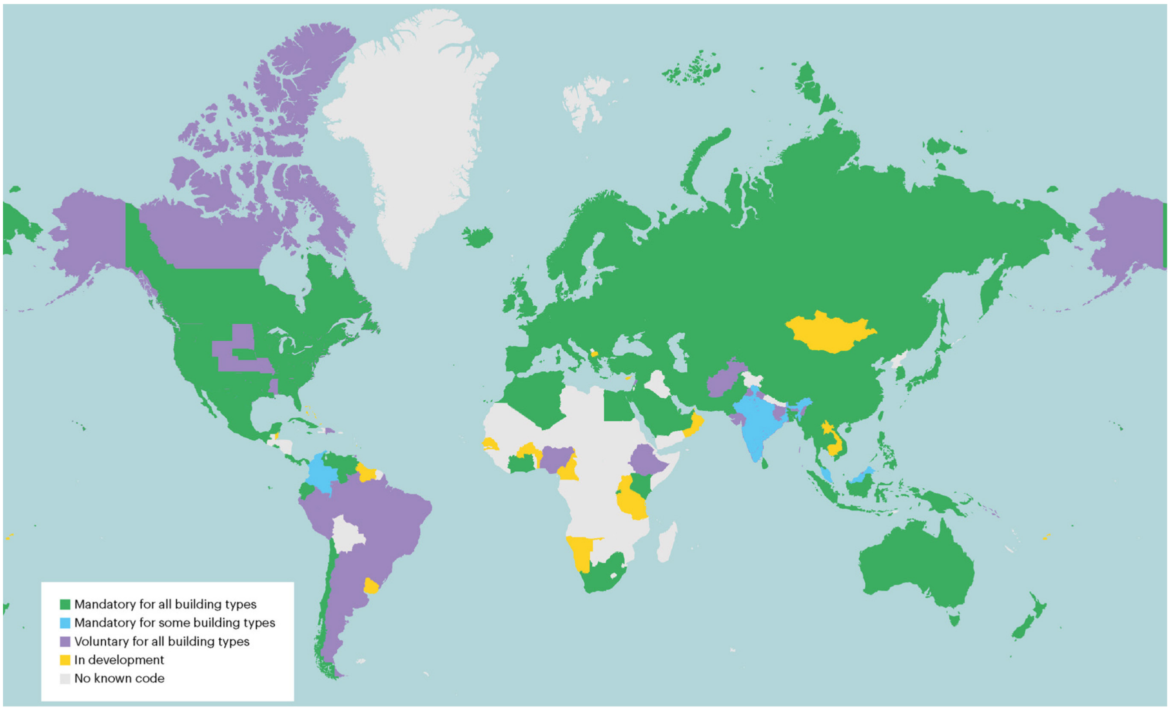
Further deployment of bioenergy will also be influenced by the development of hybrid systems, the LCOH provided from other variable renewable energy technologies (paired with energy storage solutions), and will remain context specific. In addition, the growing interest in sector coupling and availability of high-volume and low-value heat (e.g. waste heat), along with the emergence of Bioenergy Carbon Capture and Utilisation (BECCUS) technology may also impact the cost-competitiveness and deployment of bioenergy. Further deployment of bioenergy is likely to remain context specific and will require assessment of deployment opportunities, infrastructure, and technology and market maturity.

The efficiency of buildings determines how far renewables can scale in district heating

The efficiency of the building stock is an important factor for scaling renewable heat in district energy networks. Well insulated buildings require lower heating loads and can operate efficiently at reduced supply and return temperatures, conditions that dramatically improve the performance of large-scale heat pumps, geothermal systems, solar thermal, and recovery of low-temperature waste heat. Today, nearly all global district heat supply is in countries that already have mandatory or voluntary building energy codes in place, creating a structural opportunity to accelerate the shift toward lower-temperature networks. As these codes tighten and renovations progress, a growing share of buildings becomes “renewable-ready”, enabling utilities to progressively scale down operating temperatures, cut losses, and widen the range of viable renewable heat sources.

Strengthening and expanding building energy codes, paired with targeted renovation programmes, is therefore essential to unlock high renewable shares in district heating. Even where networks are modernised, inefficient buildings can force operators to maintain high temperature levels, constraining the integration of heat pumps and waste heat and limiting the feasibility of solar thermal and geothermal supply. Some municipalities have addressed this by introducing separate low-temperature zones in new developments and renovated districts, while working closely with building owners in existing areas to expand these zones over time and prepare for a broader transition of the network to lower-temperature operation. Where building codes are stringent and renovation efforts are sustained, this kind of phased transition becomes easier to implement, giving utilities greater flexibility to electrify heat cost-effectively, integrate diverse renewable sources, and reduce fossil reliance without raising consumer tariffs.

Mandatory and voluntary building energy codes, 2025



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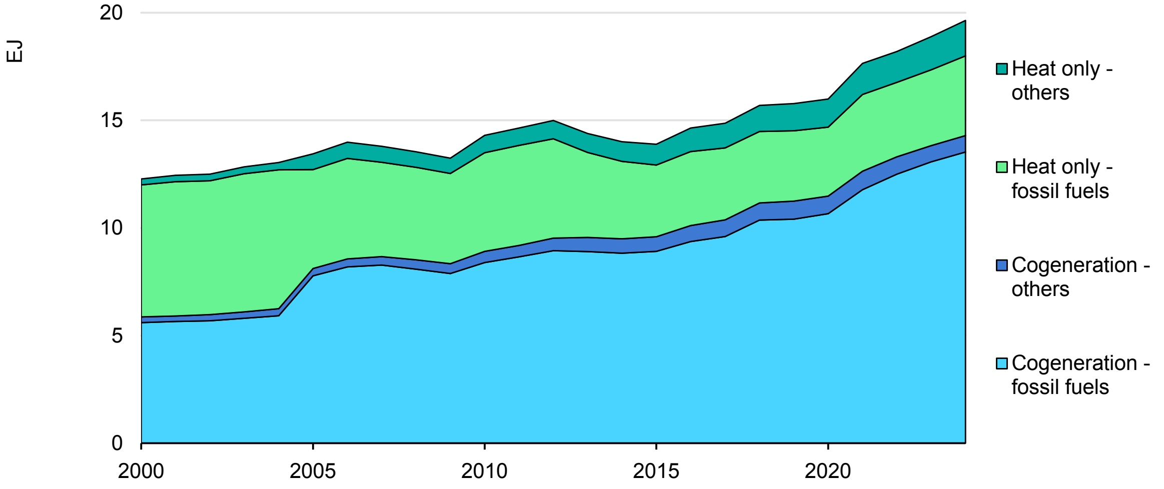
Notes: The map tracks known national building energy codes and those where a national mandate for adoption exists. In cases where the national mandate exists, the map shows its status and not its adoptions at the sub-national level (e.g. Brazil, India, Mexico). In cases where building energy codes are not mandatory at the national level, the map shows implementation at the sub-national level jurisdictions (e.g. Canada, Belgium, the United States).
Source: IEA (2025), Energy Efficiency 2025.

Displacing heat-only boilers offers the fastest near-term route to cut fossil use

Most fossil fuel-based district heat today is produced via a mix of CHP plants and heat-only boilers (HOBs). Many systems have shifted to CHP to improve overall fuel efficiency and monetise electricity generation. As networks transition toward low-carbon heat, however, the relative role of heat-only assets changes. As HOBs provide heat without the operational constraints of simultaneous power production, they often represent the most straightforward and impactful entry point for efficient and renewable heat integration.

Replacing fossil fuel HOBs typically delivers larger near-term emissions reductions and stronger economic returns than substituting CHP, especially where existing CHP units still operate at moderate efficiency or provide valuable electricity services. Modern alternatives – for example large-scale heat pumps, renewable electric boilers, geothermal units, solar thermal fields, and bioenergy boilers – can directly displace fossil heat at the margin while improving system flexibility. Unlike CHP, these technologies can supply heat without being tied to simultaneous electricity generation, allowing district heating systems to operate more flexibly. In the case of heat pumps and electric boilers, this can support the use of low-cost electricity, including during periods of high renewable generation, while also improving efficiency in lower-temperature networks. In many cases, however, this does not require the immediate retirement of existing fossil HOBs. Once new renewable capacity is added, existing boilers can often be retained as peak-load or emergency backup units, where their annual operating hours are limited and their value lies primarily in providing system security and flexibility. Where flexibility and resilience remain priorities, it can also be relevant to assess whether some existing boilers could be retrofitted to use bioenergy for peak and reserve service, particularly in systems with limited storage alternatives or high exposure to electricity price volatility.

Historical supplies to district heating networks by production technology (cogeneration versus heat-only) and fuel category, 1990-2024



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Source: IEA (2025), World Energy Balances.

District energy investment reflects regional conditions and opens new pathways for renewables

While investments in district heating are occurring, they do not follow a uniform pattern across regions. The project sample of this report suggests that the type of spending varies by region according to the condition of existing systems, tariff and regulatory structures, and immediate policy priorities. For example, in Nordic countries and much of Europe district heating systems are generally metered, and tariffs more closely reflect underlying system costs, which supports investment in more flexible and cleaner heat sources. In Eastern Europe, many systems still face ageing infrastructure, high losses, low tariffs, and funding-dependent modernisation, so current expenditure is often concentrated on rehabilitation, reliability, and reduced gas dependence, rather than on investing in entirely new systems. In China district heating remains heavily regulated, residential billing is often still based on floor area rather than actual consumption, and current clean-heating programmes therefore combine supply-side emissions reduction with pricing and regulatory reform. In Central Asia, much of the visible pipeline is tied to externally financed modernisation, rehabilitation, and extension projects.

To render these differences analytically manageable, current projects can be grouped into three categories based on their dominant capex driver. The first is the addition of renewable or other low-carbon heat sources to existing networks, for example, through waste-heat recovery, large heat pumps, electric boilers, heat storage, or fuel switching at major heat plants. The second is rehabilitation and efficiency improvement of existing networks, for example by including pipe replacement or enabling Supervisory Control and Data Acquisition (SCADA). The third is the construction of new networks, major extensions, or interconnections, such as urban expansion schemes or cross-border links. Many projects combine elements from more than one category, so the most useful classification is the one that reflects the main investment focus rather than every individual component.

A final caveat is that disclosed cost figures are not fully comparable; some refer to total project investment or an energy performance certificate contract value, while others refer only to a loan tranche, programme envelope, or financing package. The table below is best used to show the scale and direction of investment, rather than to derive precise like-for-like unit costs.

Selected examples of recent investment in district energy modernisation and expansion

Project type	Project and location	Status and stage	Disclosed investment	System elements
Low-carbon supply added to existing network	Espoo clean-heat programme, Finland	Heat recovery plants scheduled for the 2025-2026 season	EUR 225 million total investment	Waste-heat recovery from data centres, heat pump plants, and around 15 km of new or upgraded main pipeline
Low-carbon supply added to existing network	Billund municipal electrification project, Denmark	Inaugurated in October 2025	Around DKK 250 million (Denmark kroner) final cost	16 MW heat pumps, 30 MW electric boiler, 10 000 m³ thermal storage, plus transformer and switching infrastructure
Low-carbon supply added to existing network	Lutsk District Heating Phase II, Ukraine	Signed, procurement launched	EUR 15.7 million financing package	Network replacement and interconnection, heat pumps, bioenergy-fired boiler(s), and SCADA
Low-carbon supply added to existing network	Shaanxi heating decarbonisation programme, China	Approved in 2024, moving into implementation	USD 300 million World Bank loan within a USD 585 million five-year financing need	Geothermal, waste heat, and electricity, plus a heating-pricing reform pilot
Low-carbon supply added to existing network	Novi Sad district heating, Serbia	Approved in 2024	EUR 108 million, through an EBRD sovereign loan and an EU-WBIF grant	Seasonal pit thermal energy storage, large heat pumps, power-to-heat electric boilers, and solar-thermal
Rehabilitation of existing network	Bucharest hot-water pipeline replacement, Romania	Approved in Nov. 2023 and signed in Jan. 2025	EUR 87 million in EIB financing	Replacement of 106 km of district heating pipelines to reduce heat and water losses
Rehabilitation of existing network	Timișoara district heating, Romania	Signed in 2025, currently under implementation	EUR 30 million EBRD loan within a programme of up to EUR 108 million, plus EUR 63.5 million EU co-finance	Replacement of 27 km of old pipelines plus new chimneys, valves, supports, and an automated monitoring system. The package covers district heating rehabilitation and urban regeneration
Rehabilitation of existing network	Kyiv district heating rehabilitation, Ukraine	Signed, implementing	EUR 140 million EBRD loan	Rehabilitation and modernisation of district heating infrastructure, including CHP and boiler upgrades, monitoring systems, and network replacement
New networks or major extensions	United Heat, Görlitz-Zgorzelec, Germany/Poland	Construction launched at the end of Mar. 2026	Up to EUR 195 million total investment	Cross-border interconnection and a broader 12 km network with a mix including solar thermal, seasonal storage, bioenergy, power-to-heat, and heat recovery
New networks or major extensions	Ulaanbaatar district heating, Mongolia	Under implementation	USD 40 million for rehabilitation and expansion	Rehabilitation and expansion of the district-heating network; by November 2025, 12.2 km of pipelines had been rehabilitated and upgraded
New networks or major extensions	Dushanbe district-heating extension, Tajikistan	Extension signed in 2025	Original USD 5 million loan + USD 5 million grant	Rehabilitation and extension of the district-heating network, with part of the extension package postponed and then refinanced because of inflation

Notes: WIBF = Western Balkans Investment Framework; EBRD = European Bank for Reconstruction and Development.

Governance of district energy networks

District energy network governance rests on four interconnecting dimensions: Institutional frameworks that define organisational structures and stakeholder co-ordination; regulatory frameworks that set tariffs and quotas; ownership models that determine asset control; and business models that outline revenue strategies and operations. These elements interconnect to drive network expansion, operational efficiency, and emissions reduction potential. Each regional system (the Nordics, the Baltics, Central Asia, Central, Western and Eastern Europe, China) then balances investment, affordability, reliability, and other policy goals with trade-offs based on national context and priorities.

This governance analysis focuses on large-scale, urban district heating systems operating under formal regulatory and planning frameworks. Smaller decentralised networks (e.g. campus systems in the United States) and markets with low penetration (e.g. Belgium, Canada, the United Kingdom) typically rely on simpler, project-based models and are not covered in detail here, but can draw lessons on co-ordinated planning, risk allocation, and long-term investment frameworks from more mature systems.

Institutional frameworks

Institutional frameworks shape how district energy networks are planned, governed, and financed by defining decision-making authority, regulatory accountability, and co-ordination efforts across different levels of government. They influence not only the effectiveness of emissions-reduction policies, but also how well they address key governance challenges, such as balancing short-term private investments versus long-term government commitment to energy security, affordability, and emissions reductions.

Centralised state-led frameworks concentrate authority within ministries or state-owned utilities. This model is in place in China, where national institutions direct reforms, such as metering deployment and efficiency standards at the urban scale. Similar structures are in place in parts of Central Asia. While centralisation enables rapid and co-ordinated infrastructure expansion and standardisation, tariff-setting is often influenced by political and social objectives, as opposed to market factors, which can result in regulated prices that do not fully reflect market costs in some segments, particularly in residential heating. In such cases, below-cost recovery may be addressed through local government support, cross-subsidisation, or state backing of utilities. However, limited municipal autonomy can constrain system optimisation, innovation, and diversification of heat sources.

Transitioning or fragmented frameworks are systems that shift from centrally planned state-owned enterprises toward mixed governance structures involving public and private actors. These frameworks are in place in Poland, Romania, and several other Eastern European countries. Institutional overlap and unclear accountability often weaken regulatory enforcement and delay investment decisions. In some cases, politicisation of tariff-setting and continued reliance on below-cost recovery pricing, sometimes supported by state subsidies to loss-making public utilities, can further complicate the financial sustainability of district heating networks. As a result, ownership reform, business model innovation, and financing mobilisation progress unevenly despite ongoing market reforms.

Multi-level co-ordinated frameworks distribute responsibilities between national regulators and local authorities. National policies establish standards, tariff principles, and climate targets, while municipalities implement zoning, permitting, and local planning decisions. Germany, France, and Baltic countries represent mature versions of this model. They use EU regulatory frameworks to inform national regulation, which then aligns with local delivery. Versions of this system are also in place in Central European countries such as Czechia, parts of Poland, and Slovakia, where EU legislation similarly structures governance, but institutional co-ordination and municipal capacity remain more uneven. Where roles are clearly defined and administrative capacity is strong, co-ordination improves investment predictability and access to finance. However, where governance remains fragmented, implementation slows and investment risks persist.

Municipality-led frameworks place local governments at the centre of heat planning. Strong municipal mandates, supported by national regulations, enable integrated urban planning, co-ordinated infrastructure investment, and long-term system optimisation. This model is prevalent in Denmark, where mandatory zoning is part of municipal decision-making, as well as in Finland and Sweden, where cities and consumer co-operatives play central planning and operations roles. Clear local leadership reduces regulatory uncertainty and supports more stable investment.

In all scenarios, robust institutional frameworks support regulatory tariff-setting via local enforcement, ownership choices (e.g. municipal versus state), business models (e.g. demand-led revenue), and financing mechanisms (e.g. strong co-ordination attracts capital). On the other hand, unclear mandates, weak co-ordination, or restricted local authority can all increase regulatory uncertainty and slow enforcement, innovation, and access to financing.

Regulatory frameworks with tariff structures

Regulatory frameworks determine how district energy markets balance consumer protection, investment incentives, and emission reduction objectives through tariff-setting rules, market oversight, and connection policies.

Market-based regulatory frameworks treat district heating as a competitive energy service governed primarily by general competition and consumer protection law rather than sector-specific price regulation. In Finland, heat pricing is not directly regulated and customers are generally free to choose and switch heating options creating competition. However, district heating providers may retain a dominant position in existing networks, meaning pricing is expected to remain transparent, cost-reflective, and non-discriminatory under general competition rules. This model promotes operational efficiency, innovation, and diversified heat sourcing, but may still expose consumers to price volatility where switching options remain limited. Sweden's District Heating Act applies a moderated variant, offering transparent commercial pricing combined with mandatory cost disclosure and mediation mechanisms, which preserve market incentives while limiting monopolisation of market power by providers.

Cost-recovery or nonprofit regulatory frameworks link tariffs directly to verified operating and capital costs, often limiting returns and redistributing surpluses to consumers. For example, Denmark's Heat Supply Act requires cost-reflective pricing and enables municipalities to designate district heating zones through local heat planning, although mandatory connection requirements for new developments were largely phased out after 2019, while obligations may still apply in areas approved prior to this reform. Baltic countries' regulators also allow municipal operators to recover operating and capital costs in addition to a modest return. This structure provides strong revenue stability and supports long-term infrastructure planning and the integration of renewables, although it reduces incentives for profit-driven expansion.

Regulated cost-plus frameworks establish tariffs through independent regulators that approve recoverable costs and allow a defined return on assets. Croatia employs independent energy regulators to ensure financial viability while maintaining affordability objectives. Romania's recent reforms illustrate how clearer cost-plus regulation can restore investor confidence after a prolonged market decline caused by fragmented tariff governance. Where regulation remains inconsistent or politically influenced, however, tariffs often fall below cost-recovery levels, weakening utilities' financial positions.

Administrative or state-directed pricing frameworks rely on government-set tariffs and subsidies to prioritise affordability and rapid system deployment. Ukraine and Moldova blend national oversight with municipal tariff-setting that compresses tariffs below costs, which accelerates infrastructure deterioration, reducing service reliability and contributing to increased disconnections. In Central Asia and the Caucasus, flat or area-based tariffs and extensive subsidies distort consumption incentives and limit reinvestment. China operates a hybrid administrative model that allows local price bureaus to approve tariffs, which are increasingly volume-based following metering reforms. National efficiency mandates also enable rapid coal boiler phase-outs in China but constrain integration with electricity markets for waste-heat recovery and power-to-heat solutions.

Tariff designs reflect governance priorities. For example, cost-recovery regimes (e.g. nonprofit or cost-plus) anchor mature emissions reductions through revenue certainty, market approaches reward efficiency, and innovation under competition pressure. Administrative models favour affordability and deployment speed but often weaken financial sustainability and investment signals.

Ownership and business models

Ownership and business models work together to set control, revenue, emissions reduction trajectories, and investment horizons. They can be grouped into four broad categories.

Municipal ownership prevails across much of Central Asia, China, and Europe. This model sees cities operate district heating networks as public utilities to guarantee universal service and embed heat supply within broader spatial planning. These systems are typically financed through cost-recovery tariffs combined with public balance-sheet support, including municipal bonds, sovereign transfers, or national grants. This enables long investment horizons aligned with infrastructure life cycles, but outcomes depend on tariff discipline and fiscal capacity. Where tariffs are politically constrained and kept below cost-recovery levels, such as in parts of Central Asia or Eastern Europe, this can undermine financial sustainability, contribute to underinvestment, and weaken service reliability.

Consumer co-operatives in Denmark, Finland, and Sweden are based on local user ownership and democratic governance, where financing is raised through member equity, retained earnings and, in some cases, municipal loans. Revenue is demand-driven, and surpluses are typically reinvested or redistributed rather than extracted as profits. This builds resilience to fuel price volatility but limits revenues and profits that could otherwise attract private investment to support maintenance, retrofits, and expansions.

Private ownership thrives in competitive settings such as Finland. It combines commercial models with market-driven tariffs and open third-party access, which allows operators to buy the cheapest available heat from independent producers, such as bioenergy, geothermal, or waste-heat sources. This drives efficiency and innovation with 7- to 15-year horizons, which align with timelines for investors. This model is funded by project finance or commercial debt. Strict transparency rules also curb monopoly risks.

Hybrid arrangements: Public-private partnerships (PPPs) merge public land concessions with private technical expertise and capital under frameworks similar to Regulated Asset Base (RAB) models. Recent reforms in Poland and Romania mean that regulated returns (between 4% and 7%) attract EBRD debt for pipe rehabilitation across 15- to 25-year concessions while municipalities enforce social mandates. Success, however, requires clear risk splits to avoid disputes or stalled projects.

In many Western European systems such as Austria, France, Germany, and Nordic countries, ownership and business models often take hybrid forms beyond PPP arrangements, combining municipal control with commercial operating practices or private-sector participation. These systems blend public service objectives with market-based incentives, which support investment while maintaining a degree of local oversight. In some cases, hybrid arrangements also extend to operational models, where a central network operator retains responsibility for system balancing and distribution, while multiple public or private actors supply heat under contractual arrangements. This multi-actor structure, in place in Malmo and Stockholm, enables integration of diverse heat sources while maintaining co-ordinated network operation.

Lessons learned and implications for untapped markets

Evidence from mature district heating systems suggests that scaling is driven less by resource availability and more by the strength of governance frameworks. Countries at earlier stages of district heat development, such as Belgium, Canada, or the United Kingdom, may learn important lessons from established players. First, clearly defined institutional roles and co-ordination across national and local institutions are critical to reduce investment uncertainty and ensure coherent system development. Predictable tariff frameworks, whether based on cost-recovery or regulated returns, are important for securing long-term financing and enabling infrastructure investment. Third, explicit mechanisms to allocate and manage risks, particularly for capital-intensive infrastructure and resource development, are key to attracting and retaining investment. And finally, integrated heat planning, including zoning and connection policies, enables economies of scale and more efficient network expansion.

Recent policy developments in the United Kingdom illustrate how these elements are being adapted in lower-penetration markets. The introduction of heat network zoning and the Heat Network Technical Assurance Scheme aim for more co-ordinated planning, standardised performance requirements, and reduced delivery risk. While still evolving, these measures indicate a transition from fragmented, project-based development towards a more integrated and regulated market framework.

Summary of tariff groups, district heating ownership, and business models[3]

Tariff group	Ownership	Business model	Key features	Investment implications	Risks	Country examples
Nonprofit/ Cost only	Municipal/ Co-operative	Cost-recovery (opex + surpluses refunded)	Mandatory zoning, democratic governance, integrated urban planning	Long-term public grants/bonds, decades-long upgrades	Political pricing, network stagnation, deters private investment	Denmark, Estonia, Finland, Latvia, Lithuania, Sweden
Regulated cost-plus	PPPs/Municipal hybrids	Approved costs-plus regulated return, often two-part tariffs	Clear risk splits, long-term concession 15-25 years, gradual modernisation	Attracts multilateral debt and private equity	Oversight critical to curb cost inflation; Disputes if Regulated Asset Base audits fail	Croatia, Czechia, Poland, Romania, Slovakia
Market/ Commercial	Private	Market tariffs, TPA/Open access	Competition from alternatives, efficiency incentives	Project finance or commercial debt; 7- to 15-year horizons	Monopoly rents when competition is absent, consumer price volatility	Czechia, Finland, Slovakia, Sweden
Administrative/ Subsidies	State/Municipal	Flat or subsidised tariffs, volume-based	National mandates (metering, phase-outs)	Sovereign grants and/or transfers, upfront capex	Weak signals, chronic under-recovery	Central Asian countries, China, Moldova, Ukraine

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[3] These categories are simplified analytical archetypes. In practice, district energy networks often combine elements from multiple frameworks, and additional variants exist depending on historical legacies, market maturity, and regulatory objectives.

Affordability of district energy networks

Pricing structures differ significantly across regions

District heating tariffs vary widely across regions, both in terms of pricing as well as in how they are structured and applied. While most systems charge per unit of heat delivered (e.g. gigacalorie [Gcal] or per kWh), the way consumption is measured, or estimated, differs substantially. As a result, nominal tariffs are not always directly comparable across countries without understanding the underlying pricing model and the national energy tax landscape.

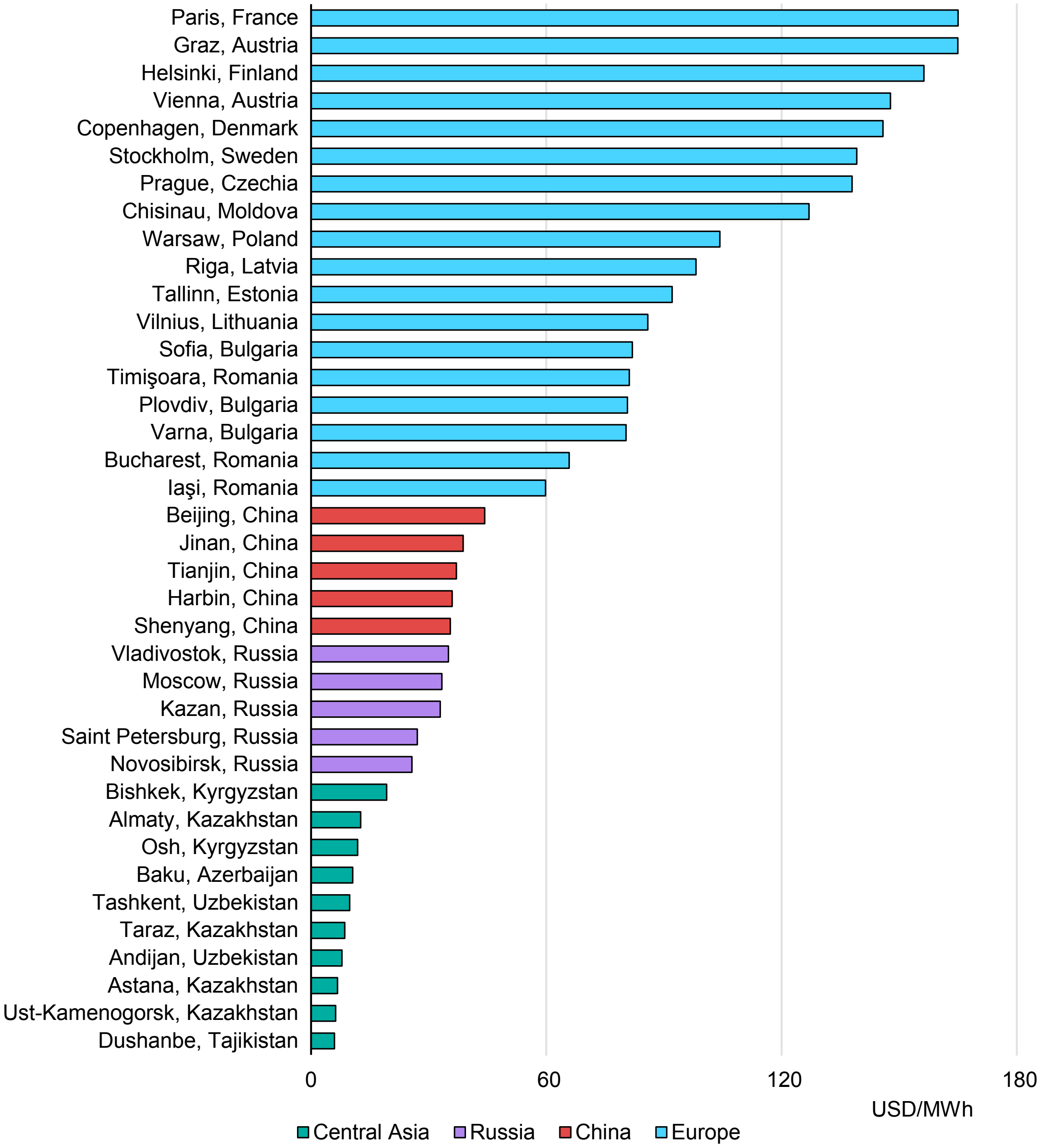
In most of Europe and the Nordics, district heating is predominantly metered at the building level and billing is based on actual heat consumption. Many systems apply two-part tariffs, combining an energy component (per MWh) with a capacity component (per kW of contracted load). This tariff structure is designed to capture both variable fuel costs and fixed network and capacity expenses, while creating incentives for demand-side efficiency and effective peak load management.

In China, by contrast, district heating for residential buildings is still largely based on flat tariffs. Households typically pay a fixed fee per square metre for the duration of the heating season, regardless of actual heat consumption. Although pilot projects have introduced consumption-based billing in some cities, flat tariffs remain widespread in the country. This approach reflects the highly regulated nature of the sector and the prioritisation of affordability and price stability over demand responsiveness.

Across parts of Central Asia, tariffs are commonly expressed per unit of heat (e.g. per Gcal). However, in practice, many residential buildings lack functioning building-level meters. In such cases, billed consumption is calculated using "normative" heat intensity values per square metre, multiplied by the floor area. While formally energy-based, this approach is economically similar to a flat tariff, as households cannot directly influence their billed consumption through behavioural changes or efficiency improvements.

In Eastern Europe, pricing structures are more heterogeneous. Many countries have introduced building-level metering and cost-reflective tariff reforms, particularly in EU member states. However, in some European countries outside of the European Union, "normative" billing and cross-subsidisation between consumer categories remain common in several markets. In some cases, tariffs for households are politically regulated below cost-recovery levels, while commercial entities pay higher rates. As a result, both affordability outcomes and investment signals differ significantly across the region.

Average retail residential district heating tariffs across selected cities, 2025



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Notes: In cities where tariffs are charged per unit of heat delivered, these are shown directly. Flat tariffs and multi-component tariffs are converted to USD/kWh based on the following assumptions. Flat tariffs charged per household or per square metre are converted to a per-kWh basis using an assumed dwelling size of 90 m² and normative building heat thermal needs reflecting local climate conditions and the average insulation level of the local building stock. For tariffs composed of a fixed capacity component and a metered energy component, the per-kWh value is estimated by allocating the fixed capacity charge based on the average building's heat consumption and average subscribed capacity.

Source: IEA analysis based on publicly available tariffs for the 2025/2026 heating season in selected markets.

On a per-kilowatt-hour basis, district heating tariffs in Europe are on average three times higher than those in China, almost four times higher than in Russia, and more than ten times higher than in Central Asia. This gap is driven less by fuel choices than by tariff structure and cost-recovery approaches. In Europe, most tariffs reflect underlying system costs and operate within competitive market frameworks. In China, Russia, and most of Central Asia, by contrast, tariffs are often subsidised or capped, limiting the extent to which costs are fully passed on to consumers.

Flat and normative billing weakens incentives for heat savings

In several large district heating markets, notably northern China, Russia, and many Central Asian countries, households are commonly billed using flat or normative tariffs rather than based on measured heat consumption.

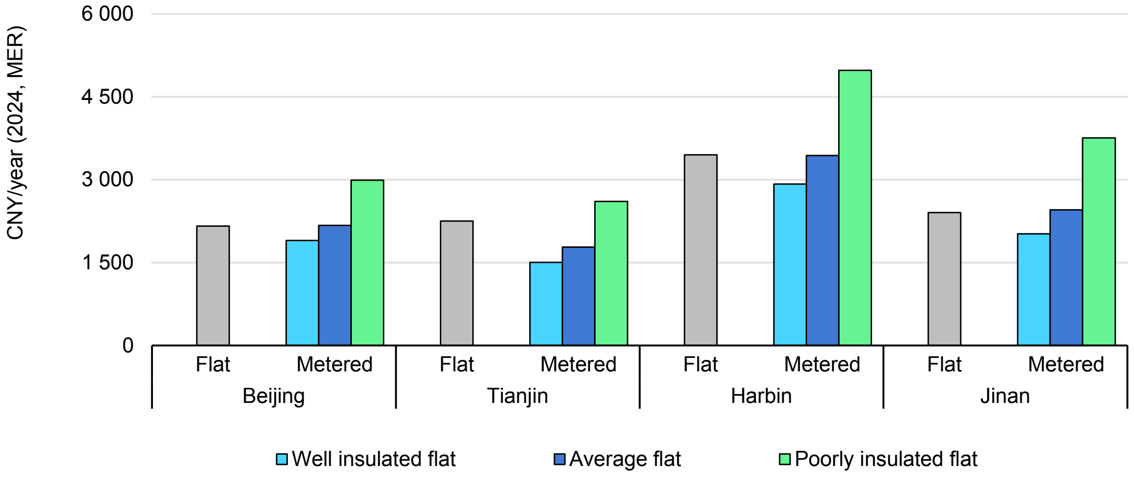
Under these structures, the marginal cost of additional heat consumption for households is effectively zero. Conversely, households that consume less than the assumed average do not pay less. This weakens incentives for behavioural energy savings and reduces the financial return from improving building insulation or installing thermostatic controls. Where indoor temperatures are centrally controlled and consumers cannot adjust heat delivery, the price signal is further diluted.

China has pursued heat metering and consumption-based billing through pilots and reforms in multiple northern cities, with uneven progress. In Russia and several Central Asian countries, building-level metering has expanded in recent years, particularly in new developments, but individual apartment-level metering and fully consumption-based billing remain far from universal.

The relative competitiveness of flat versus metered tariffs depends strongly on building insulation levels, climate conditions, and tariff design. In cities such as Beijing, Harbin, or Jinan, the annual heating bill of an average household under a metered tariff can be similar to the flat-fee payment under current tariffs and assumed consumption levels. However, in poorly insulated dwellings, which remain common across parts of Russia and Central Asia, a shift to consumption-based billing without prior renovation could lead to significantly higher bills.

Scaling up metering and introducing well-designed two-part tariffs (that would combine a fixed capacity component with a variable consumption charge) could strengthen incentives for building retrofits and behavioural change. However, tariff reform needs to be accompanied by social protection mechanisms and targeted renovation programmes to avoid disproportionate impacts on low-income households and residents of inefficient buildings.

District heating bills for a 90 m² apartment under flat and metered tariffs, selected Chinese cities, 2025 heating season



Notes: Bills are calculated for a 90 m² apartment for the 2025 heating season using official municipal district heating tariffs. Area-based tariffs assume payment per square metre. Metered tariffs include both fixed (capacity/area-based) and variable (per kWh) components where applicable. Seasonal heat consumption assumptions are based on national building energy standards: "Well insulated" reflects guideline values for new buildings; "average" reflects average values; and "poorly insulated" reflects the upper range of measured consumption in existing stock.

Trends to watch

Ambient loops

Ambient loops, sometimes referred to as thermal source networks, are low-temperature distribution networks that circulate water close to ambient ground or air temperature and rely on decentralised heat pumps to deliver building-level heating and cooling. Thermal source networks operate at very low supply and return temperatures, often around 10°C to 30°C, thereby minimising distribution losses and enabling efficient integration of diverse local heat sources. As the network acts primarily as a shared thermal reservoir, rather than a conventional heat-delivery system, decentralised heat pumps lift temperatures to meet individual building needs. This decoupled architecture offers several system-level advantages by reducing thermal losses, enhancing flexibility for both heating and cooling, and improving integration of waste heat, geothermal resources, and ambient energy sources. Modern thermal source networks also support bidirectional energy flows, enabling buildings to inject surplus heat (e.g. from cooling processes or data centres) and extract heat at other times, improving overall utilisation of local resources.

Compared with conventional district energy systems, ambient loops change the role of the network. Rather than supplying heat at a fixed temperature, thermal source networks provide a platform that maximises the value of distributed energy resources. They can integrate low-grade waste heat streams that are often too cold for direct use for traditional networks, such as heat from data centres, metro systems, or commercial refrigeration. They also facilitate direct use of free cooling from groundwater, lakes, rivers, or boreholes.

In practice, ambient loops are particularly suited to mixed-use districts, new urban developments, and areas where both heating and cooling demands coexist, enabling year-round energy sharing. Their performance depends on good building-side system design, appropriate zoning, and adequate planning for thermal storage. While not universally superior to modernised networks in all contexts, especially where higher-temperature demand persists or where higher temperature heat sources are affordable and available, they provide a powerful tool for enabling efficient, low-temperature, multi-source heating and cooling systems.

Thermal energy storage

Thermal energy storage (TES) enables heat or cold to be stored over hours, days, or entire seasons and dispatched when demand arises, increasing the flexibility, efficiency, and utilisation of district energy systems. Technologies range from short-term water tanks and ice storage to large-scale storage solutions capable of shifting summer heat into winter supply. TES also supports district cooling systems, where chilled water and ice storage help manage peak electricity demand and improve system efficiency.

TES technologies come in several forms and are categorised by storage principle and system configuration. Sensible heat storage retains energy in water, soil, or rock for short- and seasonal-term use. Seasonal sensible storage is commonly deployed as a pit (PTES), borehole (BTES), tank (TTES), or aquifer (ATES), all of which are increasingly deployed in urban systems worldwide, particularly PTES and TTES. Other forms include latent heat storage, which uses materials that absorb and release heat as they change state (e.g. from solid to liquid), to help store more energy in less space, thermochemical storage based on reversible reactions, and electro-thermal storage that converts electricity into heat.

Large-scale TES plays a complementary role in district heating systems. For example, PTES typically provides mostly low-cost, long-duration storage for seasonal balancing and large-scale load shifting, enabling the integration of renewable heat and reducing system-wide peak demand. It also requires a larger area and is typically deployed in peri-urban settings. TTES, on the other hand, offers high-power, short-term flexibility to manage intra-day load shifting and peak shaving, to optimise daily operation and respond to dynamic heat and electricity system conditions. It is also more compact and can be integrated within dense urban environments, but at a higher cost per unit of storage capacity.

When integrated with solar thermal, heat pumps, waste heat, or combined heat and power plants, TES can significantly reduce peak loads, fossil backup, and system costs, while improving resilience. TES also plays a central role in sector coupling, by storing heat produced from electricity, particularly via heat pumps or electric boilers during periods of high shares of variable renewables generation, it allows district energy systems to absorb excess renewable power and provide demand-side flexibility to the grid. This supports both higher shares of wind and solar, as well as reducing their curtailment and relieving grid congestion. Seasonal TES is particularly valuable for high renewable penetration, where it can enable renewable heat shares above 50% in suitable contexts.

TES is a mature, low-loss, cost-effective, flexible, and scalable option, with performance and costs strongly dependent on available space, geology, temperature levels, and system integration. Yet its integration with renewable energy is still a minor part of global district heating networks. In regions with strong policy support, however, large-scale seasonal storage deployment is already accelerating. For example, Denmark has deployed multiple PTES systems, while Finland, Germany, and Sweden have deployed multiple TTES systems that deliver competitive heat at low cost and enable high shares of solar thermal and heat-pump supply. These early deployments demonstrate how TES can be scaled rapidly and economically when aligned with modern low-temperature network design.

Waste heat from data centres

Data centres reject nearly all the electricity they consume in the form of low-temperature heat, making them an increasingly relevant source of recoverable energy for district heating systems. Integrating this heat is technically straightforward as it can be captured through heat exchangers and, where necessary, upgraded with heat pumps before being supplied to nearby networks. Several countries now require new data centres to assess or implement heat recovery, and municipalities across Europe are actively expanding programmes to connect data centre waste heat. The European Union’s updated Energy Efficiency Directive (EED) requires data centres with total rated energy input exceeding 1 MW to recover their waste heat, unless they can demonstrate that doing so is not technically or economically viable.

As data centre capacity rapidly grows, driven by artificial intelligence and cloud computing, local authorities are increasingly treating heat from the structures as a strategic resource that can lower system emissions, reduce fuel imports, and support more efficient low-temperature district heating.

Bioenergy carbon capture utilisation and storage

Unlike other forms of renewable energy, the biomass used to produce solid and gaseous biofuels used in district heating networks captures carbon during its growth (i.e. photosynthesis). When sourced and managed sustainably, these fuels can generate renewable low-carbon heat. When paired with bioenergy carbon capture utilisation and storage (BECCUS) technology it can generate net-negative emissions heat when appropriate infrastructure and geological storage exist and/or where demand for circular carbon for other end-use sectors exists (e.g. chemicals, materials, production of synthetic fuels).

While BECCUS technology is still being developed and tested at large scale, it has begun to be implemented in both district heating projects, for example in Norway's Veas wastewater treatment plant, as well as in non-district heating projects, such as the Serres Toundra greenhouse in Saint-Félicien, Canada, which leverages waste heat and biogenic carbon from the neighbouring sawmill's CHP, fuelled by manufacturing residues (e.g. wood chips), to grow produce such as cucumbers and blueberries. Forthcoming projects are looking to deploy the technology at larger scales, such as Sweden's Stockholm Exergi and Denmark's Orsted Avedøre, which will store CO_2 in saline aquifers in the Norwegian offshore. In addition, storage, or use, of biogenic carbon with BECCUS technologies produces low-temperature heat that could be elevated with technologies such as heat pumps, and in turn redirected back to district heating networks.

BECCUS not only helps to reduce emissions in district heating but can also offset emissions in other sectors when achieved at large scales. It can also create new revenue streams for district heat providers either through the sale of the biogenic carbon directly to end users or in carbon markets, which are beginning to grow globally as different economic sectors look to offset their emissions across their respective value chains.

Sector coupling

Combining the supply of, and demand for, heat in district energy from different sectors is emerging as an efficient, cost-effective, reliable, and secure form of heat management, distribution, and use. When integrated with electricity systems, district energy networks can function as large-scale thermal storage, effectively acting as long-duration batteries that absorb excess electricity and convert it into heat. This improves system flexibility, facilitates the integration of variable renewable energy, and strengthens links between power, heating, and cooling sectors. Ongoing research into system integration of historically separate sectors to maximise efficiency and flexibility is expanding and supported by initiatives under numerous IEA's Technology Collaboration Programmes.

Connecting surplus heat with nearby demand generates new revenue streams for non-traditional district energy stakeholders while delivering low-cost heat to local networks. This can further reduce infrastructure costs, optimise resources, and accelerate network deployment in areas where supply and demand already exist or are expected to emerge. For example, the Zibi Community Utility District Energy in Ottawa, Canada leverages waste heat from the neighbouring paper product mill to provide space heating and cooling, and hot water, to the neighbourhood.

Programmes and policies are beginning to recognise these opportunities. Germany's Funding for Efficient Heat Networks, for example, provides capital funding for projects renovating, expanding, or developing systems, including the use of waste heat. The European Union's EED strengthens the role of waste heat, high-efficiency cogeneration and sector-coupling in district energy. It sets progressively stricter criteria for "efficient district heating and cooling" systems, based on increasing shares of renewable energy, waste heat and high-efficiency cogenerated heat. It also requires local heating and cooling plans for municipalities with populations above 45 000, including mapping of waste heat recovery, high-efficiency cogeneration, renewable energy and low-temperature district heating potential.

Chapter 3. Policy opportunities and recommendations

A dual opportunity: Expanding district energy networks and renewables in parallel

District energy networks in both established and new markets offer two distinct opportunities: The expansion of networks, and the integration of renewable and recovered energy sources into those systems. In existing networks, this may entail upgrading systems to reduce emissions or expanding them where heat demand density is sufficient (e.g. in cities). For new systems, this means building networks from the outset designed to use renewable energy.

When it comes to district cooling and combined heating and cooling networks, markets are generally less mature, but the opportunity for efficient, low-emissions networks is significant. For example, in dense urban areas with rising cooling demand, networks can exploit synergies between heating and cooling, make use of renewable and recovered energy, and provide cooling much more efficiently than decentralised systems, while reducing pressure on electricity grids.

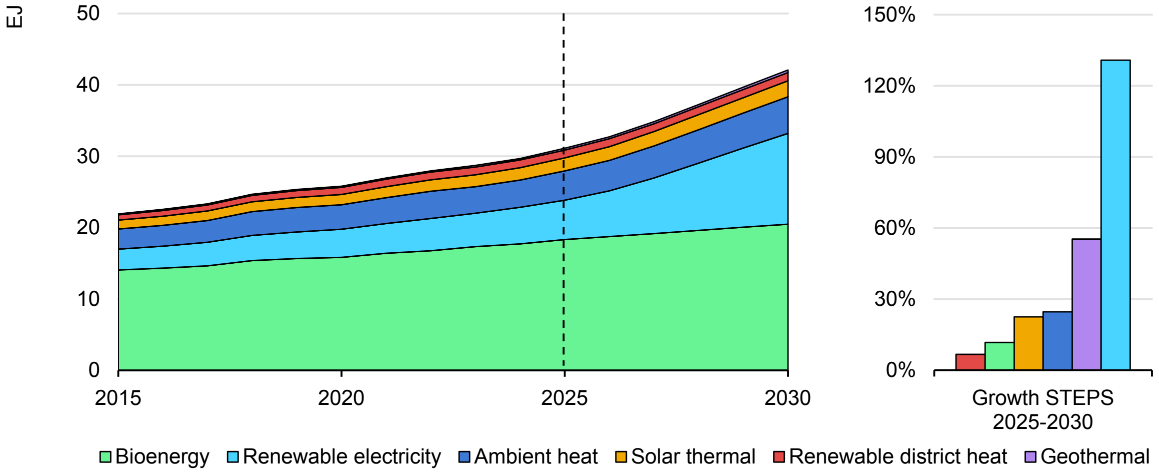
District heating: Significant global potential

District heating is fundamentally local and governed through complex multi-actor systems. Its feasibility, design, economics, and environmental performance are shaped not only by physical conditions that vary widely between regions, but also by governance structures that co-ordinate decision-making across municipalities, utilities, regulators, fuel suppliers, and other stakeholders. Population density, building stock characteristics, the age and efficiency of existing networks, local planning practices, workforce capabilities, and the availability of renewable resources all interact with these institutional arrangements, influencing whether systems deliver cost-effective and reliable heat.

The potential for renewable heating in district energy networks remains largely untapped. Today, renewables account for roughly 7% of district heating supplies, and renewable district heating represents only about 4% of global renewable heat use, well behind the direct use of bioenergy (60%) and renewable electricity (17%), which remain the largest sources of renewable heating.

According to the current policy landscape, this dynamic is not set to change. In the Stated Policies Scenario (STEPS), which reflects policies in place and policies that have been formally put forward but not yet adopted, renewable district heating shows the slowest growth to 2030 among renewable heating sources, increasing by only around 10%.

Renewable energy use for heating in the Stated Policies Scenario, 2015-2030



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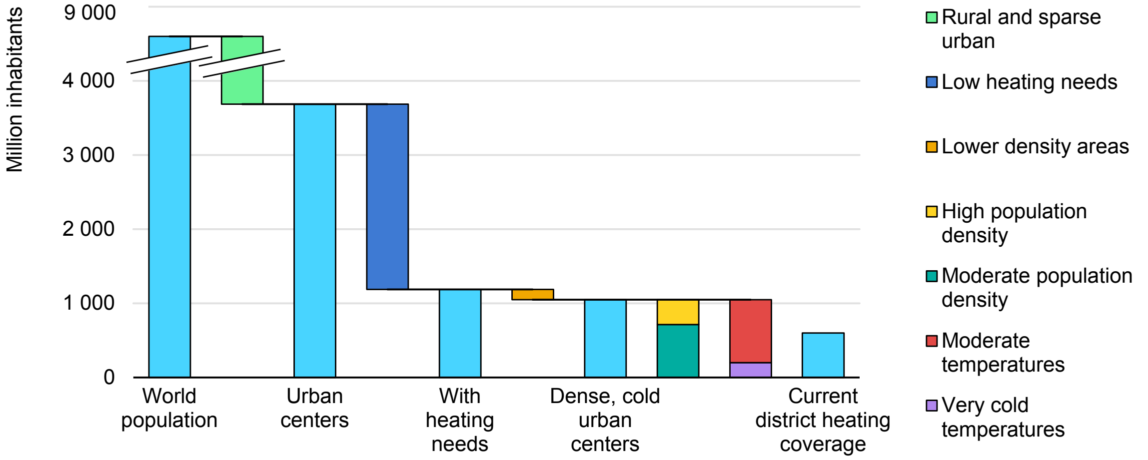
Note: Renewable district heat includes direct use of renewables (bioenergy, solar thermal, geothermal, renewable waste), indirect use of renewables (renewable electricity), and ambient heat harnessed by heat pumps.
Sources: IEA (2025), World Energy Balances. IEA (2025) World Energy Outlook.

This underscores the need for accelerated policy support to further deploy renewable energy in district energy networks. However, there remains significant potential to increase the share of renewables in existing district heating systems, which remain largely dependent on fossil fuels, and to expand, or develop, new networks that use renewable heat sources. This is particularly relevant in areas with high heating and cooling demand density – that is, regions with high population density and either hot and/or cold climates – where district heating is typically more competitive.

Today, around 1.2 billion people live in urban centres with moderate density and cold winters. District heating networks supply heat to around 600 million people worldwide, most of them living in such high-density areas. This gap illustrates the opportunity to continue to expand district heating in areas where local conditions make it technically and economically viable.

Global population filtered by urban centres, heating needs, density, and district heating coverage



Notes: Population and density data are based on the Global Human Settlement Layer (GHSL) Urban Centre Database (R2024A), which includes data on 11 422 quality-controlled urban centres worldwide. Urban centres are defined as contiguous areas with at least 50 000 inhabitants and a minimum population density of 1 500 people per square kilometre. Heating demand is approximated using population-weighted heating degree days (HDD, base 18°C), derived from the IEA's Weather, Climate and Energy Tracker. Population is filtered based on urbanisation, heating needs and density thresholds to identify areas where district heating is more likely to be cost-competitive.

Source: International Journal of Digital Earth (2024), *Advances on the Global Human Settlement Layer* (article), International Journal of Digital Earth, 17(1).

District cooling: A strategic part of energy planning

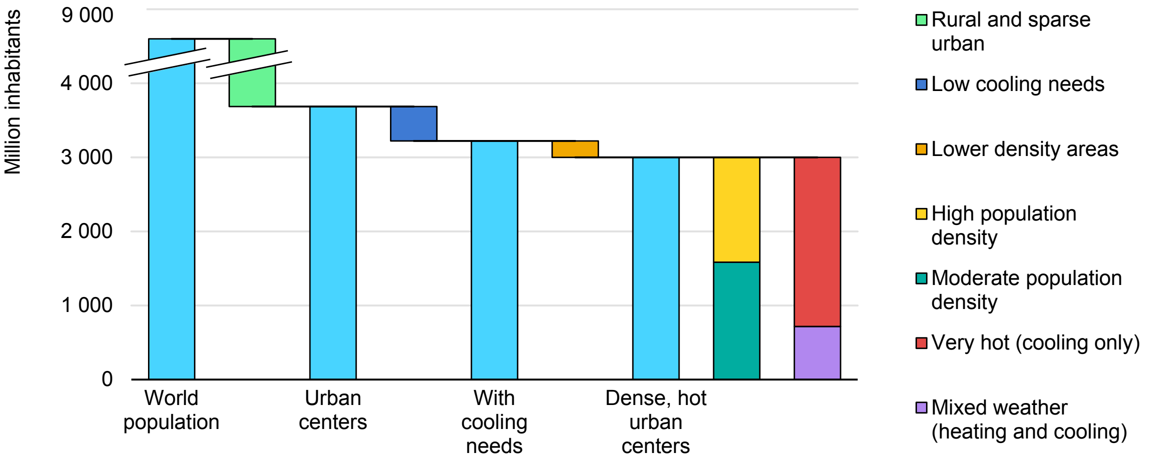
Today, more than 3 billion people, or more than one-third of the global population, live in dense urban centres with significant cooling needs, and over 700 million live in urban centres that require both cooling and heating. This points to a sizeable but highly localised opportunity. Yet deployment of district cooling and district energy networks remains limited globally.

While district cooling is well established in parts of the Middle East (most notably the United Arab Emirates), in Europe and North America it is concentrated in a relatively small number of local systems. District heating and cooling systems are present in some European countries but still represent a small share of overall district energy networks. However, interest is growing as cooling demand rises in many parts of the world, as urban centres become denser, and cities look for more efficient ways to meet cooling needs without further straining electricity systems.

The opportunity to expand district cooling systems is not confined to hot climates where demand is most visible. The viability of district cooling depends strongly on the concentration of demand, the presence of large anchor loads, and the availability of efficient local cooling sources. That means even in regions with temperate climates, the presence of dense city centres, commercial districts, hospitals, elderly care facilities, university campuses, public buildings, and mixed-use developments can all provide a critical mass needed to support network development. Even in cooler climates, better-insulated buildings, higher internal heat gains, and more frequent overheating risks are also increasing cooling needs, particularly in dense urban areas.

District cooling should therefore not strictly be seen as a solution for air conditioning in hot countries. Cooling is becoming an essential energy service, particularly in cities, for health facilities, care homes, public buildings, commercial centres, and dense residential areas exposed to heat stress. Unlike fragmented individual air-conditioning systems, district cooling can deliver cooling more efficiently, reduce local heat emissions into streets and neighbourhoods, lower refrigerant-related risks, and help limit the reinforcement of electricity grids driven by peak cooling demand.

Global population filtered by urban centres, cooling needs, and density



Notes: Population and density data are based on the Global Human Settlement Layer (GHSL) Urban Centre Database (R2024A), which includes data on 11 422 quality-controlled urban centres worldwide. Urban centres are defined as contiguous areas with at least 50 000 inhabitants and a minimum population density of 1 500 people per square kilometre. Cooling and heating demand is approximated using population and humidity-weighted cooling degree days (CDD, base 18°C), and heating degree days (HDD, base 18°C) derived from the IEA's Weather, Climate and Energy Tracker. Population is filtered based on urbanisation, heating and cooling needs and density thresholds to identify areas where district cooling and district heating and cooling is more likely to be cost-competitive.

Source: International Journal of Digital Earth (2024), *Advances on the Global Human Settlement Layer* (article), *International Journal of Digital Earth, 17*(1).

The largest strategic opportunity is a combined district cooling and heating network, especially in regions with hot summers and cold winters, allowing the system to operate across more of the year, thus strengthening the business case for such a solution. Integrated systems also allow for synergies across heating networks, cooling networks, heat pumps, waste heat, waste cooling, thermal storage, and electricity grids: Cooling processes can produce recoverable heat for district heating, while low-cost or low-carbon cooling sources – including water bodies, free cooling, waste cooling, or large energy infrastructure – can improve the efficiency and competitiveness of cooling supply.

Offering an efficient alternative to decentralised cooling, while supporting wider urban energy-system objectives, requires strong government planning (at the local, regional, and national level) to identify where network solutions are likely to be competitive. Mapping demand patterns, anchor loads, available heat and cooling sources, existing infrastructure, and future urban development zones can help distinguish areas where district cooling can scale from those where decentralised solutions are likely to remain more appropriate.

As with district heating, district cooling (as well as combined district heating and cooling) faces important barriers. High upfront capital costs, permitting and planning requirements, limited access to underground space, competition from inexpensive decentralised air-conditioning units, and uncertainty over future customer demand may all constrain deployment. Nonetheless, the opportunity for growth is significant. Rapid urbanisation, rising cooling needs, growing pressure on electricity grids during heatwaves, and increasing opportunities to link cooling, heating, storage, and recovered energy all strengthen the case for treating district cooling as a strategic part of urban energy planning.

Market clusters

When analysing district energy systems, it is most useful to group markets into categories that share common features. Creating groupings based on similar market characteristics allows for clearer identification of the challenges they face, the opportunities they can unlock, and the policy and technology solutions that can be replicated across similar contexts. To identify these, three categories have been identified based on market maturity and level of renewable energy deployment:

District heating markets with high renewable shares: These are markets with long-established networks that have made progress in lowering operating temperatures, improving efficiency, and integrating renewable energy. Examples include the Nordic and Baltic countries, parts of Central Europe, and specific regions in China, where low-carbon transformation is already underway (see Chapter 2 for more). These regions can further scale renewables through deeper electrification, seasonal thermal energy storage, advanced network optimisation, and industrial waste-heat recovery.

District heating markets with high fossil fuel shares: These regions operate extensive district heating networks but have made limited progress on energy efficiency, temperature reduction, and fuel diversification. They include:

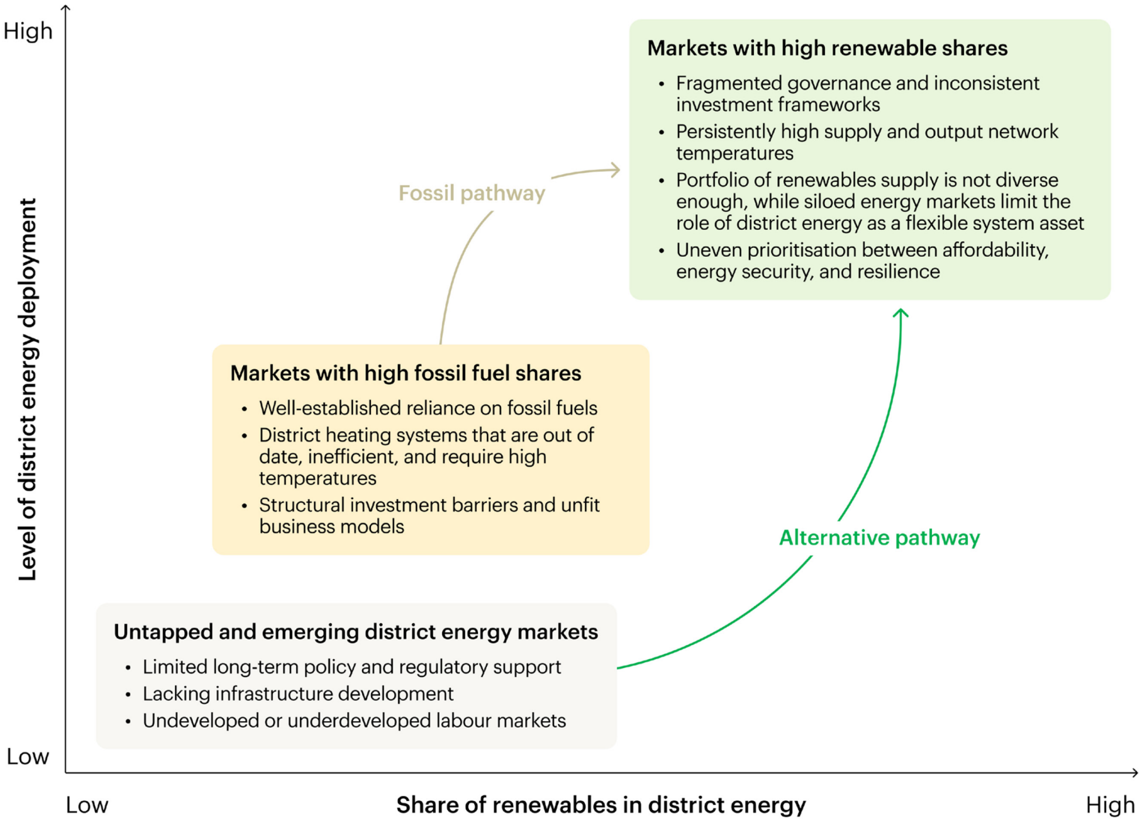
a. Fossil fuel-exporting regions, such as Russia and large areas of China where heat supply relies heavily on domestic fossil fuels such as gas or coal.

b. Fossil fuel-importing regions, such as Eastern Europe, the Caspian region, and parts of Central Asia, where heat supply depends on imported fossil fuels, making these systems more vulnerable to price shocks and supply disruptions.

Untapped and emerging district energy markets

These regions have large untapped potential because they have no, or minimal, district energy infrastructure (for either heating or cooling or combined heating and cooling) but have compelling long-term drivers for network development, including building density, emissions-reduction targets, urban planning priorities, and access to renewable heat sources. Examples include Canada, parts of the United States, and selected countries in Western and Southern Europe and the Middle East. Here, the primary opportunities lie in greenfield system design, allowing networks to be planned from the outset for low-temperature operation, heat mapping, renewable integration, and thermal storage.

Summary of the key challenges for renewable energy deployment in district energy networks by regional cluster



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By organising the global landscape into these categories, this chapter highlights how the opportunities for renewables differ depending on market maturity and how tailored technology and policy pathways can accelerate their deployment in district energy networks.

District heating markets with high renewable shares

Well-established district heating markets with large shares of renewable energy share a distinctive set of structural advantages. Decades of co-ordinated heat mapping and planning and sustained policy support have progressively lowered operating temperatures and diversified heat supply. In Nordic and Baltic countries and parts of Central Europe, these foundations have enabled large-scale integration of renewable and recovered heat, most notably bioenergy, industrial and urban waste heat, and, increasingly, large-scale heat pumps and electric boilers. As a result, these regions now operate some of the most efficient and lowest-carbon district heating systems in the world.

Having already shifted away from fossil fuel supply, the next phase of emissions reductions hinges on continued deployment of renewable energy technologies, accelerated temperature reductions, expansion of seasonal thermal storage, and widespread digital optimisation to manage multi-source systems. As these regions have mature infrastructure, strong municipal governance, and established supply chains, they are uniquely positioned to demonstrate what fully renewable, low-temperature district heating systems can achieve, setting the benchmark for system integration, resilience, and cost-effective emissions reductions globally.

However, five central challenges remain for the greater deployment of renewable energy in district energy networks in these markets: Fragmented governance and inconsistent investment frameworks; high operating network temperatures; limited diversification in the renewable energy supply portfolio; siloed energy markets limit district energy’s potential as a flexible system asset; and imbalanced prioritisation between affordability, energy security, and resilience. These are detailed below, along with recommended policy actions to address them.

District heating markets with high renewable shares: Challenges and policy priorities

Challenge	Policy priority	Selected international examples
Fragmented governance and inconsistent investment frameworks	Make heat mapping and planning a legal obligation	The European Union's Energy Efficiency Directive (EED) requires municipalities (>45 000 inhabitants) to develop local heating and cooling plans from October 2025, establishing a formal obligation for all member states; Denmark assigns municipalities a central role in heat planning via mandatory heat atlases and supply planning to define priorities and guide utilities; since 2024, Germany's Energy Industry Act (EnWG) requires cities to develop heat plans to map demand and infrastructure needs, and provide a basis for co-ordinated planning at the local level.
	Further reform district heating financing and business models to support further emissions reductions in systems	Denmark relies on cost-based, municipally owned systems with long-term planning that ensures stable recovery of investments in heat assets; France uses long-term municipal concession contracts (15-30 years) for revenue certainty for private operators investing in heat infrastructure; the Netherlands combines public heat transition funds with municipal zoning and gas phase-out strategies to reduce investment risk in district heating expansion, and Germany supports emissions reductions through targeted subsidies linked to combined heat and power (CHP) and municipal heat planning.
High operating network temperatures	Accelerate building renovations	Canada's Green Building Strategy accelerates building retrofits through grants, interest-free loans for homeowners and communities, large-scale infrastructure development, updated building codes, public procurement, and innovation. South Korea's Green Remodelling Program provides a suite of financial policy supports to fast-track retrofits in public and privately owned buildings to improve energy efficiency and support deployment of renewable energy.
	Incentivise waste-heat recovery by introducing standardised connection and contract frameworks	The European Union's EED mandates waste heat recovery from >20 MW installations (including data centres >1MW) via cost-benefit analysis, prioritises it in efficient district heating and cooling and requires member states to map potential by 2030. No standardised contractual approach for waste-heat integration, largely based on case-by-case contracts: Concessions in France and Germany; bilateral agreements in Sweden; and the Netherlands enables third-party heat injection, but leaves contract design to individual systems.
	Introduce low-temperature connection standards for new buildings and major renovations	Nordics (regulatory package for low-temperature district heating, Germany's Federal Subsidy for Efficient Heat Networks (BEW), and the Netherlands (Heat Network Investment Subsidy) use building codes, district heating guidelines, and subsidies to require new/renovated buildings connecting to district heating to support low temperatures (50°C to 60°C) heat.
	Use tariff structures that reward lower return temperatures and building-side efficiency	Viborg district heating in Denmark uses a motivation tariff to reward low-return temperatures with discounts (1% per °C below target), reducing both return and supply temperatures and saving EUR 400k/year shared across customers.
	Align renovation waves with temperature-reduction pathways	Denmark applies phased low-temperature zoning, linking new developments to low-temperature networks and gradually extending these zones through building upgrades; since 2024, Germany's EnWG integrates municipal heat planning with retrofit strategies to enable gradual network temperature reductions in designated low-temperature areas.

Challenge	Policy priority	Selected international examples
Limited diversification in the renewable energy supply portfolio	Further incentivise renewable heat deployment with integrated thermal energy storage	The European Union's Heating and Cooling strategy and AccelerateEU toolbox promote renewable heat deployment, supported by the Renewable Energy Directive's binding targets for renewable heating and cooling, including indicative targets for district heating, and the Netherlands requirements to local governments to phase out natural gas by 2049. Germany (BEW), France (Fonds Chaleur), and Denmark complement this with capital subsidies, low-cost public financing, and geothermal risk mitigation to support solar thermal, geothermal, and thermal storage.
	Reform electricity taxes and network charges to reach favourable electricity-to-gas price ratios, a critical enabler for improving the competitiveness of large-scale heat pumps	Several countries have improved electricity-to-gas ratios for district heating heat pumps through industrial tariffs: Finland and Denmark through reduced electricity taxes, Ireland through renewable share relief, and Denmark and the Netherlands via dynamic pricing to shift peak loads.
	Encourage capacity building for municipalities to plan, procure, and finance multi-source renewable systems	To comply with the European Union's EED mandate for local heating and cooling plans in cities >45,000, member states must provide national support in the form of staffing or funding; the Netherlands and Sweden fund dedicated staff, Wallonia (Belgium), France, Estonia, Ireland support feasibility studies with grants, while EIB-JASPERS expanded district heating and cooling decarbonisation advisory (including Moldova and Ukraine) in 2024.
	Support innovation in seasonal thermal storage, smart controls, and low-temperature networks	European Union's Horizon programme, Denmark's Energy Technology Development and Demonstration Programme (EUDP) or Germany (BEW) fund projects on seasonal thermal storage (e.g. Vojens pit, Darmstadt borehole thermal energy storage, or BTES), smart controls, and 5GDH networks via subsidies up to 50% and EUR 100M+ R&D.
Siloed energy markets limit district energy's potential as a flexible system asset	Enable district heating to respond to flexibility, balancing, and price signals across connected energy systems	Denmark, Finland, Germany, and the Netherlands use heat pumps, electric boilers, CHP, and thermal energy storage to optimise operation based on electricity prices and grid constraints; Canada and the United States combine CHP, heat pumps, and thermal energy storage to shift loads and reduce peak electricity demand, while China integrates district heat with power dispatch to co-optimise heat and electricity generation during peak periods.
Imbalanced prioritisation between affordability, energy security, and resilience	Target support for low-income households during renovation-driven transitions or temperature-reduction phases	The European Union's Social Climate Fund, financed by revenues from the extended Emissions Trading System 2 (ETS2) to buildings and transport, provides targeted financial support to vulnerable households to mitigate the social impacts of higher energy costs.

Notes: EIB = European Investment Bank; ERDB = European Bank for Reconstruction and Development.

Challenge 1: Fragmented governance and inconsistent investment frameworks

Even in advanced district heating markets, fragmentation persists because heat system development is split across municipal heat planning, utility investment decisions, building-level renovation policies, and increasingly coupled electricity markets. These actors operate under different regulatory mandates, cost recovery rules, and investment horizons, which leads to co-ordination gaps and inconsistent investment frameworks across the system, even in areas where planning capacity is strong. As a result, network upgrades, temperature reduction measures, and investments in large-scale heat pumps or waste-heat integration do not progress at the same pace or scale. Addressing this challenge requires clearer allocation of responsibilities and stronger (and in some case mandatory) planning frameworks that better align governance structures with investment decision-making.

Policy responses

Make heat mapping and planning a legal obligation

Mandatory heat planning forces alignment between actors that otherwise work independently. In a typical arrangement, for example, municipalities plan spatial development, utilities invest in networks, and local or national authorities set building policies that shape demand. A legal obligation ensures that heat demand mapping, zoning decisions, and network development follow a common timeline and dataset, rather than fragmented local processes, ensuring that all actors co-ordinate their work. This is particularly important in mature systems where future demand depends on renovation rates and heat electrification. Clear assignment of responsibilities reduces delays in approving network expansion areas, defining connection rules, and identifying viable zones for low-temperature operation. Effectiveness depends on enforcement and on municipalities having the technical capacity to translate plans into actionable investment pipelines.

Further reform district heating financing and business models to support further emissions reductions in systems

In advanced district heating markets, tariffs typically follow a two-part structure, combining an energy component (€/MWh) with a capacity component (€/kW of contracted load). While this design reflects both variable and fixed system costs and supports peak load management, a significant share of revenues often remains linked to heat volumes delivered. As building renovations reduce heat demand, this can weaken revenue stability and create a mismatch between declining sales volumes and largely fixed network and infrastructure costs, constraining investment in system upgrades and low-carbon assets.

Challenge 2: High operating network temperatures

Many district heating networks, even in advanced markets, still experience higher-than-optimal supply and output temperatures, meaning that heat sources that power the systems could be lower, and the heat provided by the systems could be lower, which would ultimately improve energy efficiency and enable the greater integration of renewables. The main reason why supply and output temperatures remain high is because current building stock, and heating systems within buildings, are unprepared for next-generation district heating. For example, they may have undersized radiators, poor insulation, legacy hydraulics, or limited building-side controls. The challenge is systemic, and requires co-ordinated upgrades in buildings, networks, and regulation, as well as a long-term sequencing to progressively lower temperatures as more buildings become "low-temperature ready".

Policy responses

Accelerate building renovations

Accelerating building renovations is essential to enable low-temperature district heating by reducing heat demand and improving thermal performance. Well insulated buildings with upgraded distribution systems can operate efficiently at lower supply temperatures, which improves the efficiency and cost-competitiveness of renewable heat sources, such as large-scale heat pumps, electric boilers, solar thermal, geothermal, and waste-heat recovery. Renovation programmes should therefore move beyond energy savings alone and explicitly target "low-temperature readiness" through envelope improvements and system upgrades. Phased zoning can support this transition by connecting new low-energy developments to the low-temperature network first, then gradually extending these zones into existing areas as buildings are upgraded. Aligning building policies with district heating planning in these zones helps synchronise demand and network temperature reductions and avoids getting locked into high-temperature systems.

Incentivise waste-heat recovery by introducing standardised connection and contract frameworks

Waste heat offers a major opportunity to reduce emissions in district energy systems, particularly in urban areas where industry, data centres, wastewater, and commercial buildings generate large volumes of low- and medium-temperature heat that is otherwise unused. However, much of this heat is low-grade and requires low-temperature networks or local upgrading to be efficiently utilised. Policy frameworks should therefore combine incentives for waste-heat recovery with support for upgrading networks and infrastructure to operate at lower temperatures and integrate low-grade heat. These may include mandatory assessments of waste-heat potential; requirements to connect viable sources; compensation mechanisms for suppliers; and investment support for transport and upgrading infrastructure. Further policy development could clarify and strengthen how recovered waste heat is recognised within renewable energy frameworks to improve its valuation and motivate its integration in district heating systems. Standardised connection rules and contract frameworks, including clear third-party access and price setting, are critical to enable independent heat producers to participate and scale integration.

Introduce low-temperature connection standards for new buildings and major renovations

Establishing minimum performance standards for buildings connecting to district heating networks is essential to enable a transition towards low-temperature operation. New buildings should be designed to operate with lower supply temperatures through a combination of high thermal performance, appropriately sized heat emitters (e.g. larger radiators or underfloor heating), and optimised internal distribution systems. Major renovations on existing ones should adopt the same criteria. Without such standards, new connections risk locking in high supply and return temperatures and constraining the ability of networks to reduce supply temperatures in the future. Policy frameworks should require buildings connecting to district heating to meet defined temperature or return-temperature thresholds, particularly in designated network zones. These standards are most effective when integrated into building codes, connection rules, or subsidy schemes, and when aligned with broader renovation policies.

Use tariff structures that reward lower return temperatures and building-side efficiency

Tariff structures can play a central role in incentivising consumers to optimise building-level performance and reduce return temperatures, which are a key constraint to lowering network supply temperatures. By linking part of the heat price to return temperature or system efficiency, utilities can encourage users to improve internal systems and reduce unnecessary heat losses. This helps improve overall network efficiency, lowers fuel consumption, and enables the integration of low-temperature renewable heat sources.

Align renovation plans with temperature reduction pathways

Building renovation cycles should be aligned with network transformation in order to reduce district heating operating temperatures. Building upgrades mean that structures require a lower heat demand and supply temperatures. As those buildings are upgraded, technical conditions for lower-temperature network operation and more efficient integration of renewable and waste heat sources can be put in place in heating systems. It is important that these two processes occur simultaneously, otherwise networks risk being locked into higher temperature operation, leading to inefficient investments and delayed emissions reductions. Co-ordinated sequencing of renovations and network adjustments is therefore critical to enable a gradual and system-wide transition towards low-temperature district heating.

Challenge 3: Limited diversification in the renewable energy supply portfolio

While advanced regions have already made major strides in replacing coal and oil with bioenergy and waste-based fuels – which form the backbone of renewable district heating supply in the Nordics and the Baltics, for example – the energy mix could be further diversified in all markets. Bioenergy has driven most progress to date, but complementing it with a wider renewable heat mix would improve system efficiency, resilience, and energy security, while enabling lower operating temperatures. To broaden the renewable heat portfolio, electrified heat should be scaled (for example, via large-scale heat pumps powered by renewable electricity), along with geothermal, solar thermal, ambient heat, and waste-heat recovery. This expansion and diversification would require systems to operate at lower temperatures, while also requiring storage development and digital optimisation, which would all help to improve system efficiency. Expanding renewable energy sources also depends on stable regulatory and market signals that ensure competitiveness of renewable heat with natural gas, predictable levies, grid access for heat pumps, and support municipal heating and cooling plans that designate zones for different renewable technologies.

Policy responses

Improve electricity-to-gas price ratios for large-scale heat pumps and electric boilers

To improve the competitiveness of large-scale heat pumps and electric boilers, structural end-use price distortion between electricity and fossil fuels must be addressed. In many markets, electricity prices are subject to higher taxes, levies, and network charges when compared to natural gas, despite the declining carbon intensity of electricity. This weakens the business case for electrified heat, despite its higher system efficiency and lower emissions. Investment decisions are often driven by end-user price signals, which slows the deployment of heat pumps and electric boilers even where they are cost-competitive from a system perspective.

Capacity building for municipalities to plan, procure, and finance multi-source renewable systems

Developing multi-source renewable district energy systems, combining heat pumps, bioenergy, waste heat, geothermal, solar thermal, and storage, requires significantly greater technical, financial, and organisational capacity than traditional single-source systems. Municipalities often lack the expertise to design integrated systems, structure procurement processes, assess risks, and mobilise financing, which can delay or limit project development. Strengthening local capacity is therefore critical to move from pilot projects to large-scale deployment. Policymakers can support municipalities through dedicated funding for technical staff, standardised planning and procurement frameworks, and access to advisory services for project preparation and financing.

Support innovation in seasonal thermal storage, smart controls, and low-temperature networks

Seasonal thermal storage allows excess heat from summer (e.g. solar thermal or waste heat) to be stored and used in winter, significantly increasing the share of variable renewable heat. Smart control systems and digital optimisation tools improve real-time operation, balancing multiple heat sources and demand profiles, while low-temperature network designs reduce losses and expand the range of usable heat sources. Public support for innovation and early deployment is essential to bring these solutions to commercial scale and reduce costs. This includes funding for demonstration projects, pilot networks, and system integration approaches that combine multiple technologies. By supporting innovation across storage, digitalisation, and network design, policymakers can enable more flexible, efficient, and resilient district energy systems capable of integrating diverse renewable heat sources.

Challenge 4: Siloed energy markets limit district energy’s potential as a flexible system asset

As electricity, heating, and cooling systems become more interconnected, district energy networks can provide valuable flexibility by shifting demand, storing heat or cold, and integrating large-scale heat pumps, electric boilers, CHP, thermal storage, and waste heat. However, this flexibility value is often not fully recognised in regulation, tariffs, or energy market design. District heating and cooling operators may face electricity prices, grid charges, or tariff structures that discourage flexible operation, while limited access to power-system flexibility markets can prevent them from being rewarded for reducing peak demand or absorbing low-cost renewable electricity. In many regions, planning for electricity, heating, and cooling infrastructure also remains fragmented, limiting the ability of district energy systems to support wider energy system optimisation.

Policy Responses

Enable district heating to respond to flexibility, balancing, and price signals across connected energy systems

Policymakers should adapt market rules, tariffs, and planning frameworks so that district heating and cooling operators are rewarded for the system value they provide. This includes enabling access to flexibility and ancillary service markets where appropriate; designing electricity tariffs and grid charges that encourage demand shifting rather than penalising electrified heat; supporting thermal storage deployment; and integrating heat and cooling networks into local and national energy system planning.

Challenge 5: Imbalanced prioritisation between affordability, energy security, and resilience

Advanced district heating systems need to balance three objectives simultaneously: maintaining affordability for consumers, strengthening energy security, and improving system resilience. The transition to lower-temperature, multi-source systems strengthens resilience by reducing reliance on imported fuels. But this shift requires substantial upfront investment in network upgrades, building retrofits, storage, and digitalisation. If not managed carefully, these costs can increase tariffs, affect consumer acceptance, and slow the transition. At the same time, electrification increases exposure to electricity price volatility unless market design protects the predictability of heat costs. Increased reliance on weather-dependent sources (e.g. solar thermal or ambient heat) also heightens the need for robust storage and supply diversification. The challenge lies in designing policy and regulatory frameworks that ensure stable heat prices, transparent long-term planning, effective social protections, and investment frameworks that distribute risks appropriately between operators, consumers, and public authorities.

Policy Responses

Targeted support for low-income households during renovation-driven transitions or temperature-reduction phases

The transition to low-temperature renewable district energy systems can create short-term cost pressures for consumers due to investments in network upgrades, building retrofits, and new technologies. Without targeted measures, these costs risk disproportionately affecting low-income households and undermining public acceptance. Ensuring affordability, especially for vulnerable consumers, is therefore essential to maintaining social equity and political support. Policy measures should focus on targeted support mechanisms, such as income-based subsidies, renovation grants for low-income households, or temporary compensation schemes during periods of tariff adjustment. These measures are most effective when aligned with broader renovation and heat planning policies, ensuring that vulnerable households benefit from improved building performance and lower long-term energy costs rather than being locked into inefficient systems.

District heating markets with high fossil fuel shares

As outlined in Chapters 1 and 2, many of the world's district heating markets remain primarily fossil fuel-based, often relying on imported natural gas. This leaves many countries, for example in parts of Central, Eastern, and Western Europe, along with Central Asia and the Caucasus, vulnerable to market volatility for fossil fuels. Geopolitical conflict and natural disasters can exacerbate this volatility, leading to sudden heat price increases for end users and undermining access to affordable and reliable energy. In China and parts of Central Asia and the Caucasus, fossil fuels are heavily used but are primarily sourced domestically. Those countries are therefore less exposed to market volatility, though district energy networks are still carbon intensive. In all cases, carbon intensive systems may impact local air quality and have public health implications.

Integrating renewables into fossil fuel-based district heating systems could help countries improve energy security and reduce heating-related emissions. Several factors are already in place that could allow for a relatively rapid integration of renewable energy into fossil fuel-dominated district heating systems. These include existing infrastructure that could function with the supply of renewables, existing in-country expertise in developing and operating systems (useful for expanding systems already in place, but also to develop district cooling systems in the future), and the declining costs of renewable energy. Many regions are well situated to leverage renewable energy technologies in district heating systems, as they have already begun to deploy them in other sectors, which offers the potential for sector clustering and coupling.

However, three main challenges exist for the greater deployment of renewable energy and district energy networks in these markets: well-established reliance on fossil fuels; district heating systems characterised by ageing infrastructure, low efficiency, and high operating temperature requirements; and structural investment barriers and misaligned business models.

District heating markets with high fossil fuel shares: Challenges and policy priorities

Challenge	Policy priority	Selected international examples
Well-established reliance on fossil fuels	Incentivise the transition away from fossil fuels	The European Union's Emissions Trading System (ETS) covers large-scale electricity and heat generation (>20MW), whereas ETS2 will extend carbon pricing to buildings not otherwise covered in the ETS as of 2027.The Germany Heat Planning Act requires district heating networks to reach at least 30% share of renewable and unavoidable waste heat by 2030, 80% climate-neutral supply by 2040, and full climate neutrality by 2045.
	Strengthen municipal heat mapping and planning and subsequent implementation	The Germany Heat Planning Act requires municipalities to develop local heat plans with timelines and details varying by city size. In the United Kingdom, Heat Network Zoning (2023) identifies areas where heat networks are the lowest-cost, low-carbon option, using national modelling of building type, size, and existing energy use to pinpoint suitable zones. In the European Union, the Heat Roadmap Europe provides system-level emissions reduction pathways that guide municipalities on the role of district heating in cost-effective heat planning, while the Hotmaps offers spatial data tools to support local heat planning and network design.
	Improve the viability of integrated renewable sources	Several countries have improved electricity-to-gas ratios for heat pumps used in district heat networks through industrial tariffs: Denmark and Finland through reduced electricity taxes, Ireland through renewable share relief, and Denmark and the Netherlands via dynamic pricing to shift peak loads.
District heating systems characterised by ageing infrastructure, low efficiency, and high operating temperature requirements	Target public funding for modern energy-efficient pipe replacement and return-temperature reduction measures	The EU Heating and Cooling strategy and AccelerateEU toolbox promote renewable heat deployment, supported by the Renewable Energy Directive's binding targets for renewable heating and cooling, including indicative targets for district heating, EU Modernisation Funds (provided via ETS revenues) in Central and Eastern EU countries provide additional funding for projects contributing to renovation or new construction of heat production capacity and heating pipelines. The Netherlands requires local governments to phase out natural gas by 2049. Countries such as Germany (BEW), France (Fonds Chaleur), and Denmark complement this with capital subsidies, low-cost public financing and geothermal risk mitigation to support solar thermal, geothermal, and thermal storage.
	Introduce mandatory metering and consumption-based billing to incentivise efficiency	The European Union's EED ensures that, for district heating, district cooling, and domestic hot water, final customers are provided with competitively priced meters that accurately reflect their actual energy consumption.
	Modernisation requirements tied to utility licences or concession renewals	In 2025, the Paris City Council approved a new concession contract for the production and distribution of the city's district heating network. The contract aims to achieve 76% locally produced renewable and recovered energy by 2034.
	Introduce digitalisation support: SCADA systems, predictive maintenance, real-time optimisation, and smart controls	Under the EU Modernisation Fund, Poland launched the Digitalisation of Heating Networks Program running from 2022-2025, which provided grants and loans to support construction and renovation of automation, telemetry, and telemechanics systems involving the implementation of modern IT/OT tools and solutions for supervision, control, monitoring, and analysis of qualitative and quantitative parameters of the heating system and heat/cold transmission, as well as fault location.

Challenge	Policy priority	Selected international examples
Structural investment barriers and misaligned business models	Heat-planning obligations that give long-term visibility to investors	Under the European Union's EED, member states shall ensure that regional and local authorities prepare local heating and cooling plans in municipalities with a total population greater than 45 000. The EED also establishes gradually increasing targets for renewable energy and waste heat in heating and cooling, reaching 100% by 2050.
	Concession models and Regulated Asset Base (RAB) approaches to derisk investments	The Paris City Council approved a new 25-year concession contract for the production and distribution of the city's district heating network, aiming to achieve 76% locally produced renewable and recovered energy by 2034. The Netherlands follows a regulated-asset-base approach, under the Heat Act, in which the market authority determines the maximum price a heat supplier may charge. The maximum price is composed of a usage-dependent and usage-independent part.
	Access to low-cost finance through development banks, climate funds, or green bonds	The EU Modernisation Fund provides support for energy system modernisation and energy efficiency improvements in EU countries where GDP per capita is below 60% of the EU average. The fund is financed by the sale of CO_2 emissions allowances in the European Union's ETS, with funding distributed by the European Investment Bank.
	Tariff reform with clear social protections for vulnerable consumers	The European Union's Social Climate Fund – linked to the extension of emissions trading to buildings and transport (ETS2) – provides targeted financial support to vulnerable households to mitigate the social impacts of higher energy costs.

Challenge 1: Well-established reliance on fossil fuels

In all fossil fuel-dominant district heating networks, whether fuels are imported or sourced domestically, legacy systems and well-established regulatory frameworks may hinder the integration of renewables, leading to a business-as-usual, fossil fuel-based scenario.

Policy Responses

Heat mapping and planning

Heat mapping is important for providing data on supply and demand trends for heating and cooling and identifying low-, medium-, and high-cost opportunities to integrate renewable energy into existing district energy networks. Policymakers can use this data to design policies, programmes, and regulations, while investors may use it to identify new opportunities.

Improving the viability of large-scale heat pumps

Large-scale heat pumps and waste-heat recovery offer a rapid pathway to reduce reliance on fossil fuels in district energy systems. However, their deployment is often constrained by unfavourable economic and regulatory conditions. Electricity prices frequently remain significantly higher than fossil fuels, while frameworks to incentivise or remunerate waste-heat supply are often underdeveloped. Policymakers can address these barriers by rebalancing electricity and gas price signals, introducing incentives or obligations for waste-heat recovery, and establishing clear commercial frameworks for integrating third-party heat sources into district networks.

Incentivising the transition away from fossil fuels

Policies and regulations can be important to incentivising the transition away from fossil fuels and increasing the competitiveness of renewable energy. For example, regulations such as carbon pricing can slowly increase the cost of using fossil fuels for end users. Similarly, emissions-based performance standards, often used in the transport sector, can support the gradual reduction of carbon intensity in a given sector. Policies and regulations like this can reduce the cost gap between fossil fuels and renewables and incentivise greater adoption of the latter.

Challenge 2: District heating systems characterised by ageing infrastructure, low efficiency, and high operating temperature requirements

Many systems in these regions require very high supply temperatures to operate and suffer from high leak rates and low overall efficiency, often due to old pipelines, inadequate insulation, and equipment long past its economic lifetime. These conditions constrain the integration of renewable or waste-heat sources, increase operating costs, and lock utilities into high-temperature fossil generation. The core challenge is to bring networks up to modern operating standards, both to reduce losses and to enable integration of heat pumps, bioenergy, geothermal, solar thermal, and industrial waste heat.

Policy responses

Funding for maintenance and retrofits

Maintenance and retrofits for district heating systems (e.g. pipes, return temperatures) are required to ensure they remain efficient and operable. Without this they continue to operate at high temperatures not necessarily needed for all heating purposes reducing efficient uses of heat. However, infrastructure maintenance and retrofits may require large upfront capital commitments in the short term for system operators. Financial support (e.g. grants, low-interest loans) can help support maintenance and retrofits to improve the efficiency of systems.

Incentivising efficiency

Improving the efficiency of existing district heating networks requires stronger incentives on the demand side to reduce heat consumption and optimise system performance. Mandatory metering and consumption-based billing are key to achieving this, as they shift consumers from flat or normative tariffs to pricing structures that reflect actual energy use. This creates incentives for households and building operators to reduce heat demand, improve internal systems, and avoid excessive return temperatures, all of which contribute to lowering network temperatures and improving overall efficiency. These measures are particularly important in legacy systems where billing is still based on floor area or estimated consumption, limiting incentives for efficiency and leading to higher system costs. Combined with transparent tariff structures and consumer information, metering enables more accurate pricing, supports demand-side management and facilitates the transition towards modern, low-temperature district energy systems.

Modernisation requirements tied to utility licences or concession renewals

Modernising ageing, high-temperature district heating networks often requires large, upfront investments that utilities may delay in the absence of strong regulatory drivers. Linking modernisation requirements to utility licences or concession renewals provides a powerful mechanism to accelerate upgrades by making continued operation conditional on meeting defined performance and emissions reduction criteria. These can include targets for reducing network temperatures, improving efficiency, integrating renewable and recovered heat, or replacing fossil-based generation assets. Such approaches are particularly effective at key decision points (such as concession renewals or licence extensions) when contractual terms can be renegotiated, and long-term investment plans reset.

Digitalisation support: Supervisory Control and Data Acquisition (SCADA) systems, predictive maintenance, real-time optimisation, and smart controls

Digital solutions hold significant potential to improve the performance of district energy networks by enhancing system visibility, control, and flexibility. SCADA systems enable operators to monitor key parameters across substations and along the network in real time. Beyond basic monitoring and control, more advanced digitalisation that combines SCADA with smart sensors, data analytics, and forecasting tools can unlock further efficiency gains, enabling, for example, predictive maintenance or real-time optimisation of network temperatures, flows, and supply sources. Despite these benefits, digitalisation remains uneven across regions. Targeted policy support through investment programmes, technical standards, and capacity building can accelerate the deployment of advanced control systems as a key enabler of more efficient, low-temperature, and renewable-ready district energy networks.

Challenge 3: Structural investment barriers and misaligned business models

Despite strong technical potential and growing policy ambition, investment in district energy systems continues to be constrained by structural and financial barriers. District heating and cooling networks are capital-intensive, requiring large upfront infrastructure investment, long payback periods, and high confidence in future demand. Investors face risks linked to uncertain customer connections, regulatory instability, evolving technology choices, and exposure to fuel or electricity price volatility. In many markets, these risks translate into high costs of capital or reliance on short-term public support, slowing deployment. Addressing this challenge requires policy frameworks that provide long-term visibility, allocate risks appropriately between public and private actors, and enable business models that deliver affordable heat while supporting sustained investment in low-carbon infrastructure.

Policy responses

Heat-planning obligations that give long-term visibility to investors

Mandatory local or regional heat planning can significantly reduce investment risk by providing clarity on where district energy is expected to expand, areas that will be prioritised for network solutions, and how heating and cooling demand is likely to evolve. Clear plans signal future customer bases, guide infrastructure sequencing, and reduce uncertainty around competing alternatives such as individual gas or electric solutions. When heat planning is linked to binding targets for renewable and waste-heat integration and supported by implementation timelines, it improves bankability by giving investors confidence that networks will be expanded and utilised over decades rather than subject to ad-hoc decisions.

Concession models and Regulated Asset Base (RAB) approaches to de-risk investments

Well-designed regulatory and contractual frameworks can lower investment risk and reduce financing costs for district energy infrastructure. Long-term concession agreements, when combined with clear performance and emissions reductions requirements, provide revenue stability while maintaining public oversight. RAB models similarly allow regulated returns on efficiently incurred investments, reducing exposure to volume and price risks. Both approaches can help mobilise private capital and shift investment decisions toward long-term system optimisation. This in turn may ensure that infrastructure upgrades, integration of renewables, and network expansion are undertaken in a timely manner.

Access to low-cost finance through development banks, climate funds, or green bonds

Public financial institutions play a critical role in overcoming high upfront capital costs, particularly in markets with limited access to long-term, low-cost financing. Development banks, climate funds, and green bond instruments can lower weighted average costs of capital through concessional lending, guarantees, or co-financing structures. Such financing is especially important for early-stage network development, system modernisation, and integration of renewable heat sources that generate long-term public benefits but may not be fully reflected in short-term market returns. Blending public and private finance can accelerate scale up while strengthening project pipelines.

Tariff reform with clear social protections for vulnerable consumers

Cost-reflective but socially balanced tariff structures are essential for sustainable district energy business models. Investments in network upgrades and renewable heat integration can increase tariffs in the short term, even as they reduce long-term system costs and exposure to fuel price volatility. Transparent tariff design, combined with targeted social protection mechanisms, helps maintain public acceptance and political support. Protecting vulnerable consumers through dedicated support schemes ensures that affordability concerns do not slow investment or undermine the transition, while allowing operators to recover costs and finance the long-term transformation of district energy systems.

Untapped and emerging district energy markets

Significant potential remains for the deployment of renewable district energy networks – which may include district heating, district cooling, or combined district heating and cooling – in several other regions of the world where they are not yet present or remain limited. For the purposes of this report, we refer to those regions as untapped and emerging markets. In North America in particular, conditions are ripe for deployment. The region boasts several well-populated and large urban centres; it experiences cold winters and hot summers; ageing public infrastructure requires upgrades that could integrate modern district heating and cooling systems; and the continued construction of new homes and housing projects offers the potential to integrate district energy networks into new communities. In the United Kingdom and Southern Europe, the growing need to reduce reliance on imported fossil fuels, improve energy security, and support both heating and cooling also provides opportunities for deployment of renewable district energy. Similarly, warming temperatures in South America, North Africa, and the Middle East creates potential opportunities for the deployment of district cooling systems.

Untapped opportunities also exist within regions that already have established district heating markets. In these cases, the priority may not be to create district energy markets from scratch, but to expand existing systems towards integrated district heating *and* cooling. This is particularly relevant where reliable cooling anchor loads (e.g. commercial buildings, hospitals, data centres, shopping centres or other large service-sector facilities) can improve year-round network utilisation, as well as in regions where heating and cooling needs coexist across the year and support all-year operation of district energy systems.

Introducing district heating and/or cooling systems in these areas could strongly complement efforts to electrify other economic sectors by reducing peak demand for future heating and cooling from electricity. This would reduce the need to expand electricity grids and provide cost-effective thermal storage. In addition, these regions are well situated to leverage a suite of renewable energy technologies, such as geothermal, solar thermal, bioenergy, large-scale heat pumps, and waste heat from industrial sectors.

However, three main challenges exist for greater deployment of renewable energy and district energy networks in these markets: Limited long-term policy and regulatory support; lacking infrastructure development; and undeveloped or underdeveloped labour markets.

Untapped and emerging district heating markets: Challenges and policy recommendations

Challenge	Policy priority	Selected international examples
Limited long-term policy and regulatory support	Develop long-term heating and cooling targets and strategies	India's Cooling Action Plan sets a combination of supply, demand, research, and skilled labour targets to improve cooling efficiency and support future demand.
	Implement heating and cooling mapping	The Cooling Singapore 2.0 initiative, a research initiative funded by the Singapore government, is developing a Digital Urban Climate Twin to assess different scenarios to improve urban heating, cooling, and infrastructure development and support policy and investment decision-making.
	Create measures to improve competitiveness of renewable energy	Sweden's carbon tax, implemented in 1991, applies to transport and heating fuels to increase the cost-competitiveness of renewable energy. In addition, Sweden has supplemented this with a reverse auction for BECCS to further incentivise the use of renewable energy in heat and electricity generation.
Lacking infrastructure development	Conduct feasibility studies and pilot projects	The US state of Washington's Supporting Thermal Energy Networks Act establishes a funding programme to support thermal energy network pilots and requires gas utilities to submit thermal energy network pilot project proposals.
	Provide public infrastructure funding	The US state of Illinois' Clean and Reliable Grid Affordability Act establishes funding and financing mechanisms to support deployment of thermal energy networks.
	Implement regulatory support for sustainable community energy planning	In the Netherlands, the Municipal Instruments Heat Transition Act provides municipalities with the ability to designate which neighbourhoods will switch to sustainable heat. This includes both single-building solutions and development of district energy networks.
	Advance sector coupling	Germany's Funding for Efficient Heat Networks provides funding for district energy across the value chain, including up to 40%, and a maximum of EUR 100 million per project, for renovating, expanding, and/or developing systems using waste heat.
Undeveloped or underdeveloped labour markets	Develop academic and skilled-labour training programmes	DHC Academy was developed by several European universities with funding from the European Union to develop a combined post-secondary education and vocational training programme to meet changing demands in the district energy employment labour market.
	Provide financial aid for education, training, and hiring skilled labour	Canada's Sustainable Jobs Training Fund supports training projects that help workers upgrade or learn new skills for renewable energy technologies.
	Strengthen international collaboration	Initiatives such as the IEA Technology Collaboration Programme, which includes District Heating and Cooling, Heat Pumping Technologies, and organisations, such as Euroheat and Power and the International District Energy Association, develop reports, training, and workshops to share knowledge and support capacity building across district energy network value chains.

Challenge 1: Limited long-term policy and regulatory support

In untapped and emerging markets, policy and regulatory support remains limited when compared to regions with significant district heating deployment. This is in part due to less historical exposure to fluctuations in fossil fuel prices, which is a driving factor for countries in other regions to transition to renewable energy in district heating systems, as well as a stronger policy focus on improving energy efficiency, reducing emissions, and deploying renewable energy technologies at the individual building level, rather than a broader focus on community energy planning. These factors limit investor confidence and delay development of necessary supply chains to support further deployment of district energy networks.

Policy responses

Develop long-term heating and cooling targets and strategies

National renewable heating and cooling targets and/or strategies that are clear, consistent, and timebound create policy certainty for investors. This is important for ensuring long-term investment, management, and development of district energy networks. It also ensures that other supply chain actors and end users scale up appropriate resources and investment to support network development and signals a government's commitment to support policy and regulatory innovation over the long term.

Implement heating and cooling mapping

Regional and/or municipal heat mapping is important for providing data on supply and demand trends for heating and cooling. This can be used by policymakers to design policies and regulations, and by investors to identify new opportunities. This also helps to prioritise decision-making based on the ease of developing new networks, integrating renewables, and opportunities to couple with existing sources of waste heat from different sectors.

Create measures to improve competitiveness of renewable energy

Carbon taxes and/or renewable energy support schemes, such as feed-in tariffs or subsides, can be important in supporting the deployment and integration of renewable energy in district heating networks. They can improve cost-competitiveness, especially for new and emerging technologies such as solar and geothermal, by either increasing the cost of fossil fuels or reducing the cost of renewable energy.

Challenge 2: Lacking infrastructure development

As previously noted, district energy networks are capital-intensive. They require extensive construction (which may impact day-to-day activities in the neighbourhood in which they are being deployed) and large upfront expenses in building retrofits and accompanying infrastructure. They can therefore take more time to implement in comparison to single-building renewable energy technologies (e.g. installing a heat pump) and appear more expensive than other renewable energy technologies because of the high upfront costs. In addition, the implementation of district energy networks may compete with other types of existing energy infrastructure that have already been prioritised by governments (e.g. natural gas infrastructure for houses, apartments, and buildings). These factors can sometimes limit decisions to invest in new, or expand existing, district energy infrastructure.

Policy Responses

Conduct feasibility studies and pilot projects

Developing feasibility studies and/or district energy pilot projects are lower-risk investments than full district energy network developments and can provide important data points for policymakers and investors. For policymakers these types of projects can help with designing policies and funding programmes and with drafting regulations by comparing community-level and single-building renewable energy technologies with one another to identify the best technologies to reduce emissions and improve energy security. For investors, they can provide initial capex and opex estimates to improve understanding of necessary resources required to build systems.

Provide public infrastructure funding

Dedicated funding for district energy infrastructure (e.g. pipes, heat meters, heat exchangers in buildings), as is often provided specifically for other sustainable energy technologies such as solar PV and heat pumps, can support project development given upfront capital expenditures. Measures including grants, low-interest loans, and/or investment tax credits to support project development, especially projects looking to integrate renewable energy.

Implement regulatory support for sustainable community energy planning

Regulations can support greater deployment of renewable district energy infrastructure by creating limitations, mandates, or incentives. For example, regulatory changes that limit continued expansion of existing fossil fuel networks (e.g. natural gas networks), would limit fossil fuel heating as an option for new housing, apartment, and building developments, while mandating that community energy planning with any new project development would require project developers to consider renewable energy technologies alternatives.

Advance sector coupling

Identifying and aligning cross-sectoral opportunities to enhance the supply and demand of renewable heat through leveraging waste heat, connecting to existing networks, or developing new networks around emerging industrial and building projects can reduce infrastructure costs, optimise resources, and accelerate network deployment in areas where supply and demand already exist or are expected to emerge. In addition, when coupled with electricity grids, district heating can act as a long-term battery storage for excess electricity supply, which in turn improves the ability to integrate variable renewable generation in electricity generation as well as heating and cooling.

Challenge 3: Undeveloped or underdeveloped labour markets

District heating networks require skilled and experienced project managers, technicians, and system operators. In regions where these networks are not well developed, or not developed at all, sourcing skilled labour can be a challenge. This can impact project development, system maintenance, and limit performance of these systems. This is especially true in regions with no existing district energy networks, which can further disincentivise the development of large networks.

Policy responses

Develop academic and skilled-labour training programmes

Developing educational and vocational programmes to support training, re-skilling, and up-skilling can support labour market development. The availability of programmes provides opportunities for individuals to enter district energy labour markets for the first time or transition from other energy infrastructure-related professions where only minimal training and certification may be required, which could expedite the availability of trained professionals.

Provide financial aid for education, training, and hiring skilled labour

Financial support for students and apprenticeship programmes (e.g. grants, interest-free loans, tax credits) can help ensure that students are able to attend multi-year educational programmes, attend vocational training programmes, or re-skill or up-skill with limited financial burden. This can reduce barriers to entering the labour market for young students and those looking to change careers. In addition, financial support for employers to hire skilled labour (e.g. wage subsidies) can help provide project developers with the human resources needed to develop projects while also providing employment opportunities for new students or retrained employees.

Strengthen international collaboration

Participation in international initiatives can support information sharing and capacity building across the district energy value chain, including in education, training, and labour market development. This can be extremely valuable for stakeholders with limited expertise and/or resources in developing district energy networks to have access to free or low-cost information, training materials, and subject matter experts.

Acronyms and abbreviations

BECCUS	Bioenergy with carbon capture, utilisation and storage
BEW	Federal Subsidy for Efficient Heat Networks
CAPEX	Capital expenditures
CCUS	Carbon capture utilisation and storage
CHP	Combined heat and power
DHC	District heating and cooling
EBRD	European Bank for Reconstruction and Development
EED	Energy Efficiency Directive
EnWG	Energy Industry Act (Germany)
EPBD	Energy Performance of Buildings Directive
EUDP	Energy Technology Development and Demonstration Programme
ETS	Emissions Trading System
EU	European Union
HOB	Heat-only boiler
LCOH	Levelised cost of heat
OPEX	Operational expenditures
PPP	Public-private partnership
PTES	Pit thermal energy storage
RAB	Regulated Asset Base
SCADA	Supervisory Control and Data Acquisition
STEPS	Stated Policies Scenario
TES	Thermal energy storage

See the IEA glossary for a further explanation of many of the terms used in this report.

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