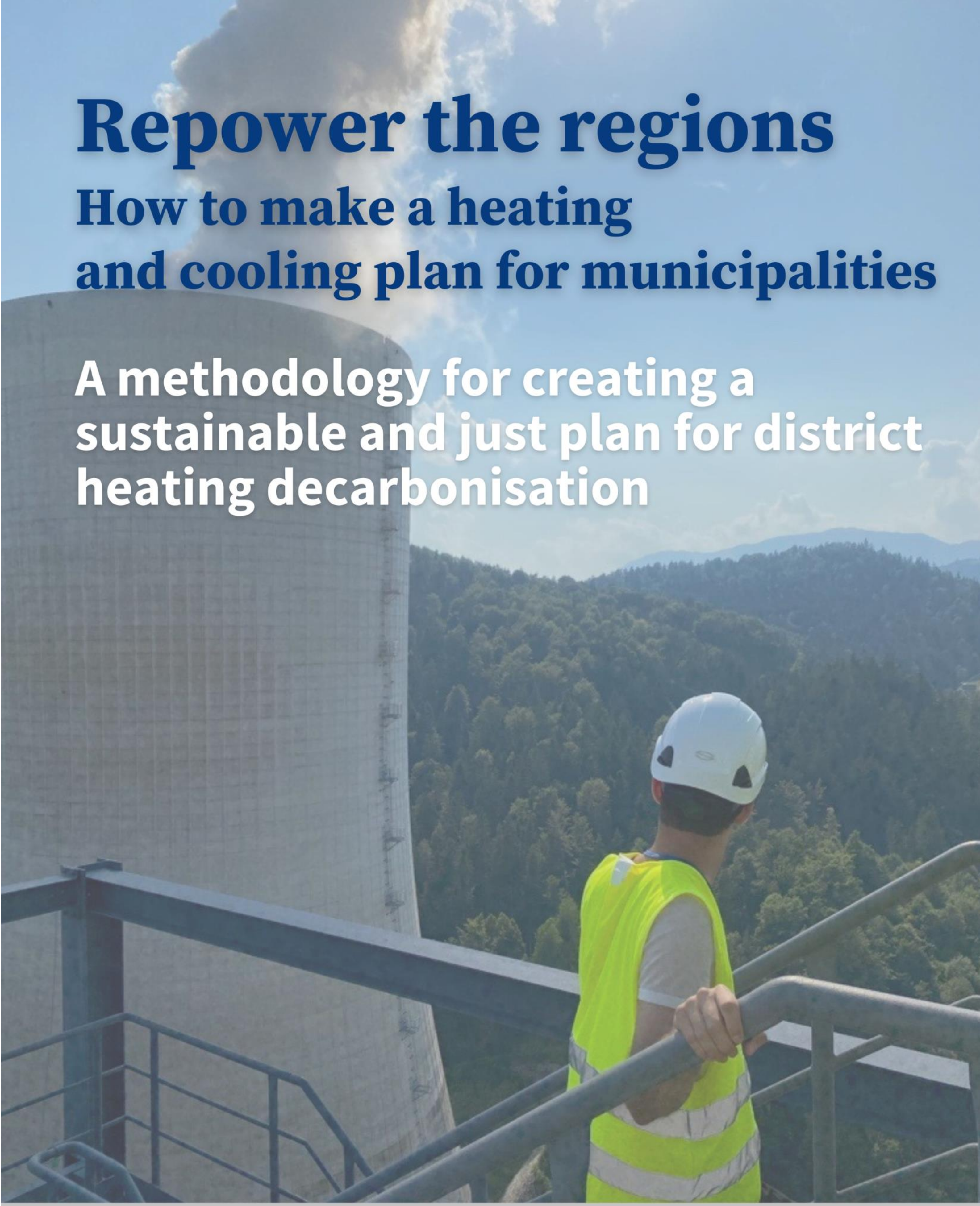

Repower the regions

How to make a heating and cooling plan for municipalities

A methodology for creating a sustainable and just plan for district heating decarbonisation

CEE Bankwatch Network

EXERGIE
too good to be wasted

SEPTEMBER 2024

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Funded by

The RePower the Regions project has received funding from the LIFE Programme of the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

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Executive summary

The European Green Deal was adopted as a growth strategy to transform the European Union (EU) into a modern, resource-efficient and competitive economy. It aims to bring about cross-sectoral, transformative change, decouple economic growth from resource use, and eliminate net emissions of greenhouse gases by 2050.

Decarbonisation poses significant challenges to regions that are heavily reliant on activities like fossil fuel extraction, related energy production, and carbon-intensive industries. To ensure a just transition for all – one that leaves no person or region behind – the EU established the Just Transition Fund. Its objectives are to alleviate the socio-economic costs triggered by the transition towards climate neutrality, support the economic diversification and reconversion of territories most affected by the shift, and help people adapt to the changing labour market.

One of the supported areas is the development of clean energy, including district heating and cooling (DHC). Heating and cooling accounts for roughly half of the EU's energy demand and more than 40 per cent of its carbon dioxide (CO_2) emissions. Therefore, accelerating the transition of the sector is essential if the bloc is to achieve its climate goals and energy independence. For this very reason, the EU's recast Energy Efficiency Directive (EED)[1] obliges (Art.25(6)) EU Member States to prepare local heating and cooling plans (LHCPs). These plans are designed to help local authorities develop a comprehensive understanding of the dynamics of heat supply and demand within their territories, enabling them to create clear, localised and effective strategies for decarbonising their heat supply and decreasing demand.

For municipalities to be effective in phasing out fossil fuels from their heating systems, they need the support of Member States. Heat planning is an intensive exercise for which most municipalities are not ready. A recently published EU tracker,[2] which assesses the state of play of local heating and cooling planning across Member States, shows that most countries lack appropriate regulatory and support frameworks for municipalities to develop and implement LHCPs.

The transition towards cleaner and diversified energy systems at the local level cannot be successful unless state authorities take a proactive approach. Adjustments or even principal changes to state legislation and regulations may be necessary to motivate citizens, municipalities, businesses and other stakeholders to change their behaviours.

With this in mind, the methodology proposed in this study for local heating and cooling planning at the local level (Chapter 3) is supplemented by a set of specific legislative and regulatory recommendations at the state level (Chapter 4).

The local heating and cooling planning methodology outlined in Chapter 3 provides comprehensive guidance for municipalities on the organisation and content of the methodology. The municipality should invite all relevant stakeholders – including operators of existing DHC systems as well as electricity and gas grids, energy communities, and other relevant entities likely to be affected by the rollout of an LHCP – to

[1] European Parliament and the Council, Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955, *EUR-lex*, 13 September 2023.

[2] Energy Cities, EU Tracker – Local heating and cooling plans. The state of play in EU Member States, *Energy Cities*, accessed 10 September 2024.

contribute to the planning process. All cooperating parties are then obliged to provide all necessary data and support the planning process.

The planning process itself begins with a thorough inventory analysis. In this phase, building types are analysed, existing heating networks and heat sources are identified, and all other relevant data are collected.

In the second phase, an analysis of the potential for heat production through RES is conducted. In addition, other heat sources such as wasted heat from industrial plants are considered.

In the third phase, scenarios for future heat supply are developed along with a definition of the target scenario, including the division of the area into prospective heat supply zones. This takes into account both climate objectives and affordability.

The LHCP should also include an implementation strategy defining who is responsible for each action, the associated costs, who will bear them, and the financing options available. Measures to encourage consumers through local subsidies or educational programs to switch to renewable energy should also be included.

The methodology also establishes requirements for district heating operators, who should incorporate heat planning into their decarbonisation plans. Infrastructure operators should also align their development plans with the results of the LHCP. For example, if an area is designated as suitable for district heating, the gas grid should not be further developed in that region, and electricity grids should be developed according to the extension plans for heat pumps.

Though DHC and infrastructure operators are often private entities, they are also subject to state regulation. Therefore, the state should adapt regulations to motivate or require these operators to act accordingly. Chapter 4 contains various other measures and policies that governments and other relevant authorities can adopt to create an effective legislative and regulatory framework, intended to support municipalities and make heat plan s enforceable.

Three annexes complement the methodology, providing an overview of relevant EU legislation, technologies, and best practices.

Introduction

Decarbonising the heat sector will require replacing the current models of fossil fuel cogeneration based on coal and gas with RES to improve energy efficiency. This shift will involve utilising renewable electricity converted to heat alongside other technologies such as deep geothermal, solar thermal, and the harnessing of unavoidable wasted heat. In addition, it will require significant improvements in energy efficiency through building renovations, grid upgrades, digitalisation, and storage solutions.

DHC is acknowledged as a key measure for decarbonising energy systems in densely populated areas, offering several advantages over individual heating systems:

1. diversification of the energy mix;
2. integration of RES (from rivers, seas, wastewater, and shallow geothermal sources) through large heat pumps;
3. integration of deep geothermal energy;
4. utilisation of wasted heat from industrial and tertiary sectors;
5. enhanced flexibility of the energy system through cost-effective thermal energy storage solutions like hot-water tanks and underground facilities;
6. contribution to air-quality objectives, particularly through replacing or avoiding domestic heating reliant on solid fuels.

DHC is a complex system that requires forward planning and considerable investment, not only from heat suppliers but also from consumers due to the long-term obligation to purchase heat. It is crucial to ensure the stability of the framework through legislation, financing, and land planning. Another pre-requisite for the successful implementation and operation of the system is to establish working relationships with consumers and other stakeholders, including municipalities and energy communities.

A complex approach involving all stakeholders is necessary to maintain, modernise, or extend the DHC system, especially in just transition regions in central and eastern Europe. Human resources are also of crucial importance. Switching to DHC necessitates a complex transition that, even for energy professionals, is not easy to understand and one that requires substantial training and pooling of resources between municipalities. Technical and personal support is also vital, particularly for smaller cities.

In recent years, several methodologies have been developed, mainly by non-governmental organisations. However, the most up-to-date benchmark is the newest German legislation in the heat sector.[3] Recognising that decarbonisation cannot be achieved without the significant development of DHC, the German government plans to increase the share of heat supply from DHC from the current 15 per cent to above 40 per cent.

[3] German government, Act on the Saving of Energy and the Use of Renewable Energies for Heating and Cooling in Buildings, *German government*, accessed 10 September 2024.

To achieve this goal, two new pieces of legislation have been introduced. The first is the Heating Act (Heizungsgesetz), which requires and financially incentivises citizens to either gradually switch to a renewable heat source or join an existing DHC system or one that is planned for their locality. The second is the Heat Planning Act (Wärmeplanungsgesetz), which reflects the requirements of Art.25(6) of the EED. It provides comprehensive guidance on local heating and cooling planning, including information on coordinating the development of heating, electricity, and gas grids.

The above framework, adapted for routine use in line with CEE Bankwatch Network policy positions, serves as the cornerstone of the proposed methodology below.

Methodology for local heating and cooling planning

Introduction

Heating and cooling planning requires strategic technical planning that explores opportunities for the expansion and further development of grid-based energy infrastructures. This approach necessitates a nuanced consideration of the heating and cooling supply, the use of heat from RES, wasted heat, or a combination of these, as well as methods for conserving heat. It must also outline the medium- and long-term strategies for supplying heat to designated areas.

A municipality in an area with more than 45,000 inhabitants should develop a heat plan that:

7. complies with the ‘energy efficiency first’ principle as set out in Article 3 of the EED;
8. considers the purpose of the National Climate Protection Act and the objectives set out for its fulfilment;
9. contains an assessment of the role of renewable energy communities or other consumer-led initiatives that can actively contribute to the implementation of local heat supply projects;
10. includes an assessment of how the implementation of the strategies and measures can be financed and identify financing mechanisms that enable consumers to switch to heat generation from renewable sources;
11. contains an assessment of potential synergies with the plans of neighbouring regional or local authorities to promote joint investment and cost efficiency; and
12. includes, where justified, cooling as part of the planning.

The municipality may commission third parties to perform or assist in conducting this task. Joint heat planning can be conducted for several municipal areas. A simplified procedure for heat planning applicable to municipalities below 45,000 inhabitants can be prepared on a voluntary basis.

The municipality should involve:

13. the public as well as all authorities and public interest groups whose areas of responsibility are affected by the heat planning;

14. any operator of an energy infrastructure located within or adjacent to the planned area;
15. any operator of a heating network located within or adjacent to the planned area;
16. any private or legal person who, as a future operator of an energy supply network or a
17. heating network within the planned area, is foreseeable;
18. existing and known potential producers of heat from RES or of wasted heat, if the heat or wasted heat is fed into a heating network within the planned area or is suitable for this purpose;
19. existing and known potential large-scale consumers of heat or gas as well as known potential large-scale consumers who use gaseous energy sources for material purposes;
20. municipalities or associations of municipalities bordering the planned area;
21. other municipalities, associations of municipalities, state authorities, local authorities, institutions providing social, cultural, or other public services, public or private companies in the real estate sector and the chambers of crafts and trades responsible for the planned area, and other legal persons or partnerships, in particular renewable energy communities, which can contribute to the decarbonisation of the heat supply in the planned area or to the expansion or conversion of the infrastructure required for this purpose or are of importance for this purpose, or whose interests are otherwise affected by the heat planning.

Requirements for cooperation

The private or legal persons or partnerships referred to above, upon request by the municipality, cooperate in the implementation of the heat planning, by providing relevant information or advice, by submitting statements or attending meetings and, if necessary, by transmitting data to the municipality.

The energy infrastructure operators should, upon request, inform the municipality of their respective plans for the expansion or conversion of electricity, gas or heating network infrastructure in the planned area by the target year, provided that such plans exist. If the operators undertake plans to expand or renovate their networks, they should take the results of the heat plan into account.

Heat planning

Heat planning includes:

1. suitability tests;
2. an inventory analysis;
3. a potential analysis;
4. the development and description of a target scenario;
5. the division of the planned area into prospective heat supply areas and the presentation of the heat supply types for the target year; and

6. the development of a heat plan.

Suitability testing and shortened heat planning

(1) The municipality should examine the planned area as part of a suitability test for sub-areas which are highly unlikely to be suitable for supply by a heating network.

(2) The suitability assessment should be conducted based on available information on settlement structure, industrial structure, renewable and wasted heat potential, the location of energy infrastructure and demand assessments.

(3) A planned area or part of an area is unlikely to be suitable for supply by a heating network if:

1. there is currently no heating network in the planned area or part of the area and there are no concrete indications of usable potential for heat from RES or wasted heat that can be made usable via a heating network, and

2. due to the settlement structure and the resulting expected heat demand, it can be assumed that a future supply of the area or part of the area via a heating network will not be economical.

(4) For an area unlikely to be suitable for a heating network, an abbreviated heat plan can be conducted. A sub-area for which an abbreviated heat plan is conducted should be indicated in the heat plan as a prospective area for decentralised heat supply, along with documentation of the results of the suitability test. As part of the potential analysis, only those potentials are to be determined that come into consideration for the supply of areas for decentralised supply.

(5) It should be examined every five years to determine whether the reasons for the lack of suitability continue to apply.

Inventory analysis

(1) As part of the inventory analysis, the municipality should determine as a basis for the target scenario, for the division of the planned area into prospective heat supply areas and for the depiction of the types of heat supply for the target year:

1. the current heat demand or heat consumption within the planned area, including the energy sources used,

2. the existing heat generation plants and

3. the energy infrastructure facilities relevant for heat supply.

(2) As part of the inventory analysis, the municipality must systematically and professionally collect the information relevant to heat planning and the data required on the current supply of heat to the planned area:

1. in the case of an existing piped gas supply, the average annual gas or heat consumption for the last three years in kilowatt hours (kWh) per year, which is address-related for multi-family houses, and

only aggregated for at least five house numbers for single-family houses, and in the case of an existing piped heat supply, which is related to the transfer station,

2. for multi-family houses, address-related information and data on decentralised heat generation systems with combustion technology, for single-family houses only aggregated for at least three house numbers:

   a) the type of heat generator, for example central condensing boiler, floor heating, thermal bath,

   b) the energy source used,

   c) the thermal output of the heat generator in kilowatts (kW),

3. Information and data on the building, address-related for multi-family houses, for single-family houses only aggregated:

   a) the situation, for use,

   b) to the usable area and

   c) the year of construction,

4. in the case of industrial, commercial or other undertakings that use heat in their processes, or generate wasted heat, property-related information and data:

   (a) on the annual process heat consumption of the last three years in gigawatt hours per year, which cannot be collected using the data referred to in point 1, in any case with an indication of the magnitude in the bandwidths from 0.1 gigawatt hour (GWh) up to 2.5 GWh, with a bandwidth of 0.5 GWh from 2.5 to 7.5 GWh and with a range of 2 GWh over 7.5 GWh

   (b) the energy sources used,

   (c) to amounts of wasted heat

   (d) on the planned transformation of the process heat supply and the measures envisaged for this purpose,

5. Information on existing, specifically planned or already approved:

   (a) heating networks

   (aa) the location, which must be specified on a street-by-street basis,

   (bb) the type, distinguishing between water and steam,

   (cc) the year of commissioning,

   (dd) on the total heat demand in kWh, both annually and yearly,

   (ee) the total connected load in kW,

(ff) on the capacity utilisation at peak load in percent,

(gg) to flow and return temperatures in degrees Celsius, measured at the heat generator,

(hh) the total route length in kilometres,

(ii) the total number of connections,

(jj) the level of heat distribution losses,

(b) Heat generators

(aa) on the situation,

(bb) on the type,

(cc) on energy sources, their type and the quantity used,

(dd) thermal power in kW,

(ee) the amount of heat fed into the grid over the last three years in kWh per year,

(ff) on existing transformation plans under the federal funding scheme for efficient heating networks,

6. Information on existing, specifically planned or already approved gas networks, in particular:

(a) the location, which must be specified on a street-by-street basis,

(b) the type of gas (biomethane or hydrogen),

(c) the year of commissioning, which must be recorded on a road-by-road basis, as far as previously documented,

(d) total gas demand by pressure level in kWh, both annually and yearly,

(e) the total connected load according to pressure level in kW,

(f) the capacity utilisation at peak load in percent, based on the supply area,

(g) the total route length according to pressure levels in kilometres and

(h) the total number of connections by pressure level;

7. Information and data on existing, specifically planned or already approved high and medium voltage power grids, including medium and low voltage substations, in particular:

(a) the situation,

(b) the amount of free grid connection capacity and

(c) in the case of planned or already approved projects, the expected date of commissioning,

8. Information on planned optimisation, reinforcement, renewal and expansion measures in the low voltage network,

9. Information on sewage treatment plants relevant for wastewater heat recovery, at least the capacity in population equivalents,

10. Information on sewage networks with a minimum nominal diameter of DN 800,

    (a) the location, which must be specified on a street-by-street basis,

    (b) the nominal width in metres, which should be specified on a road-related basis,

    (c) the year of commissioning, which should be recorded on a road-by-road basis, and

    (d) to dry weather runoff,

Information on development plans that are already in force or are being drawn up, other urban planning and concepts as well as plans by other public planning bodies that may have an impact on heat planning.

Potential analysis

(1) As part of the potential analysis, the planning authority should determine, in a quantitative and spatially differentiated manner, the potential available in the planned area for generating heat from RES, for using unavoidable wasted heat and for central heat storage. Known spatial, technical, legal or economic restrictions on the use of heat generation potential must be considered.

(2) The planning authority should estimate the potential for energy savings by reducing heat demand in buildings and in industrial or commercial processes.

Target scenario

(1) In the target scenario, the municipality should describe the long-term development of heat supply for the planned area, which must be consistent with the division of the planned area into prospective heat supply areas, the description of the types of heat supply for the target year and the objectives of the Plan.

(2) The municipality should develop the target scenario based on the results of the suitability test, the inventory analysis and the potential analysis and in accordance with the division of the planned area into prospective heat supply areas.

(3) It should give the parties the opportunity to comment. To determine the relevant target scenario, the municipality considers different scenarios that are in line with the target and that consider in particular the anticipated development of heat demand within the planned area and the development of the energy infrastructure required for heat supply. From these scenarios, the municipality develops the target scenario that is relevant for the heat planning of the planned area, explaining the reasons.

Division of the planned area into expected heat supply areas

(1) The municipality should divide the planned area, unless it is subject to the abbreviated heat planning, into prospective heat supply areas based on the inventory analysis and the potential analysis. To this end, the municipality should, with the aim of supplying the respective sub-area as cost-efficiently as possible, use cost-effectiveness comparisons to show which type of heat supply is particularly suitable for the respective planned sub-area at each of the points in time under consideration. Types of heat supply that, compared with the other types of heat supply under consideration, have low heat generation costs, low implementation risks, a high degree of security of supply and low cumulative greenhouse gas emissions up to the target year are particularly suitable, with the heat generation costs comprising both investment costs including infrastructure development costs and operating costs over the lifetime. Proposals for supplying the planned sub-area must be considered by the municipality when making the division.

(2) The division of the planned area into prospective heat supply areas should be conducted for the observation points in time: 2030, 2035 and 2040.

(3) In addition to the expected heat supply areas, the municipality should plan sub-areas with increased energy saving potential. These areas can be represented as areas which appear suitable to be designated in the future in a separate urban development decision as a redevelopment area.

Presentation of heat supply types for the target year

(1) The municipality should, on the basis of the suitability assessment, the inventory analysis and the potential analysis, present the possible types of heat supply for the planned area for the target year. To this end, it should indicate which elements a heat supply based exclusively on heat from RES or from wasted heat within the planned area can consist of by the target year.

(2) The municipality should determine the suitability level for each planned sub-area and differentiate it according to the individual anticipated heat supply areas. Suitability levels are as follows:

1. the type of heat supply is highly likely to be suitable for this area in the target year;
2. the type of heat supply is likely to be suitable for this area in the target year;
3. the type of heat supply is likely to be unsuitable for this area in the target year;
4. the type of heat supply is highly likely to be unsuitable for this area in the target year.

Heat plan

(1) The municipality should summarise the main results of the heat planning in the heat plan.

(2) If any of the parties involved in the heat planning process holds a different perspective on the heat planning procedure and/or results presented in the heat plant, they should have the right to formulate and present their dissenting views in an appropriate way.

(3) The heat planning results must be presented in the heat plan in textual, graphical and cartographical form as follows:

I. Inventory analysis

The results of the inventory analysis must be presented in textual or graphic form in the heat plan for the planned area as follows:

1. the current annual final energy consumption of heat by energy source and final energy sector in kWh and resulting greenhouse gas emissions in tonnes of CO_2 equivalent;
2. the current share of RES and wasted heat in the annual final energy consumption of heat by energy source in percent;
3. the current annual final energy consumption of piped heat by energy source in kWh;
4. the current share of RES and wasted heat in annual final energy consumption piped heat by energy source in percent;
5. the current number of decentralised heat generators, including house transfer stations, by the type of heat generator including the energy source used.

The results of the inventory analysis must be presented cartographically in the heat plan for the planned area as follows:

1. the heat consumption densities in megawatts (MW) per hectare and year in the form of a building block-related depiction;
2. the heat line densities in kWh per metre and year in the form of a road section-related depiction;
3. the share of energy sources in the annual final energy consumption for heat in the form of a building block-related depiction;
4. the number of decentralised heat generators, including house transfer stations, by type of heat generator in the form of a building block-related depiction;
5. the predominant building type in the form of a building block-related depiction;
6. the predominant age class of the buildings in the form of a block-related depiction;
7. the customers or end users in the form of a location-based depiction;
8. existing, planned and approved

   (a) heating networks and pipes with information

   (aa) on the layout,

   (bb) type: water or steam,

   (cc) the year of commissioning,

   (dd) to temperature,

(ee) to the total route length and

(ff) the total number of connections,

(b) Gas networks with information

(aa) on the area-wide location, i.e. building block-related and not line-related,

(bb) to the type: FG, biomethane, hydrogen

(cc) the year of commissioning,

(dd) to the total route length and

(ee) the total number of connections,

(c) sewage networks and pipes with information on dry weather runoff;

9. any existing, planned or approved heat generation plant, including combined heat and power (CHP) plants, feeding into a heating network, with information on the nominal output, the year of commissioning and the energy source in the form of a location-specific depiction;

10. any existing, planned or approved heat and gas storage facility, differentiated by type of gas, which is operated commercially, in the form of a location-specific presentation;

11. any existing, planned or approved plant for the production of hydrogen or synthetic gases with a capacity exceeding 1 MW of installed electrolysis capacity in the form of a site-specific depiction.

II. Potential analysis

As a result of the potential analysis for the planned area, the identified potentials must be mapped out in the heat plan quantitatively, by energy source, and in a spatially differentiated manner. The potentials are presented in the heat plan with the aim of giving heat suppliers and consumers as concrete an indication as possible of which energy sources they should examine more closely in more in-depth analyses and planning. As part of the potential analysis, exclusion areas such as water protection areas or mineral spring areas must be shown in a spatially differentiated manner. The estimated potential for energy savings through reducing heat requirements in buildings and industrial and commercial processes is presented in a spatially differentiated manner.

In areas with more than 45,000 inhabitants, the assessment should include potential synergy effects with the plans of neighbouring regional or local authorities, particularly with regard to joint investments and cost efficiency.

III. Target scenario

The target scenario uses the following indicators to describe how the goal of a heat supply based on RES or the use of wasted heat is to be achieved. Unless otherwise specified below, the indicators are to be specified for the entire planned area and for the years 2030, 2035, 2040, and 2045. The indicators are:

1. the annual final energy consumption of the entire heat supply in kWh per year, differentiated by final energy sectors and energy sources;

2. the annual greenhouse gas emissions from the total heat supply in the planned area in tonnes of CO_2 equivalent;

3. the annual final energy consumption of the pipeline-based heat supply by energy source in kWh per year and the percentage share of each energy source in the total final energy consumption of the pipeline-based heat supply;

4. the percentage share of the pipeline-based heat supply in the total final energy consumption of the heat supply;

5. the number of buildings connected to a heating network and their percentage share of the total number of buildings in the planned area;

6. the annual final energy consumption from gas networks by energy source in kWh per year, and the percentage share of each energy source in the total final energy consumption of gaseous energy sources (this should decrease, not increase); and

7. the number of buildings connected to a gas network and their percentage share in the total number of buildings in the planned area (this should decrease, not increase).

IV. Division of the planned area into prospective heat supply areas

Considering the heat planning results and balancing the public and private interests affected, the municipality may decide on the designation of an area for the construction or expansion of heating networks.

The heat plan should present a classification of plots of land and building blocks into various categories of prospective heat supply areas for the years 2030, 2035, and 2040 in both cartographic and textual formats.

A sub-area deemed highly unlikely to be suitable for supply via a heating network will be marked accordingly in the heat plan and shown on a map as a prospective area for decentralised heat supply.

Areas with a connection and use obligation based on an existing statute, where heat supplied by individual decentralised heating systems is either prohibited or only permitted in exceptional cases, will be depicted on the map in cartographic format for informational purposes.

Sub-areas with increased energy-saving potential will also be indicated cartographically and textually in the heat plan.

V. Description of heat supply types for the target year

The presentation of heat supply types for the target year should cover both the entire planned area and the expected heat supply areas. The suitability of the individual planned sub-areas for heat supply should be expressed in terms of probability, ranging from ‘very probably suitable’ to ‘probably suitable’, and from ‘probably unsuitable’ to ‘very probably unsuitable’.

VI. Implementation strategy

(1) Based on the inventory analysis, potential analysis, and target scenario, the municipality should develop an implementation strategy. This strategy should include specific measures that the body itself will directly implement to achieve the objective of supplying heat generated exclusively from RES or wasted heat by the target year.

(2) In particular, the implementation measures should be presented in such a way that:

1. the necessary steps for implementing each measure are clearly outlined;
2. the date for completing the implementation of each measure is identified;
3. the costs associated with the planning and implementation of each measure are specified;
4. the entity responsible for bearing these costs are established;
5. the positive impact of the measures on achieving the target scenario and the objectives of the law are described;
6. in the case of an area with more than 45,000 inhabitants, the financing mechanisms are identified and weighted for the implementation of strategies and measures aimed at encouraging consumers to switch to renewable energy; and
7. a risk and sensitivity analysis is included.

(2) To implement the measures, the municipality may conclude appropriate agreements with the persons concerned or third parties.

(3) The municipality is obliged to review the heat plan at least every five years and to monitor progress in implementing the strategies and measures identified. If necessary, the heat plan must be revised and updated. The update should show the development of the heat supply for the entire planned area up to the target year.

Requirements for operators of heating networks

Drawing up heating network expansion and decarbonisation plans

(1) Every operator of a heating network that is not already completely supplied with heat from RES, wasted heat, or a combination thereof is obliged to draw up a heating network expansion and decarbonisation plan for its heating network. This plan must be submitted to the authority designated by legal order and published on the heating network operator's website. Confidential data may be excluded from publication by the heating network operator. The heating network expansion and decarbonisation plan must be reviewed at least every five years and revised or updated if necessary.

(3) The heating network expansion and decarbonisation plan should consider any existing or planned heat plan, in particular with regard to the classification of planned sub-areas into a heat supply area.

Requirements for the heating network expansion and decarbonisation plan

I. Purpose of the heating network expansion and decarbonisation plan

The heating network expansion and decarbonisation plan enables the heating network operator to demonstrate in a transparent and comprehensible manner that the development and expansion of an existing network or the construction of a new heating network aligns with the existing or planned heat plan for that area.

II. Description of the current state of the heating network

The heating network expansion and decarbonisation plan must contain a depiction of the current state of the existing heating network, including its spatial environment. For a new heating network, a heating network expansion and decarbonisation plan should include a depiction of the planned new heating network, including its spatial environment. To this end, the heating network expansion and decarbonisation plan should contain at the least the following details and information:

1. a precise definition and delimitation of the heating network examined in the heating network expansion and decarbonisation plan, including details of any connected heating networks to which heat is supplied or from which heat is obtained, as well as details and information on the length of the heating network;
2. a spatially resolved depiction of heat sales over the past three years for the area supplied or to be supplied by the heating network;
3. a description of the operation of the heating network, which includes at least the following:

   (a) information on the equipment and energy sources used, along with the respective shares in the energy supply,

   (b) information on the temperature curves,

   (c) a hydraulic operating description; and

   (d) a utilisation analysis; and
4. an energy and greenhouse gas balance based on current consumption data and energy source distributions for the preceding three years in accordance with accepted technical standards.

III. Presentation of the potential for the use of renewable energy or wasted heat

The heating network expansion and decarbonisation plan must outline the potential for increasing the use of renewable energy or wasted heat and the provision of the heat obtained from this use via the existing or new heating network. To this end, the heating network expansion and decarbonisation plan should contain at least the following information:

1. a spatially resolved depiction of the potential for generating and providing heat from RES;
2. a spatially resolved depiction of the potential for the use of wasted heat;

3. a spatially resolved depiction of the potential to integrate short-term and seasonal heat storage to decouple heat demand from heat generation.

IV. Future development paths of the network towards the decarbonisation target

The heating network expansion and decarbonisation plan must outline the measures needed to achieve the goal of supplying heat exclusively from renewable sources or wasted heat by the target year at the latest, and how these measures are to be implemented with respect to the existing or new heating network. To this end, the heating network expansion and decarbonisation plan should contain at least the following details and information:

1. long-term heat demand scenarios, considering all aspects relevant to the development of heat demand up to 2045*;
2. a detailed presentation of the planned development of the heat generation portfolio, considering the use of spatially resolved potentials for heat from renewable energy or wasted heat and the aspects relevant to climate neutrality up to 2045;[4,5]
3. the share of renewable energy and wasted heat in the annual net heat generated from the network and the associated greenhouse gas emissions for the years 2030, 2035, 2040, and 2045;
4. a description of the planned phase-out of the use of CHP plants powered by fossil fuels;[6]
5. a description of planned connections to other heating networks to which heat is supplied or from which heat is obtained;
6. a description of the planned temperature reduction; measures to reduce the temperature that are only possible in cooperation with the heat customer or by the heat customer must be described separately; and
7. a description of the planned use of internal network measurement technology.

V. Planned expansion of the heating network

The heating network expansion and decarbonisation plan shows, for an existing heating network that is to be expanded, which measures are necessary for its expansion and the connection of additional customers to the heating network and how they are to be implemented. To this end, the heating network expansion and decarbonisation plan contains at least the following details and information:

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[4] The figures and dates should align with the EU's ambition to be fully powered by renewable energy by 2040.

[5] For networks with a length of more than 50 kilometres, the target share of biomass in the annual amount of heat generated from the network should be limited to only peak demand that cannot be covered by other RES while taking into account the limited long-term availability of secondary biomass.

[6] It is assumed that the operation of CHP plants will increasingly be driven by the electricity market and will be used in the electricity sector in the long term to cover residual peak loads. We do not foresee a role for CHP plants powered by hydrogen or synthetic fuels in heating networks over the long term. However, if they are included in the plans, their role must be significantly limited in alignment with the outcomes of the heat plan, and provided specifically for peak load coverage, residual load coverage, and security. Any deviations from the assumptions in the transformation plan requires detailed justification.

1. a spatial and temporal depiction of planned extensions of the heating network, differentiated according to heating network densification or expansion including the planned route layouts,
2. a depiction of the expected heat consumption by newly connected consumers,
3. information on the status of the consultations with the municipality concerned and
4. a presentation of two- to three-year milestones for the development of the area with a
5. heating network.

VI. Necessary measures in the network

The heating network expansion and decarbonisation plan describes in detail the measures required to implement the planned decarbonisation and the planned heating network expansion or the planned new heating network construction. To this end, the heating network expansion and decarbonisation plan contains at least the following information:

1. a plant-related technical description of the planned network expansion or reconstruction measures, including a detailed description of the measures planned for the next four years,
2. a description of the investments expected to be necessary to implement the measures and the necessary operational management measures,
3. a calculation of the energy saved, and the greenhouse gas emissions saved, broken down into electricity, heat, fuel and auxiliary energy savings, specifying the calculation method chosen; the calculation must be conducted in accordance with recognised technical standards,
4. a presentation of the forecast development of heat production costs after implementation of the measures and a presentation of the effects on the development of end customer prices.

State policy, legislation and regulatory framework

The transition towards a cleaner and more diversified energy system at the local level cannot be successful without the proactive approach of state authorities. Adjustments or even principal changes of various pieces of state legislation and regulations may be necessary to motivate citizens, municipalities, businesses and other stakeholders to change their behaviour.

The municipalities and heating industry need a clear and strong legislative and regulatory framework, corresponding to the challenges faced by that sector. In this chapter various measures are suggested the state must adopt to create a supportive framework for municipalities for promotion of DHC and decarbonisation.

General recommendations[7]

- Together with broader policy goals, targets related specifically to district heating (e.g. district heating penetration, integration of RES, wasted heat recovery plans) are important to drive the transition to efficient district heating networks.
- Building and expanding district heating networks is extremely capital-intensive, and market expansion requires investors to have visibility and be supported by long-term measures. These can include specific financing tools, stable economic incentives (which can be financed through land value capture strategies, i.e. local governments to charge fees and taxes to developers and property owners), and regulation to define and mandate connection zones, thus ensuring an anchored load and economies of scale.
- Policy makers should also streamline administrative procedures for modern district heating projects to facilitate and accelerate permitting, and the integration of specific criteria into buildings energy codes.
- Building capacity for energy and infrastructure mapping at the local level allows advanced urban planning practices to integrate energy, infrastructure and land planning. For instance, excavation costs for district energy systems could be shared with other infrastructure construction projects, and district heating expansion could be coordinated with building renovations.
- Improving the technology and expanding its application in the longer term calls for allocated funding for research and innovation to optimise district heating system operation with high shares of renewable sources, for testing different technology solutions, and for establishing training programmes for all stakeholders involved.

The following sections provide more specific recommendations.

[7] International Energy Agency, Tracking District Heating, *International Energy Agency*, accessed 10 September 2024.

Support for municipalities when preparing Plans

While the municipalities are responsible for preparing Plans according to Art.25(6) of the EED, the Article also obliges Member States to 'support regional and local authorities to the utmost extent possible by any means, including financial support and technical support schemes'.

Recommendations

- The government should prepare a thorough and comprehensive heating and cooling assessment according to EED, Art.25(1) as a base for setting local heating and cooling planning targets.
- The state should set binding decarbonisation targets for DHC operators.
- The legislative framework should make the heat plans enforceable. There should be a legal mandate to force utilities and grid infrastructure operators to comply with local heating and cooling plans.
- Municipalities should be able to rule out some heating technologies, such as fossil gas and hydrogen, from buildings.
- 'Energy efficiency first' should be prioritised as a guiding principle for all energy planning, policy, and investment decisions. This includes implementing measures to make energy demand and energy supply more efficient through cost-optimal energy end-use savings, demand-side response initiatives, and enhanced energy conversion.
- The state should issue a comprehensive methodology for local DHC planning.
- Guidelines and recommendations should be developed to support regional and local authorities in implementing energy-efficient heating and cooling measures and policies based on RES, using the potential identified at local and regional levels.

  One national agency or ministry should be responsible for coordinating support for local authorities and launching a national programme involving academic and scientific experts, local authorities, energy suppliers and distribution system operators, social housing, industries, and the building sector. This programme should propose guidelines and tools and update them with new knowledge and lessons learned over the years. This technical support (both online and in-person) should include step-by-step guidance, calculation methodologies – tools, costs, economic parameters (NPV, IRR, LCOH) – as well as training, peer-to-peer exchanges, working groups, and expertise.
- The expertise should be drawn from a pool of reliable consulting companies that can support local authorities. It is important to ensure that both reputable firms as well as local and smaller consultancies have the opportunity to participate in the heat planning process.
- The government should regularly evaluate the heat plans and impact of the regulations on heat planning and the achievement of national municipal targets.

DHC regulation – Heat price regulation and obligation to connect to DHC

Whereas the heat price is the subject of state control or regulation, electricity is sold on the free market. It is also worth considering the revision of the existing regulation of objectively adjusted prices and consumer protection. In Denmark in the 1970s, compulsory connection to district heating was seen as the best way to reduce the country's dependence on imported oil. Local authorities defined areas where connecting to district heating was mandatory for all buildings. At the same time, consumer protection was comprehensively addressed.

In 2000, under the pressure of liberalisation, municipalities were deprived of the opportunity to define new areas for mandatory connection. However, new buildings are still obliged to connect within the existing defined areas. The situation there is also made easier by the fact that heating companies are mostly owned by citizens or municipalities. An interesting tool for ensuring efficiency is the voluntary comparison of heat prices between heating companies. Currently, interest in connecting to district heating in Denmark has increased significantly, primarily due to the fact that 80 per cent of networks did not increase their heat prices during the recent energy crisis.

In the Netherlands, a new law on district heating is being discussed to quickly get rid of their dependence on gas, which is intended to ensure the massive development of the heating industry. The possibility of introducing a mandatory connection to district heating is also being considered. However, public opinion is restrained, and regulatory authorities have been careful not to secure a monopoly position for private entities, which own most heating networks. Municipalities have called for the introduction of tariffs based on the actual costs of heat production and the transfer of ownership of the network to public entities to ensure greater transparency.

Recommendations

- The obligation to connect, or remain connected, to DHC should be discussed. However, this is a sensitive topic that requires thorough discussion before being applied nationally or locally.
- In cases of electricity and heat cogeneration, emissions and costs should be fairly distributed between the electricity and heat produced.[8]

Primary energy and emission factors for electricity and heat

The EU has set ambitious targets to reduce primary energy consumption and CO_2 emissions. Primary energy factors (PEFs) are used for converting electricity use to primary energy and for assessing energy conservation measures. However, Member States may set different PEF values (average or marginal, current or forecast) for various purposes, thus promoting fewer desirable alternatives. For example, if a higher PEF is set, solutions like gas-fired cogeneration will indicate higher primary energy savings than a heat pump.

[8] LowTEMP, CO2 emission allocation in CHP systems and recommendations, *LowTEMP*, accessed 10 September 2024.

Recommendations

- Forward-looking (lower) values should be applied for PEF and emission factors for electricity to make electricity-driven heat pumps a more favourable solution for primary energy and emission savings.
- Create legislation for the individual calculation of the primary energy factor for heat from district heating to increase its competitiveness when assessing building energy demands (see EPBD, Annex 1).

Gas infrastructure regulation

Changing heating sources, especially shifting from individual to centralised solutions like district heating, can significantly impact peoples' homes and lives. This creates an opportunity for fossil gas providers to promise unrealistic solutions like biomethane or hydrogen as easy and non-disruptive options.

In addition, there is a lack of readiness, willingness and transparency on the part of gas operators to adapt gas infrastructures. This undermines the ability of local authorities to align the planning and development of energy infrastructures and heating systems with their local climate-neutral ambitions. To ensure a rapid and fair phase-out of gas, new depreciation policies and pricing methods are needed, along with changes in public investment patterns and a reorganisation of energy infrastructure planning mandates and competencies.[9]

Recommendations

- The state should clearly declare that gases such as biomethane and hydrogen are far too valuable (limited and expensive) to use for heating residences. Electricity-based solutions should be preferred.
- Coordinating the decommissioning of fossil fuel boilers and gas grids through local heat plans.
- Legal obligations to connect buildings to gas networks should be withdrawn.
- Heat plans should be reflected in gas infrastructure planning, and the state should incentivise and mandate operators to downsize and adapt grids for lower demand.

Insurance pool for geothermal drilling

Although drilling for deep geothermal wells is cost-intensive, there is no guarantee that the well will be fully suitable for heating.

Recommendations

- Following the examples of France and other countries, introduce a geothermal well insurance system to compensate for incurred costs in cases where the parameters needed for the efficient use of geothermal energy are not achieved.

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[9] Energy Cities, Changing regulatory frameworks and conditions for a rapid and just phase-out of natural gas, *Energy Cities*, 2024.

Water use regulation

River water is an important source of energy for heat pumps. Unlike extracting water for cooling purposes in fossil power plants, extracting heat from water for energy use cools the water, which may be beneficial, especially in summer.

Recommendations

- Simplify the procedure for authorising water use for energy extraction in heat pumps, provided environmental impacts are assessed.

Prices forecast - commodities, EUA

The EU Emissions Trading System (ETS) is not only a cornerstone of the EU's policy to combat climate change, but also its key tool for reducing greenhouse gas emissions in a cost-effective way. A new emissions trading system named ETS2, separate from the existing EU ETS, will be implemented from 2027. This new system will cover and address the CO_2 emissions from fuel combustion in buildings, road transport and additional sectors.

Recommendations

- The EU and its Member States should be more transparent about the intended trajectory of EU allowance (EUA) pricing.
- The EU and its Member States should be transparent about the introduction of ETS2 allowances, factoring in timing, procedure, and intended price trajectory.
- Commodity and CO_2 prices may be different in the future. EU supranational values should be applied for ETS and ETS2. 'With additional measures' (WAM) scenarios should be applied to achieve EU climate neutrality (Figure 6).[10]

[10] European Commission, Recommended parameters for reporting on GHG projections in 2023, European Commission, 2022.

Figure 1. EU-recommended parameters for carbon and fossil fuel prices.[11]

Carbon prices

Table 3 shows the trajectory of the carbon price of the existing ETS in its current scope (power, industry, centralised heat and aviation sectors) up to 2030, corresponding to the legally binding -55% climate target context and considering the central trajectory for international fuel prices.

For long-term values beyond 2030, Table 3 shows two trajectories: a trajectory based on the EU Reference Scenario 2020 for the EU ETS carbon price in "WEM" scenarios, and an indicative carbon value trajectory across the economy to reaching the EU climate neutrality[a] for national ("WAM") scenarios.

Table 3. Harmonised trajectory for the carbon price / value (EUR2020 / tCO2)

EUR 2020 / tCO2	Common trajectory carbon price existing ETS up to 2030	
2018*	16	
2019*	25	
2020*	24	
2021*	54	
2022	75	
2023	77	
2024	78	
2025	80***	
2030	80***	
	WEM trajectory	WAM trajectory
2035	82	120**
2040	85	250**
2045	130	360**
2050	160	410**

*Note: * 2018-2021 data are yearly average of daily value expressed in current EUR of dated EUX EUA. The conversion from current EUR and EUR2016 to EUR2020 uses the ESTAT HICP index (data extracted in May 2022).** The indicative post-2030 "WAM" trajectory is a modelling driver to reach the EU 2050 climate neutrality in the FF55 package analysis. It is acknowledged that national analyses projecting economy-wide GHG emissions compatible with the EU 2050 climate neutrality objective may provide a different carbon value trajectory.*

**** The corresponding carbon prices expressed in nominal values are about 90 and 100 EUR / tCO2 for 2025 and 2030, assuming an index of 105.76 in 2020, 118.6 in 2025 and 130.9 in 2030, compared to 100 in 2015[a].*

International oil, gas and coal fuel import prices

Table 1 shows the proposed central harmonised trajectories for oil, gas and coal fuel international prices.

Table 1. Proposed harmonised central trajectories for international fuel prices (EUR2020)

	Oil			Gas (NCV)		Coal	
EUR2020	€/GJ	€/toe	€/boe	€/GJ	€/toe	€/GJ	€/toe
2018*	10,9	454	62	7,8	325	3,0	126
2019*	10,2	425	58	4,5	189	2,1	87
2020*	6,4	268	37	3,1	130	1,6	67
2021*	10,5	438	60	15,1	634	3,8	157
2022	15,4	643	88	33,2	1391	5,3	220
2023	15,4	643	88	24,0	1005	4,2	176
2024	15,4	643	88	14,6	611	3,2	132
2025	15,4	643	88	13,2	554	3,1	128
2030	15,4	643	88	11,3	473	3,1	130
2035	15,4	643	88	11,3	473	3,1	131
2040	16,3	680	93	11,3	473	3,3	139
2045	17,6	738	101	11,3	473	3,5	146
2050	19,7	824	112	11,8	494	3,7	153

*Note: The conversion toe/GJ is 41.868, the conversion boe/toe is 7.33. * 2018-2021 data are yearly average of daily value expressed in current EUR of dated Brent for oil, TTF day ahead for gas, steam coal CIF ARA 6000k for coal. The conversion from current EUR and EUR2016 to EUR2020 uses the ESTAT HICP index (data extracted in May 2022).*

Electricity tariffs

The tariff structure should be reviewed and adjusted to enable the transition. Various stakeholders have diverse needs, and it is difficult to set optimal tariff structure. Nevertheless, the state should be transparent and try to give the stakeholders certain forecast about the strategy of changing the tariffs for the future so that it can be considered in the decisions (the most probable trend is increasing the fix and decreasing the variable share of the tariff).

Recommendations

- Tariffs for the use of the distribution system should be set in such a way as to motivate the flexible use of excess electricity, especially in the summer months.[12]
- Electricity used to drive heat pumps should be exempted from the RES-support fees.

Labour market in just transition regions[13,14]

The labour market transition is a major challenge for the just transition regions. For instance, jobs in the mining sector have been declining for years due to mechanisation, substitution by other fuels and low economic competitiveness of mines and this process will be accelerated by the need to reduce CO_2 emissions. Many of these areas depend on one type of industry and often one employer for economic

[11] Ibid.

[12] Agora Energiewende, Boosting flexibility in distribution grid, *Agora Energiewende*, April 2024.

[13] Wuppertal Institut, Just Transition Toolbox for coal regions, *Wuppertal Institut*, March 2022.

[14] International Labour Organization, Skills for a greener future, *International Labour Organization*, 2019.

prosperity. When this industry comes under threat, this will have severe economic consequences for the regions and communities.

Recommendations

1. Labour market intelligence and skills anticipation should enhance the understanding of the changing demand for skills needed to drive the green transition. Countries need to systematically integrate the development of skills for green jobs into their systems and make these skills more recognisable.
2. Forward-looking skills strategies should be integrated in climate and environmental policies, coupled with an active labour market and career guidance measures and social protection mechanisms.
3. Ensuring a just and inclusive transition necessitates paying priority attention to the needs of disadvantaged and vulnerable groups. It will also require joint and active engagement by governments, employers' and workers' organisations through social dialogue as well as engagement with civil society actors, education and training providers.

Abbreviations

LHCP	local heating and cooling plan (in this study abbreviated also as ‘plan’ or ‘planning’)
DH	district heating
DHC	district heating and cooling
4GDH	4th generation DH (also called low-temperature district heating (LTDH))
5GDH	5th generation DH (also called Anergy or ambient grid)
FG	fossil gas (such as ‘natural gas’ and coal gas)
LNG	liquified natural gas
LCOH	levelised cost of heat
HP	heat pump
MS	Member States
PEF	primary energy factor
PTES	pit thermal energy storage
RES	renewable energy sources
TES	thermal energy storage
BTES	borehole thermal energy storage
COP	coefficient of performance (of a heat pump)
SPF	seasonal performance factor (of a heat pump)
NPV	net present value
IRR	internal rate of return
WTP	water treatment plant
NCV	net calorific value (lower heating value (LHV))
GCV	gross calorific value (higher heating value (HHV))

Annex 1 – Relevant EU legislation

District heating and cooling is considered one of the key future-proof heating and cooling solutions and is extensively promoted in various parts of EU legislation. The key document is the EU Heating and cooling strategy and the role of DHC is subsequently reflected in the major pieces of EU energy sector legislation: the Energy Efficiency Directive (EED), the Renewable Energy Directive (RED) and the Energy Performance of Buildings Directive (EPBD). Below are the most important stipulations related to DHC.

EU Heating and Cooling Strategy[15]

The EU Heating and Cooling Strategy, published in 2016, provided a first overview of the energy consumption and fuel mix of the heating and cooling sector in the main end-use sectors: buildings and industry. Decarbonisation entails renovating the existing building stock, along with intensified efforts in energy efficiency and renewable energy, supported by decarbonised electricity and district heating. It also set out actions and tools to ensure that the heating and cooling sector contributes to the EU objective of climate neutrality by 2050. These actions and tools, implemented in the Clean Energy for all Europeans package adopted in 2019, relate to increasing renewable energy and energy efficiency in this sector, while applying in parallel an integrated approach to the energy system.

Energy Efficiency Directive (EED)

Energy efficiency helps reduce overall energy consumption and is therefore central to achieving the EU's climate ambitions, while enhancing present and future energy security and affordability. The revised EED[16] significantly raises the EU's energy efficiency ambitions. It establishes 'energy efficiency first' as a fundamental principle of EU energy policy, giving it legal standing for the first time. In practical terms, this means that energy efficiency must be considered by EU countries in all relevant policy and major investment decisions taken in the energy and non-energy sectors.

Article 25 (1–5) – Heating and cooling assessment and planning (abbreviated)

As part of its integrated national energy and climate plan and its updates each Member State should:

- submit to the Commission a comprehensive heating and cooling assessment,
- ensure that stakeholders affected are given the opportunity to participate in the preparation of heating and cooling plans, the comprehensive assessment and the policies and measures,
- conduct a cost-benefit analysis covering their territory on the basis of climate conditions, economic feasibility and technical suitability,
- where the comprehensive assessment identifies a potential for the application of high-efficiency cogeneration and/or efficient DHC from wasted heat, whose benefits exceed the costs, Member States should take adequate measures for efficient DHC infrastructure to be developed, to

[15] European Commission, EU Strategy on Heating and Cooling, COM(2016), *EUR-Lex*, 16 February 2016.

[16] EU/2023/1791

encourage the development of installations for the utilisation of wasted heat, including in the industrial sector,

- adopt policies and measures which ensure that the potential identified in the comprehensive assessments is realised.

Article 25 (6) – Heat planning

Member States should ensure that regional and local authorities prepare LHCPs at least in municipalities having a total population greater than 45,000. Those plans should at least:

a) be based on the information and data provided in the comprehensive assessments conducted pursuant to Art. 25(1) and provide an estimate and mapping of the potential for increasing energy efficiency, including via low-temperature district heating readiness, high efficiency cogeneration, wasted heat recovery, and renewable energy in heating and cooling in that particular area;

b) be compliant with the energy efficiency first principle;

c) include a strategy for the use of the identified potential pursuant to point (a);

d) be prepared with the involvement of all relevant regional or local stakeholders and ensure the participation of general public, including operators of local energy infrastructure;

e) consider the relevant existing energy infrastructure;

f) consider the common needs of local communities and multiple local or regional administrative units or regions;

g) assess the role of energy communities and other consumer-led initiatives that can actively contribute to the implementation of local heating and cooling projects;

h) include an analysis of heating and cooling appliances and systems in local building stocks, considering the area specific potentials for energy efficiency measures and addressing the worst performing buildings and the needs of vulnerable households;

i) assess how to finance the implementation of policies and measures and identify financial mechanism allowing consumers to shift to renewable heating and cooling;

j) include a trajectory to achieve the goals of the plans in line with climate neutrality and the monitoring of the progress of the implementation of policies and measures identified;

k) aim to replace old and inefficient heating and cooling appliances in public bodies with highly efficient alternatives with the aim of phasing out fossil fuels;

l) assess potential synergies with the plans of neighbouring regional or local authorities to encourage joint investments and cost efficiency.

Member States should ensure that all relevant parties, including public and relevant private stakeholders, are given the opportunity to participate in the preparation of heating and cooling plans, and the comprehensive assessment and policies/measures referred to in Article 25(1-5).

For that purpose, Member States should develop recommendations supporting the regional and local authorities to implement policies and measures in energy efficient and renewable energy based heating and cooling at regional and local level using the potential identified. Member States should support regional and local authorities to the utmost extent possible by any means, including financial support and technical support schemes. Member States should ensure that heating and cooling plans are aligned with other local climate, energy and environment planning requirements in order to avoid administrative burden for local and regional authorities and to encourage the effective implementation of the plans.

LHCPs may be conducted jointly by a group of several neighbouring local authorities provided that the geographical and administrative context, as well as the heating and cooling infrastructure, is appropriate.

LHCPs should be assessed by a competent authority and, if necessary, followed by appropriate implementation measures.

Article 26 – Efficient district heating and cooling (EDHC) systems

In order to ensure more efficient consumption of primary energy and to increase the share of renewable energy in heating and cooling supply going into the network, an EDHC system should meet the following criteria:

a) until 31 December 2027:

a system using at least 50 per cent renewable energy, 50 per cent waste heat, 75 per cent cogenerated heat or 50 per cent of a combination of such energy and heat;

b) from 1 January 2028:

a system using at least 50 per cent renewable energy, 50 per cent waste heat, 50 per cent renewable energy and waste heat, 80 per cent of high-efficiency cogenerated heat or at least a combination of such thermal energy going into the network where the share of renewable energy is at least 5 per cent and the total share of renewable energy, waste heat or high-efficiency cogenerated heat is at least 50 per cent;

c) from 1 January 2035:

a system using at least 50 per cent renewable energy, 50 per cent waste heat or 50 per cent renewable energy and waste heat, or a system where the total share of renewable energy, waste heat or high-efficiency cogenerated heat is at least 80 per cent and in addition the total share of renewable energy or waste heat is at least 35 per cent

d) from 1 January 2040:

a system using at least 75 per cent renewable energy, 75 per cent waste heat or 75 per cent renewable energy and waste heat, or a system using at least 95 per cent renewable energy, waste heat and high-efficiency cogenerated heat and in addition the total share of renewable energy or waste heat is at least 35 per cent;

e) from 1 January 2045:

a system using at least 75 per cent renewable energy, 75 per cent waste heat or 75 per cent renewable energy and waste heat;

f) from 1 January 2050:

a system using only renewable energy, only waste heat, or only a combination of renewable energy and waste heat.

Alternatively, an EDHC system should have the following maximum amount of GHG emissions per unit of heat or cold delivered to customers:

(a) until 31 December 2025: 200 g/kWh;

(b) from 1 January 2026: 150 g/kWh;

(c) from 1 January 2035: 100 g/kWh;

(d) from 1 January 2045: 50 g/kWh;

(e) from 1 January 2050: 0 g/kWh.

Article 31 – Conversion factors and primary energy factors

1. For the purpose of comparing energy savings and converting to a comparable unit, the net calorific values in Annex VI of Regulation (EU) 2018/2066 and the primary energy factors set out in paragraph 2 of this Article should apply unless the use of other values or factors can be justified.

2. A primary energy factor should be applicable when energy savings are calculated in primary energy terms using a bottom-up approach based on final energy consumption.

3. For savings in kWh electricity, Member States should apply a coefficient in order to accurately calculate the resulting primary energy consumption savings. Member States should apply a default coefficient of 1,9 unless they use their discretion to define a different coefficient based upon justified national circumstances.

4. For savings in kWh of other energy carriers, Member States should apply a coefficient in order to accurately calculate the resulting primary energy consumption savings.

5. Where Member States establish their own coefficient to a default value provided pursuant to this Directive, Member States should establish that coefficient through a transparent methodology on the basis of national, regional or local circumstances affecting primary energy consumption. The circumstances should be substantiated, verifiable and based on objective and non-discriminatory criteria.

6. Where establishing an own coefficient, Member States should consider the energy mix included in the update of their integrated national energy and climate plans submitted pursuant to Article 14(2) of Regulation (EU) 2018/1999 and their subsequent integrated national energy and climate plans notified to the Commission pursuant to Article 3 and Articles 7 to 12 of that Regulation. If they deviate from the default value, Member States should notify the coefficient that they use to the Commission along with the calculation methodology and underlying data in those updates and subsequent plans.
7. By 25 December 2026 and every four years thereafter, the Commission should revise the default coefficients on the basis of observed data.

Point 107:

Heat pumps are important for the decarbonisation of the heating and cooling supply, also in district heating. The methodology established in RED, Annex VII provides rules to count energy captured by heat pumps as energy from renewable sources and prevents double counting of the electricity from renewable sources. For the purposes of calculating the share of renewable energy in a district heating network, all the heat originating from the heat pump and going into the network should be accounted as renewable energy, provided that the heat pump meets the minimum efficiency criteria set out in Annex VII to RED at the time of its installation.

Renewable energy directive (RED)

The revised directive introduces stronger measures to ensure that all possibilities for the further development and uptake of renewables are fully utilised. A strong policy framework will facilitate electrification in different sectors, with new increased sector-specific targets for renewables in heating and cooling, transport, industry, buildings and district heating/cooling, but also with a framework promoting electric vehicles and smart recharging.

Article 24 – District heating and cooling

1. Member States should ensure that information on the energy performance and the share of renewable energy in their DHC systems is provided to final consumers in an easily accessible manner, such as on the suppliers' websites, on annual bills or upon request.
2. Member States should lay down the necessary measures and conditions to allow customers of district heating or cooling systems which are not EDHC systems, or which are not such a system by 31 December 2025 on the basis of a plan approved by the competent authority, to disconnect by terminating or modifying their contract in order to produce heating or cooling from renewable sources themselves. Where the termination of a contract is linked to physical disconnection, such a termination may be made conditional on compensation for the costs directly incurred as a result of the physical disconnection and for the undepreciated portion of assets needed to provide heat and cold to that customer.

3. Member States may restrict the right to disconnect by terminating or modifying a contract in accordance with paragraph 2 to customers who can demonstrate that the planned alternative supply solution for heating or cooling results in a significantly better energy performance. The energy-performance assessment of the alternative supply solution may be based on the energy performance certificate.

4. Member States should lay down the necessary measures to ensure that DHC systems contribute to the increase referred to in Article 23(1) of this Directive by implementing at least one of the two following options:

   (a) Endeavour to increase the share of energy from renewable sources and from waste heat and cold in DHC by at least one percentage point as an annual average calculated for the 2021–2025 period and for the 2026–2030 period, starting from the share of energy from renewable sources and from waste heat and cold in DHC in 2020, expressed in terms of share of final energy consumption in DHC, by implementing measures that can be expected to trigger that average annual increase in years with normal climatic conditions. Member States with a share of energy from renewable sources and from waste heat and cold in DHC above 60 per cent may count any such share as fulfilling the average annual increase referred to in the first subparagraph of this point.

   Member States should lay down the necessary measures to implement the average annual increase referred to in the first subparagraph of this point in their integrated national energy and climate plans pursuant to Annex I to Regulation (EU) 2018/1999.

   (b) Ensure that operators of district heating or cooling systems are obliged to connect suppliers of energy from renewable sources and from waste heat and cold or are obliged to offer to connect and purchase heat or cold from renewable sources and from waste heat and cold from third-party suppliers based on non-discriminatory criteria set by the competent authority of the Member State concerned, where they need to do one or more of the following: (i) meet demand from new customers; (ii) replace existing heat or cold generation capacity; (iii) expand existing heat or cold generation capacity.

5. Where a Member State exercises the option referred to in point 4(b), an operator of a district heating or cooling system may refuse to connect and to purchase heat or cold from a third-party supplier where:

   (a) the system lacks the necessary capacity due to other supplies of waste heat and cold, of heat or cold from renewable sources or of heat or cold produced by high-efficiency cogeneration;

   (b) the heat or cold from the third-party supplier does not meet the technical parameters necessary to connect and ensure the reliable and safe operation of the DHC system; or

   (c) the operator can demonstrate that providing access would lead to an excessive heat or cold cost increase for final customers compared to the cost of using the main local heat or cold supply with which the renewable source or waste heat and cold would compete.

Member States should ensure that, when an operator of a district heating or cooling system refuses to connect a supplier of heating or cooling, information on the reasons for the refusal, as well as the conditions to be met and measures to be taken in the system in order to enable the connection, is provided by that operator to the competent authority.

6. Where a Member State exercises the option referred to in point 4(b), it may exempt operators of the following DHC systems from the application of that point:

   (a) EDHC;

   (b) EDHC that exploits high-efficiency cogeneration;

   (c) DHC that, on the basis of a plan approved by the competent authority, is efficient district heating and cooling by 31 December 2025;

   (d) DHC with a total rated thermal input below 20 MW.

7. The right to disconnect by terminating or modifying a contract may be exercised by individual customers, by joint undertakings formed by customers or by parties acting on behalf of customers. For multi-apartment blocks, such disconnection may be exercised only at a whole building level in accordance with the applicable housing law.

8. Member States should require electricity distribution system operators to assess at least every four years, in cooperation with the operators of district heating or cooling systems in their respective area, the potential for district heating or cooling systems to provide balancing and other system services, including demand response and storing of excess electricity from renewable sources, and whether the use of the identified potential would be more resource- and cost-efficient than alternative solutions.

9. Member States should ensure that the rights of consumers and the rules for operating DHC systems in accordance with this Article are clearly defined and enforced by the competent authority.

Annex 7:

The amount of aerothermal, geothermal or hydrothermal energy captured by heat pumps to be considered to be energy from renewable sources for the purposes of this Directive, ERES, should be calculated in accordance with the following formula:

$E_{RES} = Q_{usable} * (1 – 1/SPF)$ where

- Q_{usable} = the estimated total usable heat delivered by heat pumps fulfilling the criteria referred to in Article 7(4), implemented as follows: Only heat pumps for which SPF > 1,15 * 1/η should be considered,

- SPF = the estimated average seasonal performance factor for those heat pumps,

- η = the ratio between total gross production of electricity and the primary energy consumption for the production of electricity and should be calculated as an EU average based on Eurostat data.

(currently η = 1/*1,9, see EED point.107*).

Energy Performance of Buildings Directive (EPBD)[17]

According to the directive, all new buildings after 2030 need to be zero-emission buildings, and existing buildings must meet the minimum energy performance standards set by the Member State and transform into zero-emission buildings by 2050. DHC systems are considered one of the future-proof heating solutions, hence networks meeting the Efficient District Heating and Cooling Systems (EDHC) definition set out in the EED are allowed to be connected to zero-emission buildings.

Point 78:

In the area of district heating, it is therefore crucial to enable the fuel-switching to energy from renewable sources and prevent regulatory and technology lock-in and technology lock-out through reinforced rights for renewable energy producers and final consumers, and bring the tools to final consumers to facilitate their choice between the highest energy-performance solutions that take into account future heating and cooling needs in accordance with expected building performance criteria. Final consumers should be given transparent and reliable information on the efficiency of DHC systems and the share of energy from renewable sources in their specific heating or cooling supply.

Point 79:

In order to protect consumers of DHC systems that are not EDHC systems and to allow them to produce their heating or cooling from renewable sources and with significantly better energy performance, consumers should be entitled to disconnect and thus discontinue the heating or cooling service from non-efficient DHC systems at a whole building level by terminating their contract or, where the contract covers several buildings, by modifying the contract with the district heating or cooling operator.

Article 11(7):

Zero-emission buildings are allowed to use energy from renewable sources generated onsite or nearby, renewable energy from a renewable energy community, energy from carbon-free sources, and energy from an EDHC system in accordance with Article 26(1) of the EED.

Annex 1:

Member States should take the necessary measures to ensure that, where buildings are supplied by district heating or cooling systems, the benefits of such supply are recognised and accounted for in the calculation methodology, in particular the renewable energy share, through individually certified or recognised primary energy factors

[17] European Parliament and the Council, Energy building performance Directive (EU) 2024/1275, *EUR-lex*, May 2014.

Annex 2 - Technological solutions

1. Renewable energy sources and technologies

Renewable energy sources (RES)

Production of heat from sustainable RES includes sources and technologies such as:

- ambient air;
- wastewater;
- solar thermal energy.
- heat pumps supplying heat to a heating network, provided that the heat pump, at the time of its installation, complies with the requirements set out in Annex VII to Directive (EU) 2018/2001 (RED);
- electricity obtained from the general supply based on the average renewable share (set by the government for the target year) of the nationwide gross electricity consumption of the previous calendar year;
- electricity generated in an RES plant connected to a heat-generating plant via a direct line and for which a guarantee of origin has been issued for heat from RES;
- heat storage facilities, provided that the energy comes from either RES or wasted heat produced by the sources referred to in points 13 and 15 and powers the heating network;
- the conditional use of geothermal energy;[18,19]
- biomass, but only as a last-resort transitional solution after maximising energy efficiency through energy-saving and renewable energy options such as building insulation;[20,21] and
- green hydrogen produced using renewable energy.[22]

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[18] If deep wells are used, the project must ensure that the water is injected back into the ground, prevent discharges that could thermally pollute river or lake systems while avoiding depletion of aquifers, and make sure that the necessary equipment is in place to capture harmful emissions of greenhouse gases, hydrogen sulphide, and other gases released from thermal water. In addition, clear EU legislation is needed to ensure these provisions are implemented.

[19] CEE Bankwatch Network, Change the lending, not the climate, *CEE Bankwatch Network*, November 2009.

[20] Only crop residues or secondary forest biomass should be used. The capacity of biomass-based energy must be limited to the minimum necessary to respond to peak demand. This strategy must be guided by a thorough and conservative assessment of the availability of feedstocks in the vicinity of the plant, as well as a realistic projection of future availability. This is essential in order to avoid switching to primary forest biomass and minimise excessive transport.

[21] European Commission, Primary woody biomass, *Knowledge for Policy*, 12 April 2024.

[22] Although hydrogen could play some role in the future energy system, it is too often used as a justification for the continued development of fossil gas infrastructure, thereby postponing the phase-out of fossil gas. Hydrogen should be primarily used in sectors where reducing emissions and direct electrification is difficult, such as steel, chemicals, aviation, long-distance shipping, and heavy-duty road transport. The use of hydrogen in DH should be avoided.

The following section provides a brief description of the key technologies that enable the efficient utilisation of RES.

Heat pumps

Renewable electricity will play a crucial role in decarbonising district heating through the use of heat pumps, which are much more efficient than simply relying on electric heating systems. Heat pumps can raise the temperature of low-potential, seemingly unusable energy from the environment. Heat pumps derive their energy from river water, sewage treatment plants, geothermal energy and air. For example, one cubic metre of water flowing from a sewage treatment plant is estimated to contain energy equivalent to one cubic metre of fossil gas. While air is the most easily accessible source of energy, air heaters have certain drawbacks. Their performance and efficiency tend to drop in winter, when heat demand is at its highest, while installing them in urban areas can prove challenging due to, among other things, noise and the dimensions of air evaporators.

However, integrating heat pumps into DHC systems is not without its challenges. For example, water sources such as rivers, seas, and water treatment plants are often located far from populated areas, necessitating long-term conceptual spatial planning. Additionally, substations for heat pumps typically require a larger electrical connection capacity than conventional gas boiler rooms. In contrast, installing heat pumps at heat plants with cogeneration electricity systems can be advantageous, as the existing electrical connection can be used bi-directionally. The economic operation of hot-water heaters is also influenced by the temperature of both the heating and return water.

The use of modern refrigerants of natural origin such as CO_2, propane, ammonia, and butane is more developed in large heat pumps compared to residential applications. This provides a significant environmental advantage over small heat pumps, which transition more slowly to natural refrigerants and result in the inevitable production of per- and polyfluoroalkyl substances (PFAS) such as trifluoroacetic acid (TFA).

Thermal energy storage (TES)

Any modern heating source should be equipped with extensive heat storage, which will enable connection with the electricity market. It will be also of advantage to oversize the resources like HPs and electric boilers for the use of even short-term fluctuations in the price of electricity and thus enhancing the utilisation of fluctuating renewable energy and improving the economy of the heat production.

Four main criteria define the heat store technologies:[23]

(a) the heat storage period

seasonal or long-term heat storage, when storage period is about several months,

short and medium-term heat storage when storage period is about up to a week

(b) temperature level

[23] Acta innovations, OVERVIEW OF THE EXISTING HEAT STORAGE TECHNOLOGIES: SENSIBLE HEAT, *Pro Academia*, 2014.

High-temperature (HT) heat storage when the temperature of the stored heat is above 200 °C. In this case, the stored heat has the greatest energy potential and can be used as a backup heat source to support power generation in the concentrating solar thermal power plants.

HT storage is not relevant for typical DH application.

Middle-temperature heat storage when the temperature of the stored heat is above 40 °C. Such temperature levels of the stored heat are particularly suitable for district heating and domestic hot water preparation.

Cooling applications, when the temperature of the stored heat is below 20 °C,

(c) design of the TES

HWTES - hot water above or underground steel tank

underground storage in several forms

BTES – borehole thermal energy storage

PTES – pit thermal energy storage, filled with water or a gravel-water mixture

ATES – aquifer thermal energy storage

(d) medium - water, gravel, sand, various chemicals (should be checked on sustainability)

2. Development of district heating

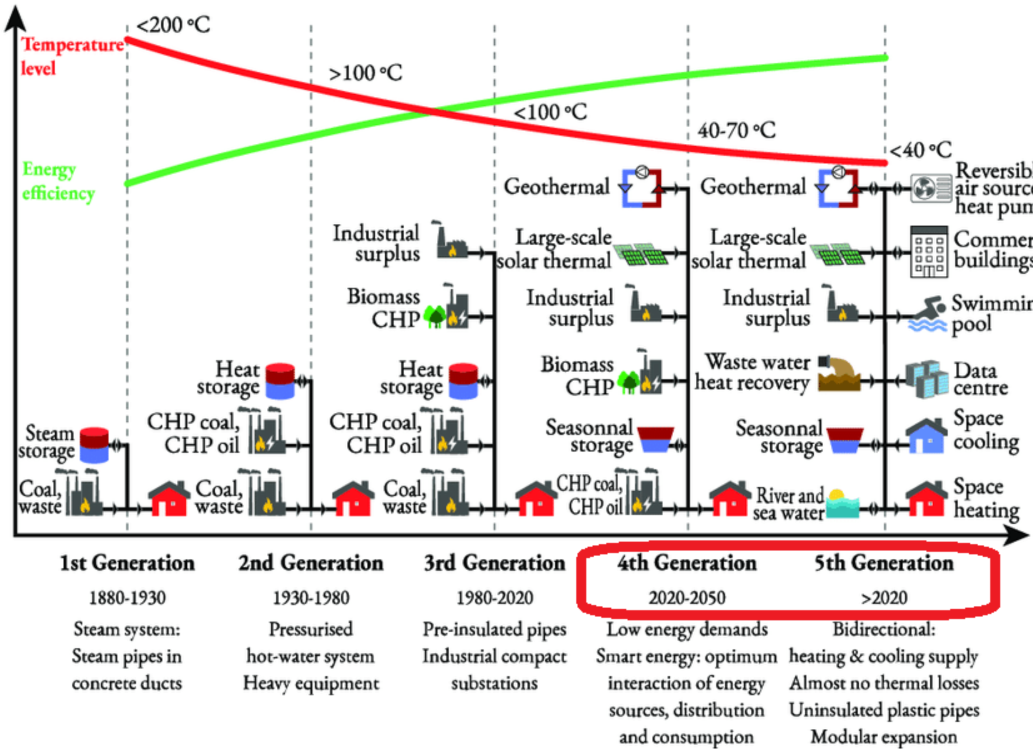
DH systems have been commonplace in Europe for over a century. These systems have undergone an evolution since their conceiving, and today we are at the precipice of the next major transition from the third-generation district heating system (3GDH) to the fourth generation (4GDH) and fifth generation (5GDH) (Figure 2).

Current 3GDH systems operate at a supply temperature of between 80 and 100 °C and a return temperature of around 45 °C. 4GDH systems, also known as low-temperature district heating (LTDH) systems, operate at a supply temperature below 70 °C and a return temperature as low as 25 °C, and therefore can integrate wasted heat available at low temperatures as well as renewable heat sources.

In 5GDH systems, also known as ‘ambient’ or ‘anergy’ grids, cold water flows at a temperature below 40 °C, which draws heat directly from low-potential energy sources such as groundwater, geothermal wells, and river water. The fundamental difference in comparison to 4GDH systems is the absence of a central source of energy production.

4GDHC systems are suitable both for older and newer buildings where there is no requirement for cooling, or the volume of cooling does not exceed the volume of heat. If it is a new construction, where the consumption of heat is minimised and the consumption of cold becomes more significant, a 5GDHC system may be more suitable.

Figure 2. DHC generations[24]



4th generation DHC system

It is a classic system of heat and cold production in a central source, an energy centre, with distribution of heat and cold to individual buildings (Figure 3). A heat and cold transfer station is in each building, which also pressure-separates the primary DHC circuit from the circuits in the building.

The system usually includes a heat or cold storage tanks. These ensure the flexibility of the system, so that heat pumps or cogeneration units can provide power balancing services. It is a robust solution with a higher installed power than the maximum consumption of the system. An outage of any equipment will therefore not cause difficulties in meeting the demand for heat or cold supply.

Lowering the temperatures[25] in the DHC system leads to an increase in efficiency. And not only the temperature on the water heating side, but also on the return water side. The low temperature of the return water is the key to the efficient use of low-potential energy either directly through wasted heat, flue gas condensation technology, or indirectly through heat pumps. In addition, with a low temperature in the DH, heat losses decrease, which leads to a reduction in operating costs.

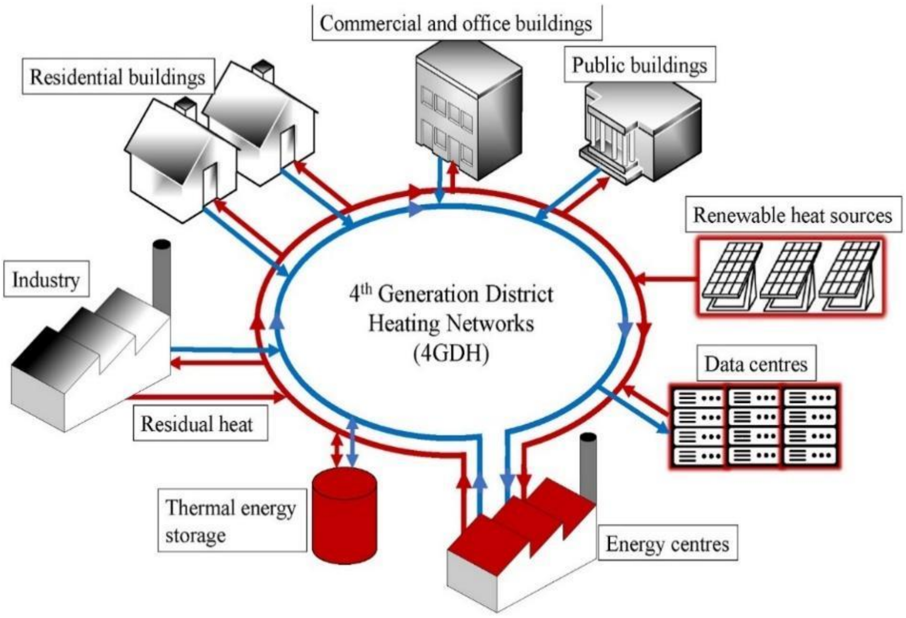
In the Nordic region, the return water temperature can range from 30 to 40 °C and the heating water temperature from 60 to 80 °C. Such parameters lead to the expansion of air-to-water heat pumps there because it is a less investment-intensive solution than the entire water-to-water heat pump system in

[24] Saleh S. Meibod, Fleur Loveridge, The future role of energy geostructures in fifth generation district heating and cooling networks, *Science Direct*, 1 February 2022.

[25] Gradyent, How lowering temperatures drives savings and futureproofs your heating network, *Gradyent*, June 2024.

combination with geothermal wells. At such temperatures, the air-to-water heat pump can operate with an efficiency close to that of a water-to-water heat pump. Another advantage of large air heat pumps is their speed of start-up, when they can provide power balance services of the electricity system. In combination with a hot water tank, these air heat pumps can be a very efficient and effective technology that smartly connects the heating sector with the electricity system.

Figure 3. 4th generation DHC system.[26]



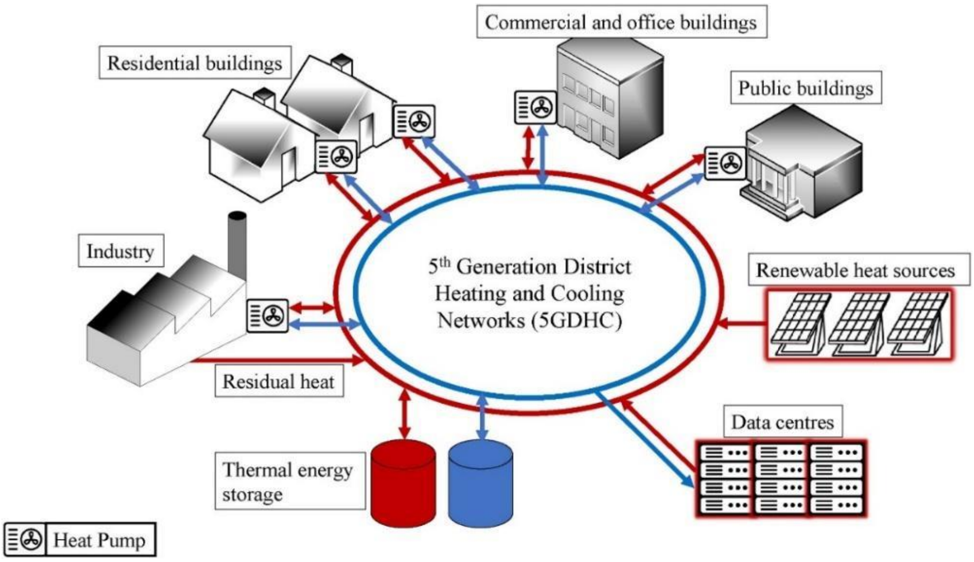
In existing DH systems, especially in coal regions where the heat was produced by 'cheap' coal, the temperatures are high, typically 2nd or 3rd generation networks. Upgrading to 4GDH low requires upgrading of the whole temperature chain, including deep renovation of the buildings, insulated heating grids, professionally designed/refurbished heat transfer stations and hot water preparation and the storage and proper concept of the heating source.

5th generation DHC system

Individual objects are connected to the ambient network (Figure 4). Each building has its own mostly reverse heat pump, which either draws energy from the ambient network to provide heating or prepare domestic hot water or stores energy in the ambient network from cooling. There is therefore a spillover of energy when individual objects send heat or cold to each other. Free cooling is often used, using the circulating cold medium, without the need to use the heat pump or chiller. The DHC 5th generation system is particularly suitable for a new construction with a low need for heat and a similar or more dominant need for cooling. An important requirement is the readiness of the objects and a plentiful source of low-potential heat. If both of these conditions are met, the 5th generation DHC system can be an interesting and effective choice.

[26] Saleh S. Meibod, Fleur Loveridge, The future role of energy geostructures in fifth generation district heating and cooling networks.

Figure 4. 5th generation DHC system[27]



[27] Saleh S. Meibod, Fleur Loveridge, The future role of energy geostructures in fifth generation district heating and cooling networks.

Annex 3 - Best practice

1. Countries

Energy Cities: EU Tracker – Local heating and cooling plans[28]

The EU's recast Energy Efficiency Directive, adopted in July 2023, includes a new obligation (Article 25.6), which requires Member States to ensure that municipalities with over 45,000 inhabitants prepare LHCPs. This proposition can be a GAME CHANGER to decarbonise the heating and cooling sector, and to provide citizens with healthier and more resilient living environments. To maximise the potential of this measure, the Member States need to put in place robust legal and extensive support frameworks, which ensure that local governments have the knowledge, resources and capacity needed to effectively prepare and implement their plans. This tracker shows the current state of play for LHCPs for each EU country. The tracker will be regularly updated to follow the progress of Member States in transposing the obligation into their national context in the coming two years.

Denmark: Heat plants are owned by consumers and municipalities[5]

There are more than 400 district heating companies in Denmark and about 350 of them (85 per cent) are owned directly by the consumers. They then account for 37 per cent of the total heat supply for households and the industry. The remaining 15 per cent are owned by local authorities and supply 66 per cent of the total amount of heat sold. Renewable sources, albeit not necessarily sustainable sources, account for about 60 per cent of the district heating supply, a share the country wants to increase to 90 per cent by 2030.

Netherlands: District heating as a key tool for decarbonisation[29]

Increasing the current low share of DH (5 per cent) is considered one of the key tools for successful decarbonisation of the heating sector. In their National Climate Agreement, the Dutch have even set a target of ending fossil gas as the main source of heating in 7 million households by 2030, and 1.5 million of them will be heated completely without gas. The system of collective ownership of cooperatives in the energy sector has a tradition in the Netherlands and energy communities play a key role in the transformation of the heating sector. In 2022, the Netherlands had 705 energy communities with 120,000 members, represented in 86 per cent of all Dutch municipalities.

Belgium is developing district heating systems in partnership with energy communities

Belgium is also relying on the development of new DH systems as a tool for decarbonisation and is investing EUR 500 million in 20 heating infrastructure projects by 2050. Belgium has a long tradition of energy communities which may be active partner for the municipalities in the heat planning. To this day, almost 50 per cent of the district heating comes from RES and the country completed a coal phase-out in 2016. Belgium uses data-based strategic planning to build its new district heating system, which makes it easier to identify investment needs in specific areas.

[28] Energy Cities, EU Tracker – Local heating and cooling plans.

[29] Frank Bold, Examples from four countries show how to decarbonise the heating sector, *Frank Bold*, July 2023.

2. Projects

Sonder Felding, Denmark: Novel district heating system[30]

A system comprising two air-to-water heat pumps from Danish manufacturer Fenagy, a hot-water storage tank and an electrical hot-water boiler has been installed this year to expand, and often replace, the heating capacity of an existing biomass boiler, cutting heating costs and helping to balance the electrical grid.

Mannheim, Germany: Replacing coal with river heat[31]

Mannheim still generates most of its electricity and heat from coal, which is particularly harmful to the climate. A river heat pump started operating here in 2023 and is currently the largest in Germany.

Esbjerg, Sweden: One giant heat pump for a whole city[32]

To generate heat, seawater is drawn from the harbour basin and thermal energy extracted before it is pumped back into the sea. CO_2 is the refrigerant used in the process which enables the heat pump to be very flexible. The unique features of this heat pump solution are that its use of excessive wind power can balance the grid if required.

Vienna, Austria: Europe's biggest heat pump system put into operation in Vienna[33]

Vienna aims to become climate-neutral by 2040, and a key step toward achieving the goal is to decarbonise heating. The project in Simmering which is the largest green heat pump system in Europe utilises thermal energy from wastewater in the adjacent wastewater purification plant. Upon completion, the capacity of the heat pumps in Simmering will reach 110 MW.

Stockholm, Sweden: Stockholm innovates district heating with renewable sources[34]

Central Stockholm boasts one of Europe's largest DHC systems. Close to 90 per cent of the city's buildings are connected to the district heating network. In Stockholm there is the world's largest heat pump plant that extracts DHC from purified wastewater. At the same time, the process generates cold water, which in the next step is used to produce cooling in the district cooling network. Stockholm has also taken a world leading position in large-scale heat recovery from data centres. In the future, Stockholm Exergi expects to provide 10 per cent of the city's heating needs with recovered heat from data centres.

Marstal, Denmark: Sunstore – Solar thermal district heating[35]

An example of a successful community project where an efficient combination of technologies including solar thermal supplies about 2300 inhabitants with renewable heat all year long. What is also unique about

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[30] Saroj Thapa, ATMO Europe: Novel District Heating Plant in Denmark, *Natural Refrigerants*, October 2023.

[31] Tim Schauenberg, Could large heat pumps revolutionize how we warm our homes?, *Deutsche Welle*, January 2024.

[32] Niels Anner, One giant heat pumpfor a whole city, *MAN Energy Solutions*, accessed 10 September 2024.

[33] Jelisaveta Perišić, Europe's biggest heat pump system put into operation in Vienna, *Balkan Green Energy News*, 11 December 2023.

[34] Laura Puttkamer, Smart City Stockholm: A connected, sustainable, data-driven city, *Bee smart city*, 17 May 2023.

[35] Marstal, About Marstal District Heating, *Solar Marstal*, accessed 10 September 2024.

this project is that the company is a non-profit organisation that returns all potential profits back to the local residents in the form of lower energy prices, and all the shareholders in the company have equal voting rights.

Gelsenkirchen, Germany: Iqony baut Groß-Wärmespeicher[36]

The energy supplier Iqony is building a 57-metre-high hot water tank in Gelsenkirchen. With a capacity of 31 million litres, the storage facility will be one of the largest in Germany.

[36] Manager-Magazin, Iqony baut Groß-Wärmespeicher in Gelsenkirchen, *Manager-Magazin*, May 2024.

3. Technologies

AGORA Energiewende: Rollout of large-scale heat pumps in Germany[37]

In a recent German study (Agora Energiewende: The rollout of large-scale heat pumps in Germany) it is assumed that in 2045 over 70 per cent of heat production will be covered by heat pumps. Interestingly, they assume an installed capacity of 90 gigawatts (GW) and pump operation only about 1400 hours per year. The operation should be concentrated during the period of low electricity prices using thermal storage with storage capacity for up to several days of heat supply.

IRENA: Integrating low-temperature renewables in DH[38]

This guidebook by the International Renewable Energy Agency (IRENA) and Aalborg University (AAU) provides information for policy makers and examples of available tools and solutions to facilitate the use of low-temperature renewable heat sources in new and existing district energy systems. An overview of applications and enabling technologies for DHC utilising low-temperature renewable energy is also presented.

Bayern: Heat pumps with river water[39]

Heat pump technology is mature and suitable for use with river water as a heat source. This is also demonstrated by the projects implemented to date. River waters offer several advantages over other heat sources, such as outside air. However, the use of heat pumps along watercourses as heat source is not yet sufficiently standardised due to their special characteristics. The cooling of watercourses with heat pumps can be regarded as positive and is less critical than the warming of water. However, there are no uniform regulatory requirements in this regard. A wide variety of framework conditions and location factors must be considered when developing the potential and planning specific plants.

EHPA: Industrial heat pumps overview[40]

In industry, heat represents more than 60 per cent of energy use. Industrial heat pumps can help decarbonise low temperature heat supply within industries by using renewable energy and wasted heat recovery. Industrial heat pumps can provide energy at temperature levels of up to 160 °C. Prototypes are operating at around 180 °C and industry experts expect temperatures of 200 °C and beyond in this decade. They can provide about 10 per cent of total final energy demand of industry (approximately 2000 terawatt hours (TWh)) and hence are a significant contributor to Europe's energy and climate targets that should be recognised in the renewable energy directive and in energy statistics.

[37] Agora Energiewende, The roll-out of large-scale heat pumps in Germany, *Agora Energiewende*, December 2023.

[38] International Renewable Energy Agency, Integrating low-temperature renewables in district energy systems: Guidelines for policy makers, *International Renewable Energy Agency*, March 2021.

[39] FfE Munich, Heat pumps along watercourses – analysis of the theoretical potential in Bavaria, *FfE*, April 2024.

[40] European Heat Pump Association, Industrial heat pumps can deliver 180°C and higher under development, *European Heat Pump Association*, accessed 10 September 2024.

White paper: Cold grids in Germany[41]

Cold district heating networks have great potential for the heat transition in Germany. Compared to traditional district heating networks, only a few systems exist to date, but the growth rates of cold district heating networks in recent years show the potential of the technology. This white paper provides an overview of cold district heating networks in Germany and evaluates a scientific survey conducted by RWTH Aachen in 2022, in which the stock of cold district heating in Germany was analysed.

Oddgeir Gudmundsson: Twelve years of district energy [42]

It is important to state that district energy is an open and flexible infrastructure. This means that district energy is different from individual heating or cooling solutions. The district energy concept is an enabler for societies to design their thermal supply system for fulfilling multiple agendas, among those can be sustainable decarbonisation, affordability, resilience and so forth.

EHPA: Large-scale heat pumps in Europe, vol. 2[43]

Although heat pump technology has been in existence for over 150 years, its widespread adoption has been delayed due to the availability of cheap oil and gas. Except for a short heyday during the two oil crises of the 1970s, heat pumps have remained a niche product, with some manufacturers even halting production entirely.

These attitudes have recently changed, with the public and regulators starting to recognise the limitations and availability of fossil fuels as well as the negative impact of burning these fuels on the climate. Since the development of the technology in the 1980s, the trend towards heat pumps for heating purposes has accelerated to the point that it is now much more reliable, cost-efficient and flexible across a number of applications. At the same time, heat pump technology has successfully addressed its own environmental issues, and now exclusively utilises ozone-friendly refrigerants with increasingly low global warming potential. The technology's ability to use ambient air as a cheap, clean and efficient heat source has been a major breakthrough for its employment in residential heating. Today, there is no doubt that heat pump technology will become the dominant method residential and district heating in the years to come.

[41] Marco Wirtz, White Paper:Kalte Nahwärme in Deutschland, *nPro Energy*, June 2023.

[42] Oddgeir Gudmundsson, Twelve years of district energy, *LinkedIn*, 22 April 2024.

[43] European Heat Pumps Association, Large scale heat pumps in Europe, Vol.2, *European Heat Pumps Association*, 2020.

4. Methodologies

ActionHeat[44]

In ActionHeat, a workflow for strategic heating and cooling (H&C) planning was developed, structured and transferred into a workflow.

AGFW Praxis Leitfaden Kommunale Wärmeplannung[45]

The two German rule-setting associations - the AGFW and the DVGW, with scientific support from well-known universities, institutes, state energy agencies and experts, have developed a practical guide for municipal heat planning. The practical guide also offers heat supply companies a basis for implementing a process with their municipalities that is realistic, open and oriented towards implementation on site. The practical guidelines from the two associations are based on minimum standards for achieving the goals of municipal heat supply. This should make on-site processing much easier in a realistic and goal-oriented manner.

Municipal heat planning in Germany[46]

In a joint Danish–German effort, the project selects relevant knowledge and collaborate to strengthen and accelerate the municipal heat planning. Four topics has been identified so that experience and sparring from Denmark can support a stronger heat transition in Germany: DH is energy infrastructure and brings a wider value to the local society, how to set the scene for a successful heat plan, how to make a plan step-by-step, ownership and organisation of DH.

HOT|COOL heat planning[47]

A special edition of the Danish Board of District Heating’s HOT|COOL magazine, dedicated to exploring the impact of heat planning, reports that local heating and cooling planning is set to be implemented in every European city with over 45,000 residents. This could prove a significant shift for district heating and play a crucial role in furthering Europe’s climate ambitions.

Accelerating the decarbonisation of DH through mandatory connections[48]

District heating is becoming an increasingly important topic for municipalities. It is clear that district heating has a role to play where heat demand density is high enough to make it cost-efficient, in combination with other solutions. One possible way of accelerating its development is to mandate connections to the network in specific buildings and areas.

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[44] Act!onHeat, Act!on Heat Workflow Guide, *Act!onHeat*, 13 December 2022.

[45] AGFW, Kommunaler Wärmeplan, *AGFW*, accessed 10 September 2024.

[46] DBDH, Municipal heat planning in Germany, *DBDH*, accessed 10 September 2024.

[47] Adrian Hiel, Is this the moment we kick out the fossil fuels?, *HotCool Magazine, DBDH*, p. 5, January 2024.

[48] DecarbCityPipes, Accelerating the decarbonisation of district heating networks through mandatory connection, *DecarbCityPipes*, 3 October 2022.

Euroheat&Power: DHC market outlook for 2024[49]

According to a study from Aalborg University, expanding district heating to cover 20 per cent of the EU heat demand by 2030 (compared to 13 per cent today) would save 24 billion cubic metres of gas demand by 2030. This would require bold policies to modernise and expand district energy networks, building at least 3500 new district heating networks by 2030, for an investment estimated at EUR 144 billion. The lack of level playing field and economic incentives to switch away from fossil-based heating remains a major obstacle to the deployment of efficient and sustainable district energy systems. In 2023, the average prices in the EU for wholesale and retail gas went down respectively by 66 per cent and 16 per cent. The market fundamentals of the pre-crisis remain unchanged, holding back the deployment of much needed clean heat solutions, such as DHC.

[49] Euroheat&Power, DHC Market Outlook 2024, *Euroheat & Power*, accessed 10 September 2024.