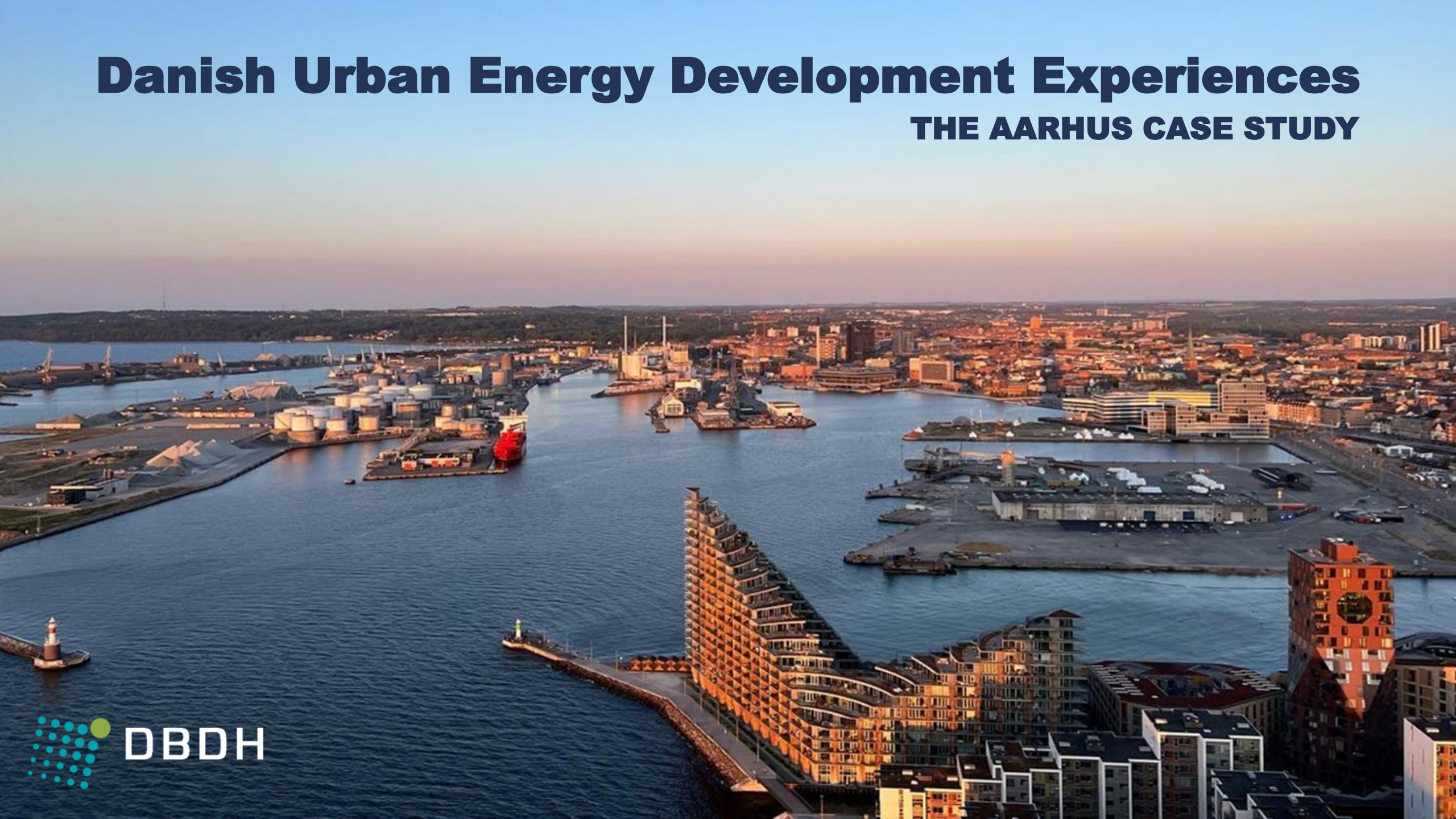
Danish Urban Energy Development Experiences

THE AARHUS CASE STUDY



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About this publication

From the author

Denmark's continuous development of district heating is based on political decisions to provide citizens with cheap, reliable, and environmentally friendly heating while also contributing to solving some of society's other challenges. As someone who works internationally with district heating, I see a lot of interest and obstacles. I hope this publication will provide a rewarding overview and answer many questions about district heating in Denmark.

I would like to give special thanks to Elsebeth Arendt, head of district heating at the Danish utility Kredsløb in Aarhus, for sharing information and insights.

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Foreword

District heating offers essential solutions to the sustainable transition. This story about district heating in Denmark and the city of Aarhus is relevant to anyone looking for sustainable solutions in heating and other sectors such as power, industry, and hydrogen.

The aim is to inspire other cities to succeed with their sustainable transition. With a history of coal-based heating, Aarhus succeeded with carbon-neutral district heating in 2017 and continues the journey toward sustainability. They are making the district heating system even more energy efficient and implementing renewable heat sources.

Innovation and knowledge-sharing are key to realising clean heating solutions. Denmark and China have extensive experience in district heating, and this publication contributes to the ongoing knowledge exchange to improve and expand district heating.

Liu Rong
Vice-president,
China District Heating Association

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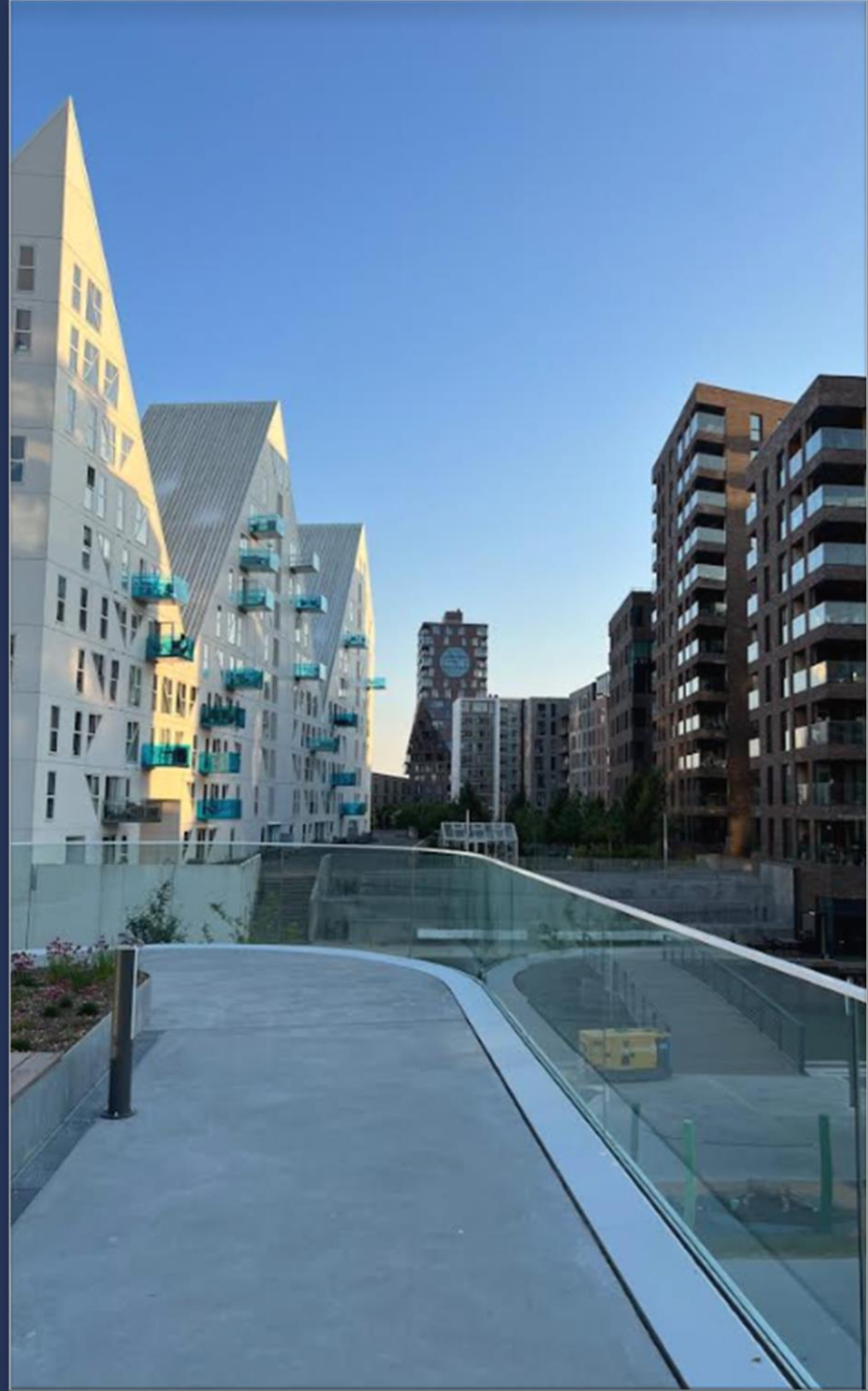


Part of a Bigger Picture

The municipality of Aarhus owns the district heating utility Kredsløb, which supplies carbon neutral heat to citizens, public buildings, and companies.

The city council values district heating because it supports a more beautiful, liveable, and sustainable city.

About Aarhus and Kredsløb

The municipality of Aarhus

- 362,000 inhabitants (increasing 1,5% per year).
- Heat planning is part of the climate and strategic energy planning for the whole municipality. Authorised to make local heat planning.
- The climate goal is to be carbon neutral by 2030.
- For the benefit of the citizens and society, the municipal owner requires the utility Kredsløb to deliver on three different bottom lines.

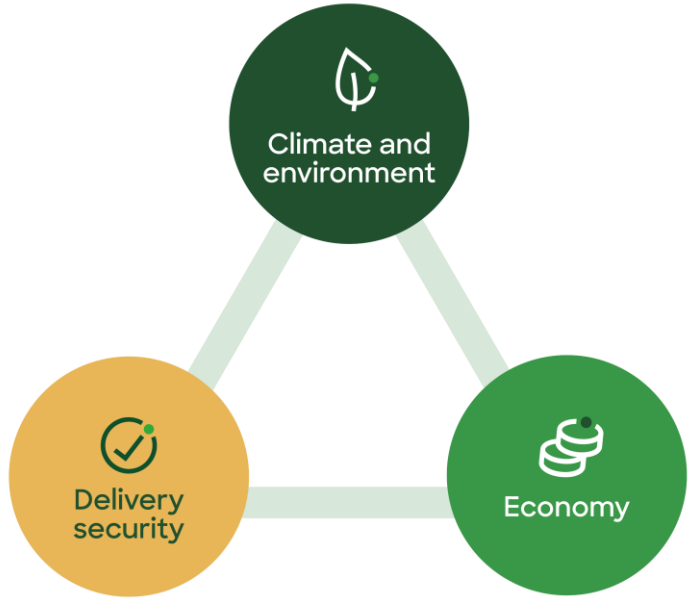
Kredsløb - the utility for Energy and Waste

Kredsløb is responsible for recycling, waste management, and district heating and cooling. The following focusses on the district heating part of Kredsløb.

- Supply district heating to 95% of all buildings in Aarhus, with a total of 65,000+ customers (meters).
- Carbon-neutral district heating since 2017.
- Mainly not-for-profit activities with 90% financed by cost-based tariffs.
- Owned by Aarhus municipality and also in close collaboration with three surrounding municipalities.
- Professional company with a diverse and independent board.

Kredsløb

We ensure low emissions and create a clean environment



We ensure a stable heat supply

We ensure a low heating price

Strategic Energy Planning

Denmark has a tradition of holistic planning, which involves planning across different energy sectors to increase energy efficiency, reuse resources, and save money. The mindset is about not wasting resources.

This has resulted in three different types of combined heat and power (CHP) units in Aarhus. They co-produce electricity for the Danish power transmission system and district heating for the Aarhus area. Co-production is more efficient than producing power and heat separately.

Waste-to-Energy: This type of CHP is based on waste incineration of residual (not reusable) waste. Kredsløb uses heat from two such units.

Straw: The straw-fired CHP plant converts agricultural waste to heat and power and returns the ashes to replenish the soil. Local farmers supply the straw through a tendering process.

Wood pellets: At the site in Studstrup, a CHP unit was based on coal until 2016, when it was refitted to run on wood pellets. Heat delivery is specified in a contract between the owner (Ørsted) and Kredsløb, ending in 2030.

The integration of the power and district heating systems has changed over time and will continue to do so. In the past, the need for power resulted in CHP units that also supplied cheap and energy-efficient district heating.

CHP units will also have a place in the future energy system, but heat production will become more diversified. One result is that the district heating system will become a net electricity consumer. This underlines the need to understand developing trends and coordinate the planning of the heat and power systems.

Sector Integration

The district heating system is about moving heat – from where it is cheap and available – to where it is needed. It is the infrastructure that enables the use of surplus heat from industry, data centres, CHP-based power production, hydrogen and e-fuel production, district cooling, and wastewater systems. Large-scale heat pumps and district heating systems are needed to effectively harness energy from seawater, rivers, lakes, groundwater, district cooling, or underground.

Power production from wind and solar covers approximately 60% of the Danish electricity demand. Several measures help to balance the power system, and the district heating systems contribute with three essential elements:

Flexible storage: Heat storage is cheap and provides a buffering between energy demand and production on a large scale. Energy is often needed in the form of heat; if so, there is no need to convert the heat back to electricity later.

Flexible production: District heating units such as CHPs and boilers can be turned on or off depending on what is needed. They provide security of supply for both the power and district heating systems. They also offer an alternative to large-scale heat pumps and electric boilers when electricity is expensive.

Flexible demand: Large-scale heat pumps and electric boilers produce heat from electricity. When part of a robust district heating system, they can delay, increase, or decrease their electricity consumption. This flexibility is used to bid into the different power markets, which reduces the costs of heat production and supports the balancing of the power system.

More sector integration is on the way. District heating can reuse surplus heat from producing green hydrogen for e-fuels and processes like steel production.

Carbon capture is one of the technologies under development. District heating units are part of the carbon capture setup, both as a site where concentrated CO_2 can be captured and as a way to reuse the surplus heat from the carbon capture processes.

Urban planning

Cities are constantly changing, and the necessity of a sustainable transition is accelerating the need to plan and implement changes. Planning and implementation of heat infrastructure and production sites require coordination with urban planning. Space is limited, and many areas have restrictions or develop over time.

Experiences from Aarhus:

- Detailed coordination between heat planners and urban planners is invaluable. They should also continuously collaborate on the use of areas, environmental assessments, and approval processes.
- Technical innovation and collaboration with architects make DH installations less visible and more flexible. They can also be designed to stand out and enrich the neighbourhood with aesthetic solutions.
- Engage with a wide range of stakeholders. This will improve and facilitate solutions. The municipality of Aarhus does this in its work on climate and strategic energy plans, and the utility Kredsløb participates as a key stakeholder.
- Emphasize that district heating may take up space in some places but also free up space in others, such as rooftops for green oases.

Achieved Carbon Neutrality in 7 years

By 2017, seven years after the political decision in the city council, the district heating system was carbon neutral.

The new target is district heating based on renewable sources and, ultimately, a fully sustainable system.

Coal is History

As a response to the energy crises in the 1970s, Denmark transitioned from oil to coal-based CHPs. The electricity and heating infrastructure expanded, and in Aarhus, the construction of coal-based units at the Studstrup plant northeast of the city resulted in a significant change to the district heating system.

Most of the heat was produced at Studstrup and the Waste-to-Energy site north of the city and then transported in large heat transmission pipes to the different parts of the city. This setup provided Aarhus with cheap and energy-efficient heat for many years.

With increasing awareness of the climate crisis, it was time for coal to become history. Wood pellets replaced coal by refitting a boiler at the Studstrup plant. It reduced the carbon emissions significantly, but in the big picture, it was a minor change to the system. The heat was produced at the same place, at the same temperature, and flowed in the same pipes to consumers who experienced no changes.

The District Heating System Today

The whole pipe network is built to transmit heat from the production sites in the north to the consumers in all the connected areas.

- Kredsløb supplies 3,100 GWh of heat through this system in a year.
- Four main production units at three locations, with 90% of the heat produced in the north. There are 713 MW of main heat production capacity and 1038 MW of peak and backup capacity.
- The heat transmission network is 130 km long and operates at 25 bar and 110-120 ºC.
- Substations with pumps and exchangers supply 50 distribution networks (2,200 km, 10 bar, 70 °C)

The System is Carbon Neutral Today

District heating in Aarhus is carbon neutral and based on a combination of different types of heat production. The decisions behind this new combination were based on planning, analyses, and stakeholder involvement.

Approximately 2/3 of all Danish households have district heating, and model-based planning and project proposals are standard. The utility companies are supported by technical consultancies and software models specialising in district heating.

Actually, the system is not 100,0% carbon neutral. Some old units are still operational and function as peak and backup capacity. They need to be tested each year and provide security of supply for the system when other units fail or are out for maintenance. Replacing a lot of backup capacity is expensive, and the old units will gradually be phased out.

50 % Wood pellets	25 % Waste	20 % Straw	3 % Surplus (heat pumps)	2 % Electricity	<1 % Oil

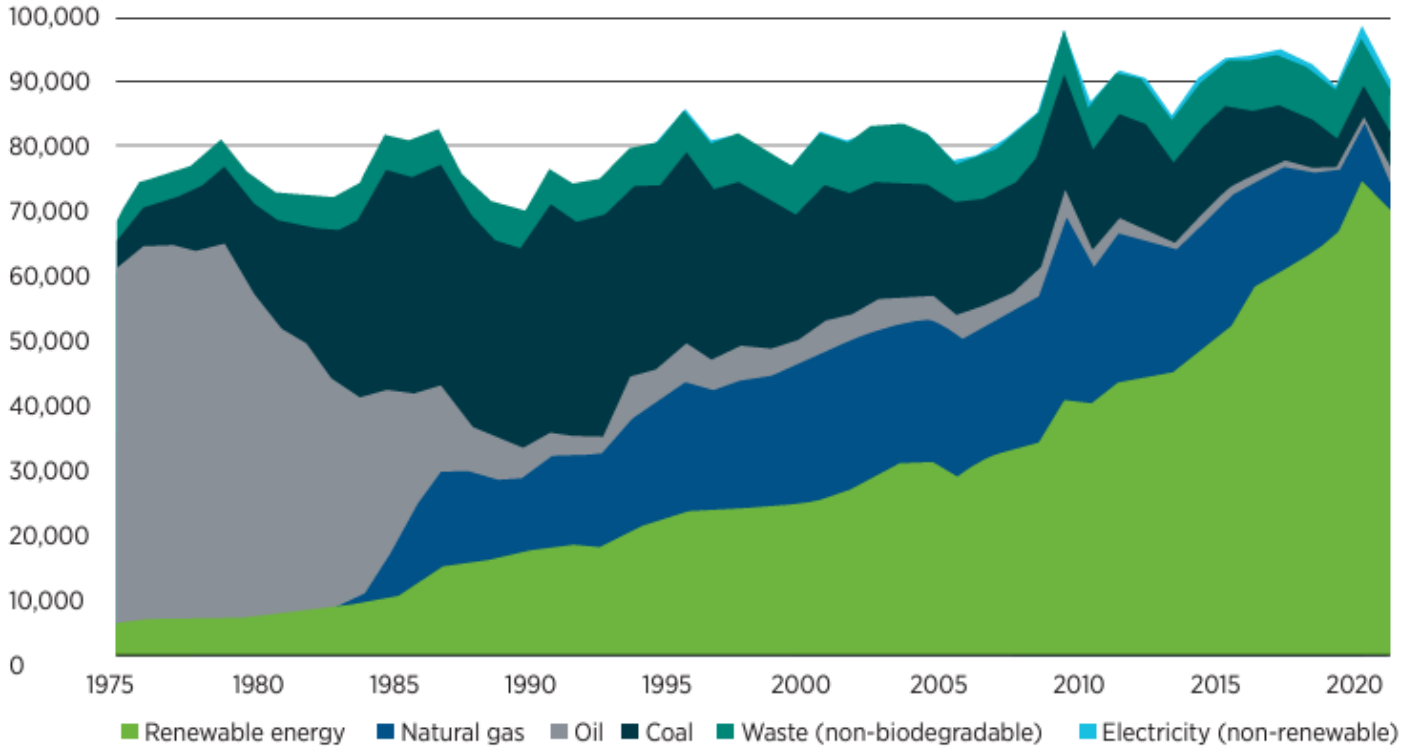
Strong Heat infrastructure enables transitions

District heating in Denmark is based on approximately ¾ renewable heat sources, and the sector has pledged to be 100 % green by 2030. The sector plays a significant role in meeting the climate goals, starting with a focus on reducing emissions in heat production and now with an increasing emphasis on supporting other sectors as a system integrator and collector of surplus heat.

District heating is well-established in Denmark, and the infrastructure has already witnessed several energy system transitions. The figure shows the development in fuel consumption for district heating production from 1975 to 2022.

The experience in Denmark is that district heating has the same positive “lock-in” effect as electricity, water, and wastewater infrastructure. It is a durable, efficient, and necessary solution that enables transitions in production and operation systems without significantly affecting customers. The mentality is that district heating is a no-regrets solution as long as it is based on sound planning.

Fuel consumption in district heating in Denmark (TJ)



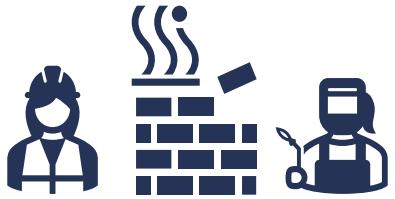
Source: © Danish District Heating Association

Three challenges

Where the change from coal to wood pellets only had a minor impact on the district heating system, going from carbon neutral to renewable sources requires another approach. All parts of the system are involved in making the solution as energy - and cost-efficient as possible. This should be considered in the system design when establishing a new district heating system.

Renewable energy sources are more efficient with lower flow temperatures

- Look at the whole system and make improvements wherever possible.
- Use data, models, and new technology



You can’t rebuild the entire district heating system over night

- Long-term and coordinated planning is needed
- Implement step-by-step

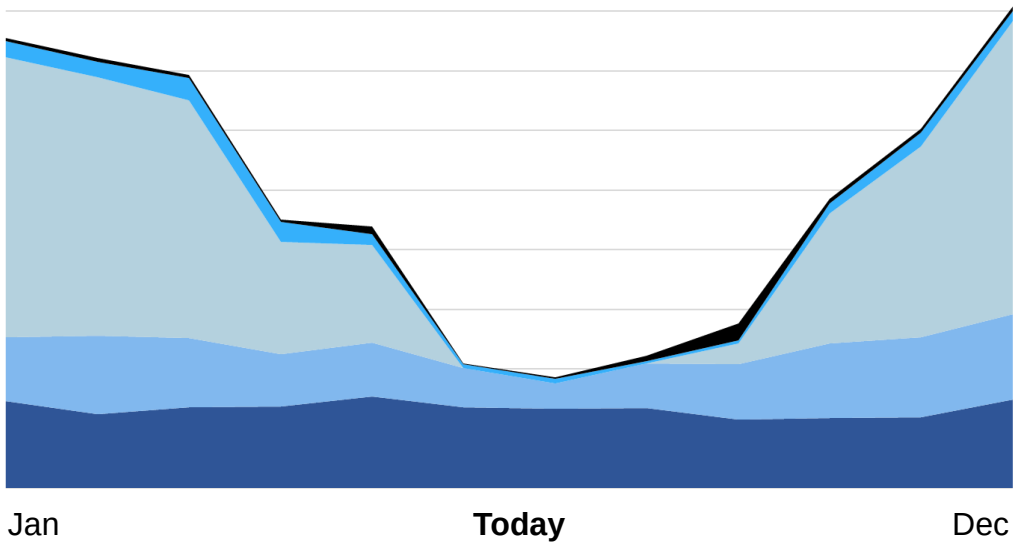
An efficient district heating system depends on the customer's heat exchanger

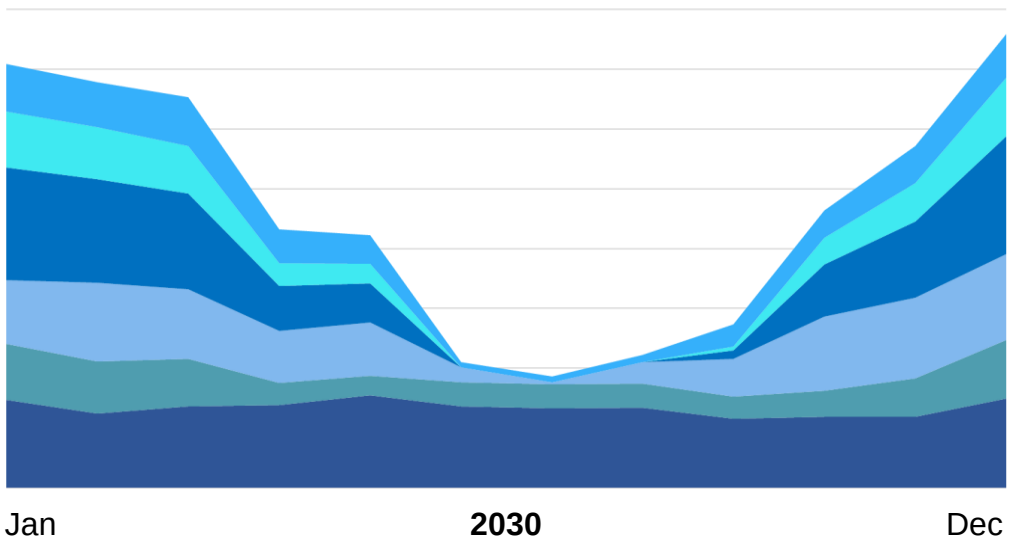
- Focus on customer satisfaction
- Investments in the customer's heat installation

Model-based Master Plan with Renewable Sources

Detailed discussions on assumptions, potential placements, development scenarios, political preferences, and analysis results were part of the two-year process to create the master plan for the district heating system in 2030. A combination of distributed heat sources will replace a large unit based on wood pellets.

Kredsløb prepares the master plan with help from technical consultants, and the city council makes significant decisions.





Heat Production

- Oil boiler
- Electric boiler
- CHP, wood pellets
- Heat pump
- Geothermal heat
- CHP, straw
- Carbon Capture
- CHP, waste

Heat Source Strategy

Combining heat sources makes district heating robust in a changing world.

Planning a cost-efficient district heating system is about making the most of the locally available options.

Heat is available, but utilisation often requires a district heating system.

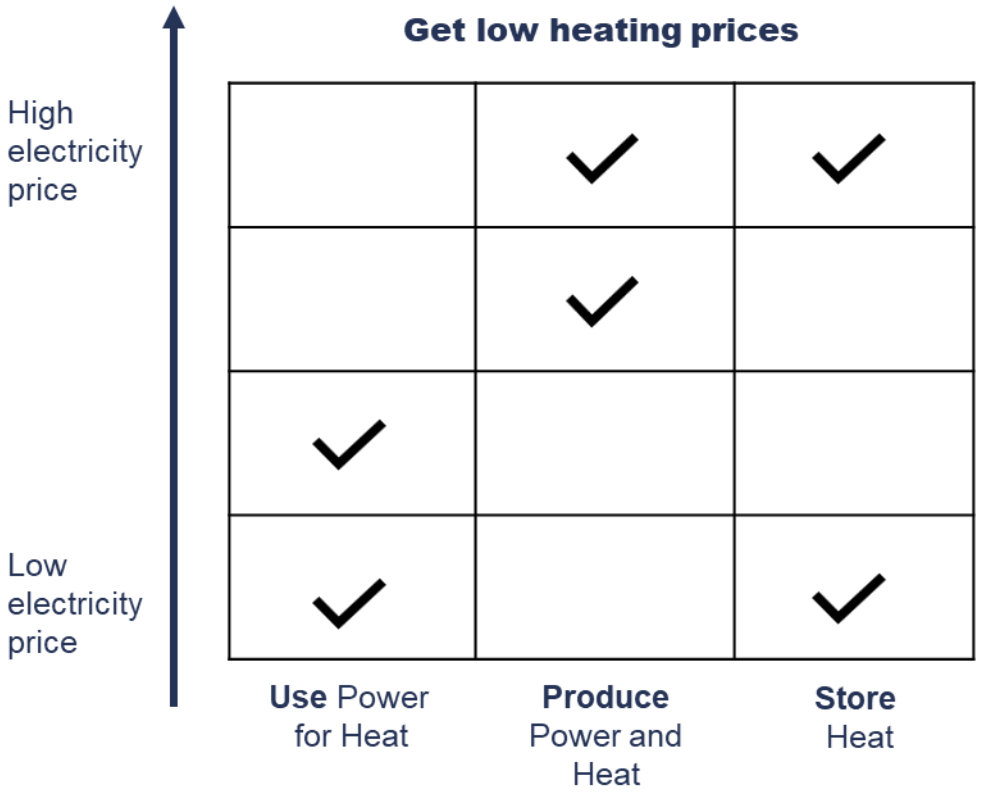
A Resilient Mix of Heat Sources

Two common questions about district heating are: What does it cost, and where does the heat come from? Other questions are: How do we make the system sustainable and resilient? How do we protect the resources on Earth through a local transition? A sound heat source strategy will help find good answers to these questions.

There is a long list of potential heat sources, and the 350 Danish district heating systems display a wide range of heat sources. They are combined in different ways depending on what was locally available and past decisions. The figure's example illustrates a robust combination against fluctuating electricity prices.

Experts look at how the heat sources fit together to build a resilient combination that simultaneously offers security of supply, low and stable prices, sustainability, and efficient operation and maintenance. The first step is to investigate potential heat sources in the area. Kredsløb investigated all potential heat sources on the list and used the findings in the technical and economic analyses for the 2030 master plan.

The following pages introduce key heat sources that are all worth investigating. For sustainability reasons, coal, natural gas, Hydrogen for heating, and uncertified biomass are not included in the list.



Electrification

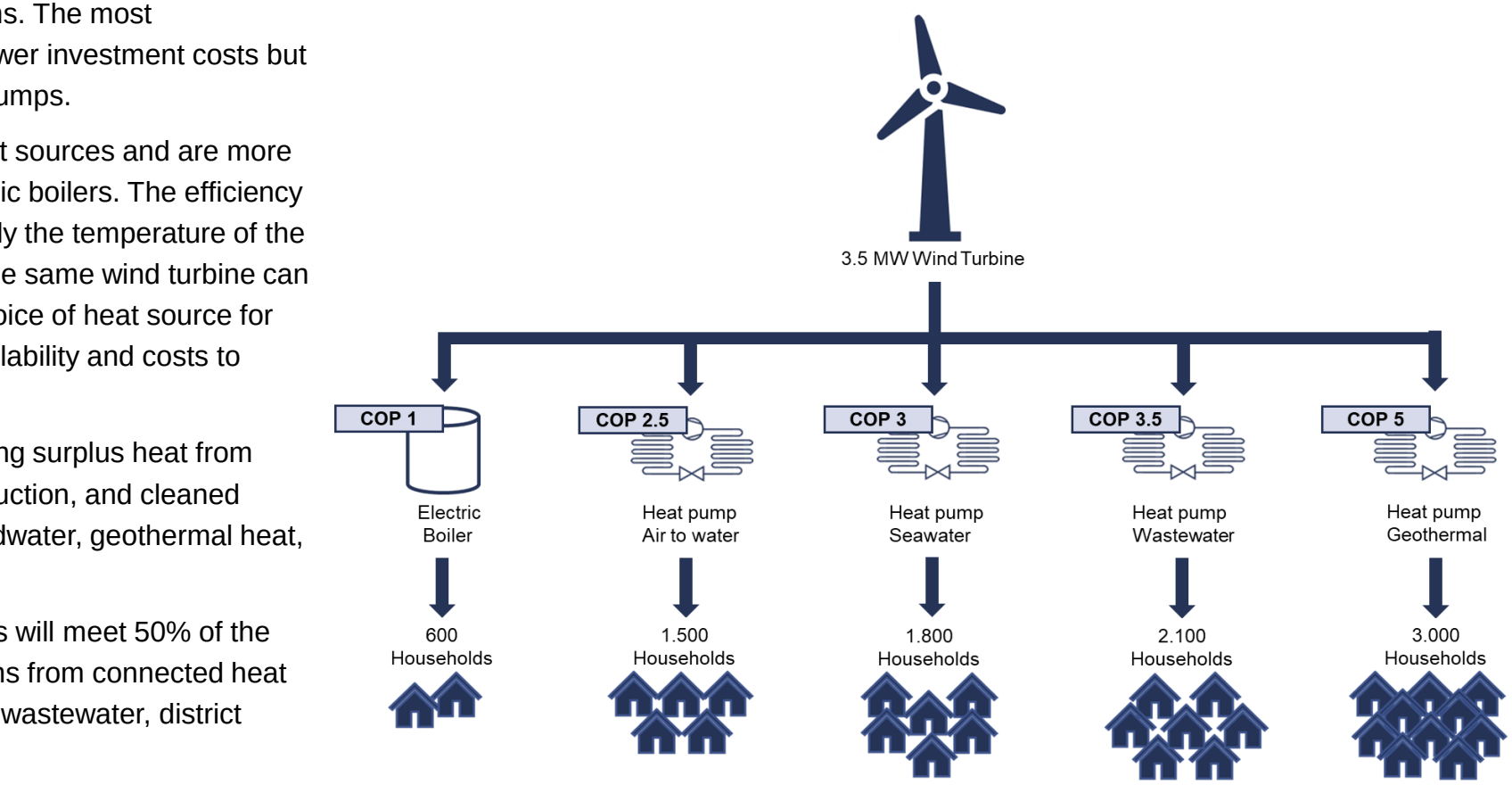
Heat production will increasingly be based on electricity, and two types of units are making their way into district heating systems. The most straightforward unit is the electric boiler, which has lower investment costs but a higher heat production cost than large-scale heat pumps.

Large-scale heat pumps can use a wide range of heat sources and are more energy efficient than individual heat pumps and electric boilers. The efficiency (COP factor) depends on the heat sources, particularly the temperature of the heat source. The figure illustrates how energy from the same wind turbine can heat more houses if the COP factor is higher. The choice of heat source for the large-scale heat pump also depends on local availability and costs to connect the heat source influence.

Heat pumps can use a range of heat sources, including surplus heat from industry, data centres, metro stations, hydrogen production, and cleaned wastewater, as well as seawater, rivers, lakes, groundwater, geothermal heat, ambient air, and co-production with district cooling.

Kredsløb estimates that heat pumps or electric boilers will meet 50% of the heat demand in Aarhus in 2030, including contributions from connected heat sources such as geothermal heat, seawater, cleaned wastewater, district cooling, and ambient air.

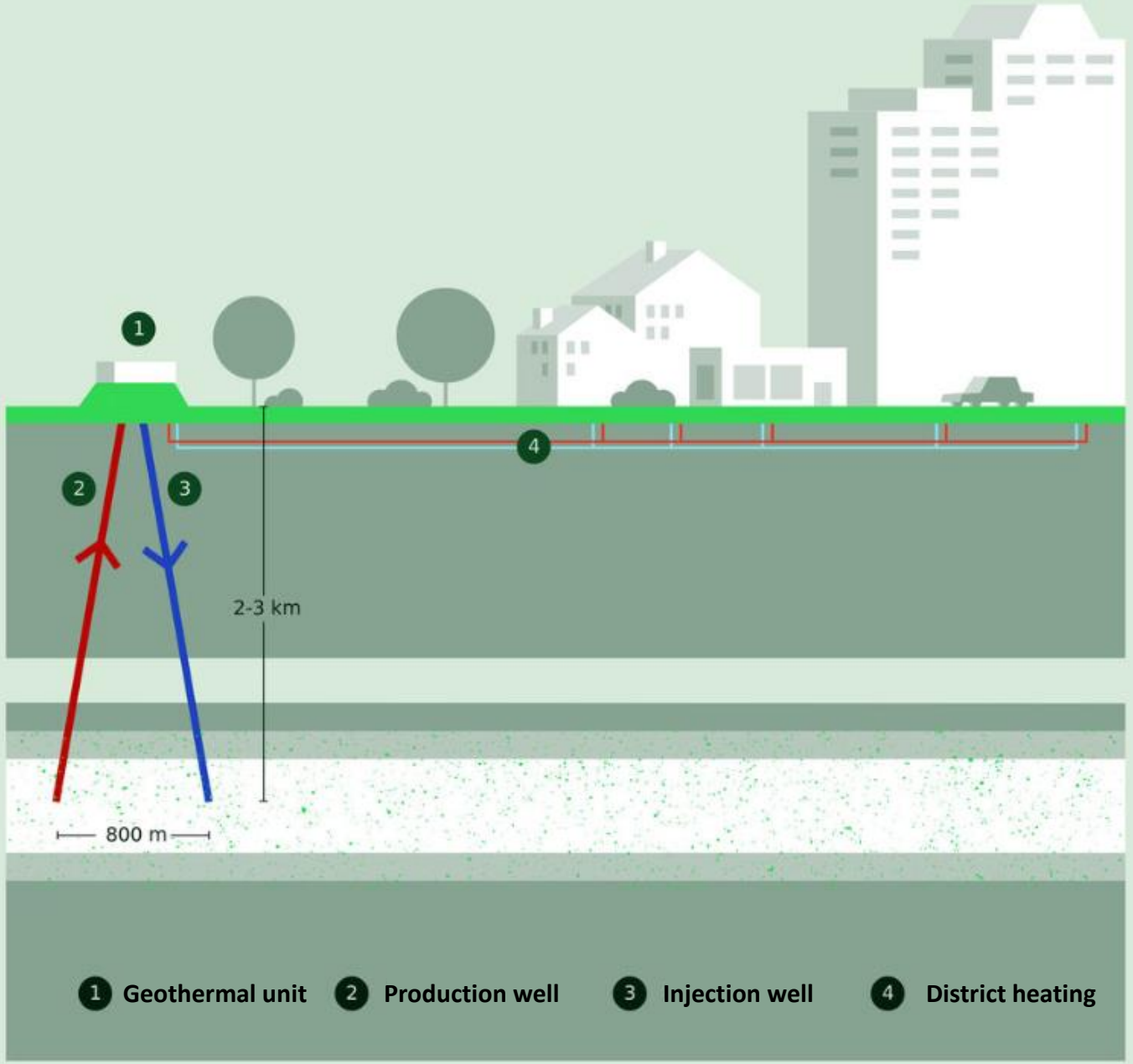
Different ways to use power for heat



Geothermal Heat

Deep geothermal heat is expected to supply large amounts of renewable heat to European district heating systems. Kredsløb is among the front runners, and 20% of the heat demand in Aarhus will be based on deep geothermal heat by 2030. During 2025-2030, seventeen wells will come into operation and deliver heat from the 78 degrees C warm reservoir 2.5 km underground. In total, the geothermal heat production will have a capacity of 110 MW.

Deep geothermal heat requires specific underground conditions. Although it is not available everywhere, there is substantial potential for deep geothermal heat across most European countries, and cities like Berlin, Poznan, Kiel, Copenhagen, Budapest, and Vienna are actively investigating the possibilities.



Waste-to-Energy

Kredsløb is responsible for recycling, waste management, and district heating. The guiding principle is to avoid wasting resources, so the first step is to recycle as much as possible. This starts with households sorting their waste into ten categories.

Kredsløb handles 260,000 tons of waste each year, of which 65% is recycled or used to produce biogas. Some of the waste is not suitable for recycling materials; instead, the energy is recycled into energy. This is a preferred alternative to landfills. 34% of the waste is burned at the two Waste-to-Energy plants, which produce electricity and heat with high energy efficiency.

Biomass

A political agreement in 2012 resulted in massive carbon reductions as the large coal-based CHPs were refitted to use wood pellets. These large units are gradually being phased out and replaced by combinations of smaller units, just as will be the case in Aarhus, where several decentralised geothermal and heat pump units will contribute to the heat supply.

Many district heating systems use locally supplied straw and wood chips. These choices are based on assessments of potential heat sources, such as leftover materials from local agriculture or production forests. The decisions are based on getting the lowest heating price, but additional benefits such as local businesses and jobs are also appreciated in the communities.

Does biomass have a place in new district heating systems? Investigating if certified and local biomass can be part of a sustainable production mix is a good idea. For district heating companies, it could support the economy, sustainability, and robustness. For society, it could support the development of rural areas, villages, and towns.

The use of biomass for heating is continuously being debated, and there are many nuances to consider, such as the length of carbon cycles for different types of biomass materialsmaterials and what else to do with waste products like coffee shells and cherry and olive stones.

Carbon Capture, Hydrogen, and PtX

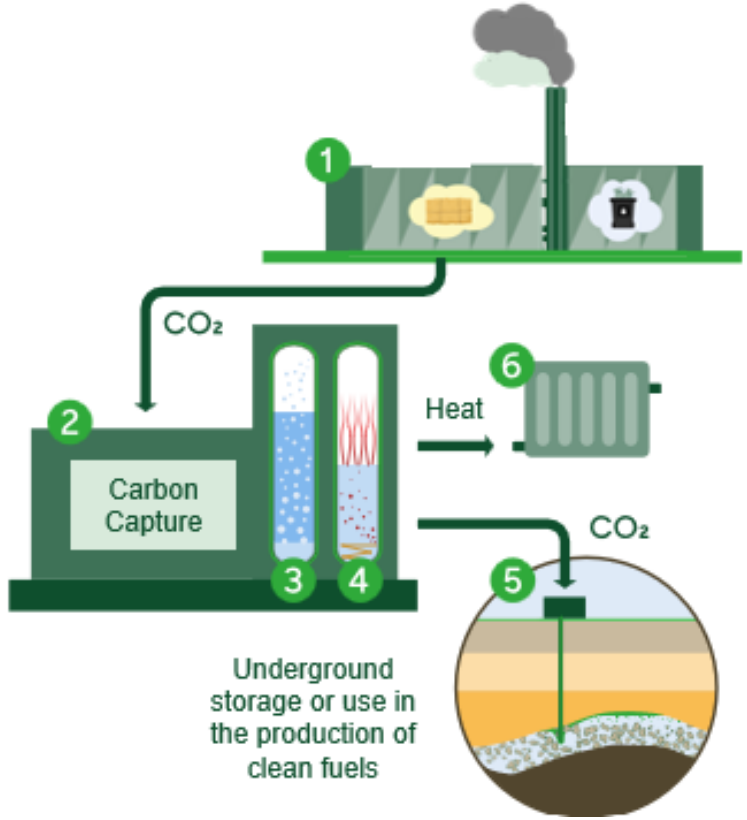
District heating has two strong synergies with carbon capture, hydrogen production, and power-to-X processes.

Reduce energy waste: These processes struggle with energy efficiency, and the heat losses can be significant. The heat is often at temperatures that can be used directly in district heating systems or boosted by heat pumps.

Make concentrated CO_2 sources available: The concentration of CO_2 in purified flue gas is higher than in the ambient air. For this reason, district heating units based on biomass and waste are relevant sites for investigating the potential for carbon capture. Here, it is important also to keep track of the carbon accounting, which depends on parameters such as origin and lifecycle.

Hydrogen is not considered an option for heating in Denmark. Green hydrogen is more valuable to other sectors, and many heat sources are cheaper than hydrogen. What does make sense is to reuse the surplus heat from the hydrogen production for district heating.

From a planning point of view, the sector integration of hydrogen and e-fuels with the power, water, and heating systems is an interesting challenge discussed at both local and national levels.



1: The combustion process emits CO_2 in concentrations that make carbon capture relevant. In Aarhus, 230,000 tons of CO_2 are from waste-based (CHP) units, and 250,000 tons are from straw and wood chip (CHP) units.

2-4: The flue gas is purified, and the CO_2 is extracted by first absorbing and then desorbing with an amine liquid.

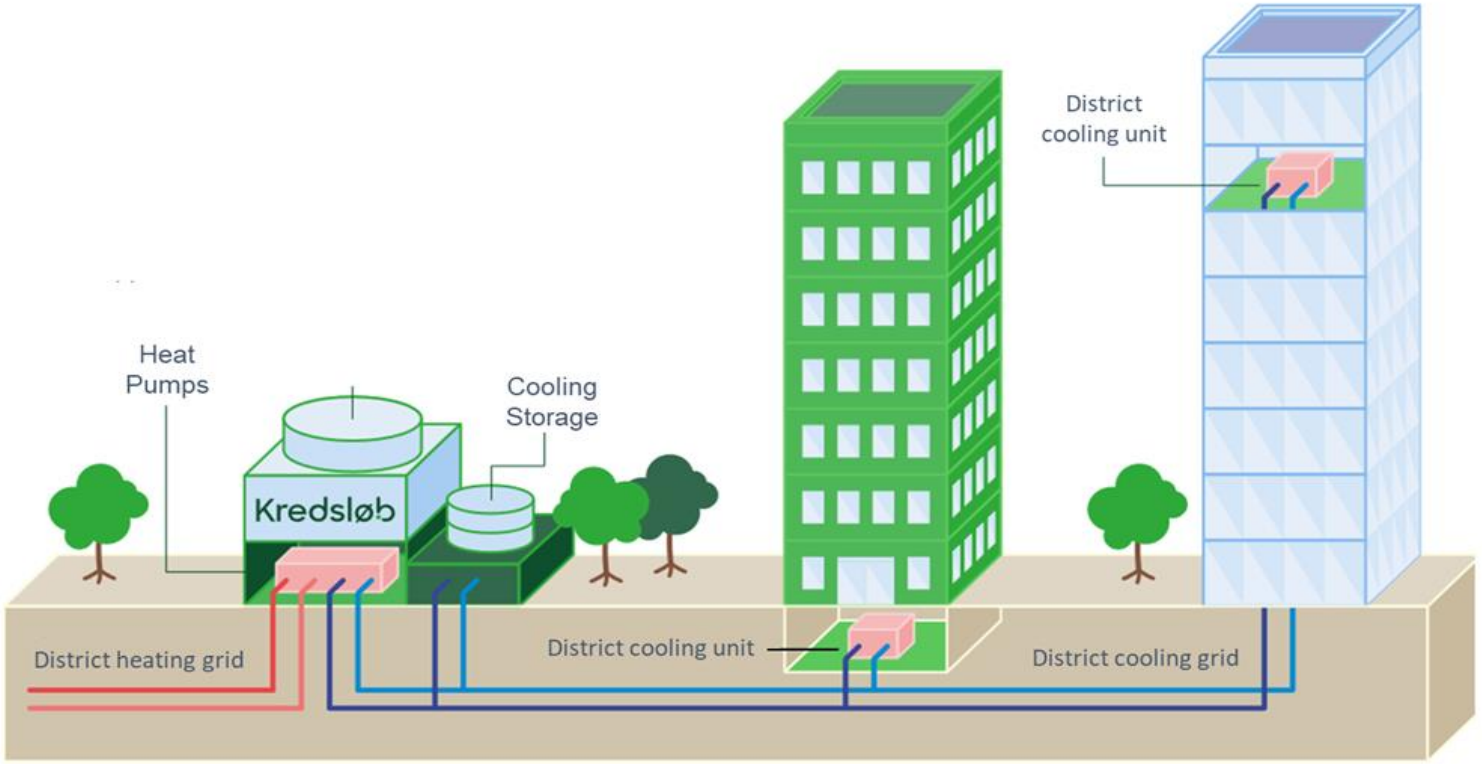
5: The captured CO_2 can be stored (CCS) or used to produce clean fuels (CCU) to replace fossil-based fuels for cars, trucks, or aviation.

6: The carbon capture process has a heat loss, but the heat can be collected and reused in the district heating system.

District Cooling

District cooling can replace air conditioning produced by electricity in each building. It can use cooling sources directly or use cooling from large-scale heat pumps. The cold side of the heat pump supplies the district cooling system, and the warm side of the heat pump supplies the district heating system. This setup has a high energy efficiency and is flexible enough to supply either both sides simultaneously or only one of the sides, depending on the demand.

District cooling is a new service from Kredsløb. The target group is clusters with office buildings, hospitals, and shopping centres. District cooling is operational in one cluster, and Kredsløb is implementing more clusters and working to attract more building owners.



Heat Storage

Heat storage does not produce heat, but it can reduce the need to build heat production capacity, support the integration of renewable sources, and lower the heat price. Heat storage is an increasingly important part of district heating operations and should be part of all heat source strategies.

Short-term heat storage in accumulation tanks is a standard solution that provides flexibility and security of supply. As a result, they can facilitate income from the power markets and better working hours and conditions for the staff. Intermittent and long-term heat storage technologies are under continuous development because they can deliver cheap energy storage over extended periods and support sector integration.

Heat storage is most valuable when designed to match the district heating system. This means that a suitable type of storage is selected, placed, and dimensioned to support the rest of the system. For example, the district heating systems in Copenhagen and Aarhus are different, which has resulted in different heat storage strategies.

How much does it Cost?

Democratic ownership characterises district heating in Denmark, and low and stable prices are key selling points.

District heating is critical infrastructure, and consumer protection and longevity govern the framework behind the investments and cost structure.

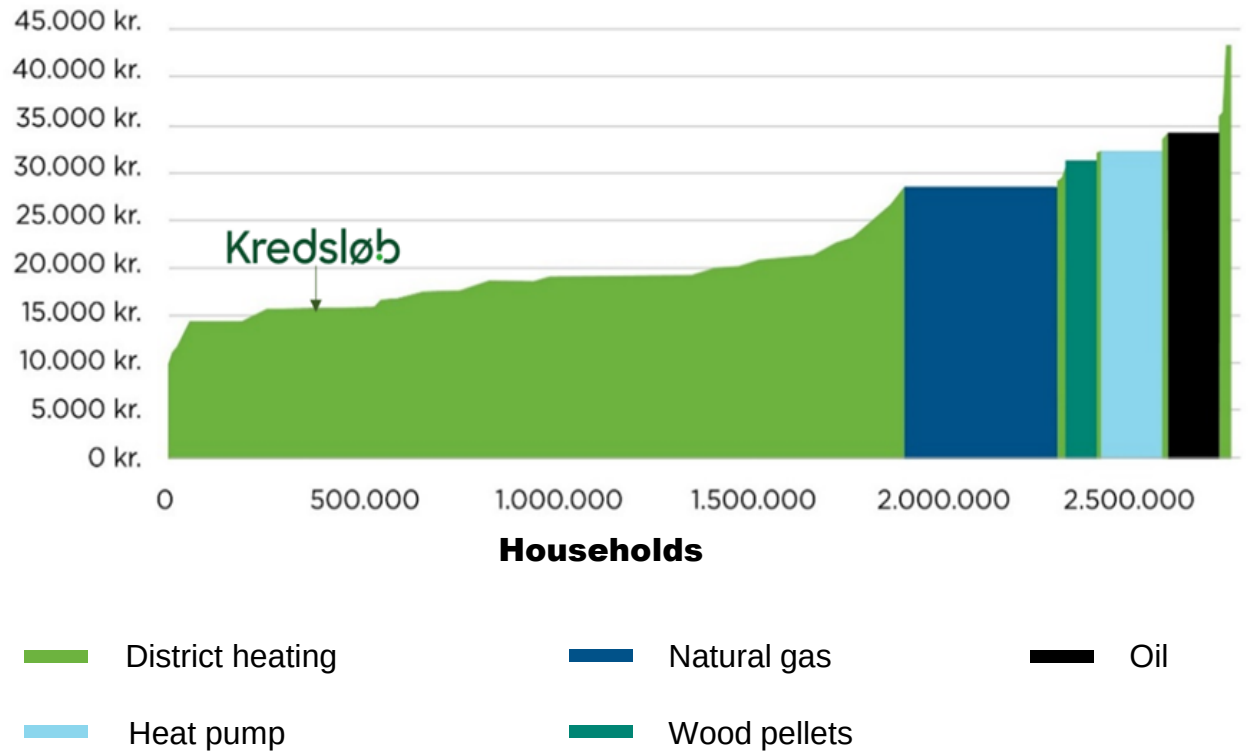
The Price of Heat in Aarhus

To compare, all Danish utilities calculate heat prices based on a “standard house” of 130 m2 with a heat consumption of 18.1 MWh/year. Every six months, the Danish Utility Regulator investigates and publishes the heat prices in all Danish district heating companies.

The figure compares the “standard house” heating costs (2023) for the 2.8 million Danish households, of which 2/3 have district heating. Most district heating customers have lower heating costs than consumers with other types of heating. Oil and natural gas boilers are expected to have been phased out by 2035 and replaced by either district heating or individual heat pumps.

The numbers in the figure are based on a standard house and include investments and operational costs to make a fair comparison between different alternatives. The number for Kredsløb (2023) was 15.600 DKK incl. 25% VAT (2.100 EUR), where 12.300 DKK was the heating bill to Kredsløb, and 3.300 DKK was the estimated investment and maintenance costs within the household. District heating is typically not more than 5% of a household budget.

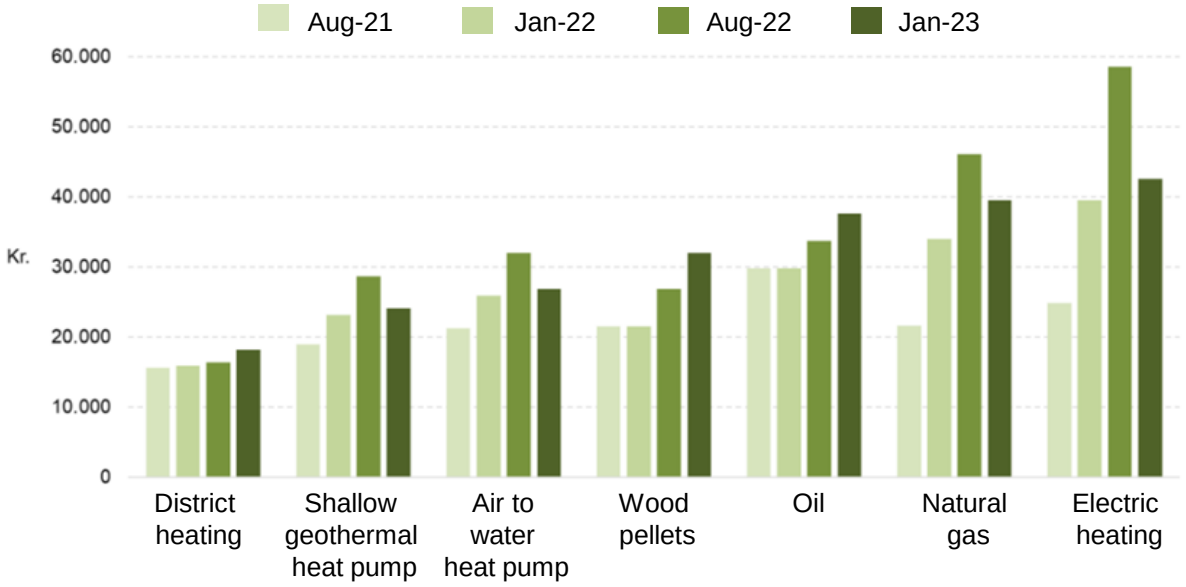
Source: Danish District Heating Association



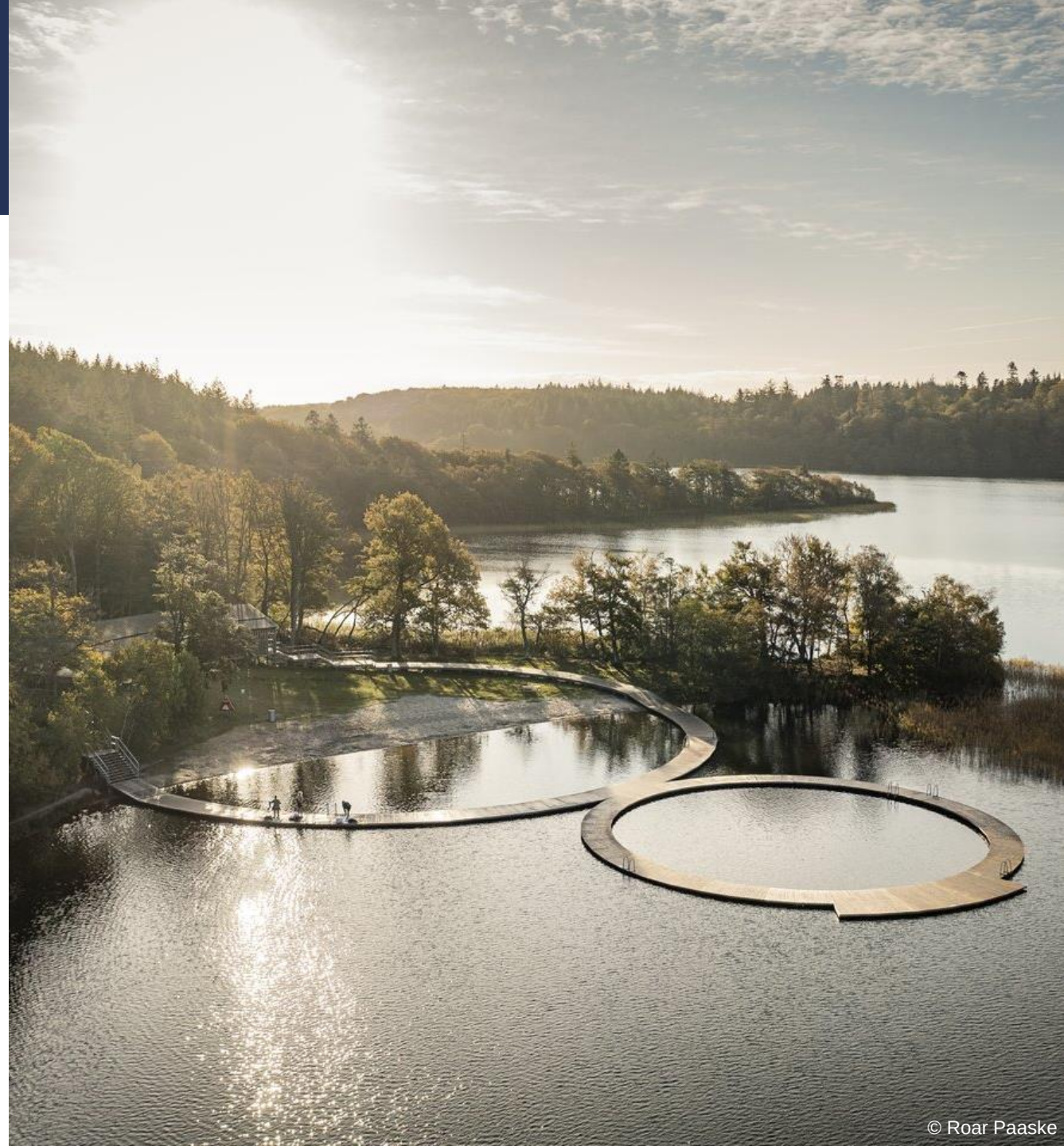
Keeping the Heat
Price low and stable

The heat price is based on the costs of producing and distributing the heat and running the system and the company. Prices vary from year to year and from company to company, mainly due to variations in fuel costs. With a combination of different fuel types, heat storage, and power production and consumption, most district heating systems have the flexibility to keep prices low and stable.

When natural gas, power, and biomass prices increased significantly in 2022, it directly impacted household economies. However, the effect was less pronounced for the households connected to district heating compared to the different types of individual solutions.



Source: Danish District Heating Association



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Regulation and Consumer Protection

District heating is a natural monopoly regulated by the Danish heat law to ensure consumer protection, fair access, and value to society. The district heating company must evaluate three criteria before making significant changes or investments.

- Heat must not become more expensive for the end users.
- The project must be viable for the company, which typically assesses this over a twenty-year period while also investigating potential risks.
- Standardised socio-economic assessments must show that the proposed solution is the best for society.

District heating companies operate as not-for-profit and must ensure the lowest possible heat price. This means they cannot favour their own heat production units or refuse new heat producers if they are competitive. This is handled with heat contracts, and in the more complex Copenhagen system, activation of heat production is managed through an independent setup, called Varmelast, based on bids submitted by all heat suppliers.

Taxes are used to induce specific changes, like when the tax on electricity for heating was reduced to support investments in large-scale heating pumps as an alternative to natural gas-based units. Consumer protection is a main priority, but district heating is not a tool to handle issues like fuel poverty. That is managed by social policy initiatives, not through the heating bill.

Collective Ownership

District heating in Denmark is characterised by democratic ownership, directly through cooperatives or indirectly through municipally owned companies. There are 286 cooperatives and 58 companies owned by municipalities, and each group supply approximately 50% of the heat. There are about ten small private companies. The same regulation governs all companies, and they operate in the same way.

Each district heating company makes a budget and announces the heating price through its tariff sheet, which applies to all consumers. Reality rarely matches budgets perfectly, so imbalances are compensated for in the following tariff sheet. The Danish Utility Regulator oversees the tariff sheets. Consumers can leave a district heating company, and although this rarely happens, it is part of ensuring that the companies do their best.

A guiding principle for district heating companies is to consider the total cost of ownership. By including the costs of operation and maintenance and not focusing mainly on the investment costs, the long-term consequences are higher energy efficiency and lower heat prices.

Kredsløb is responsible for not-for-profit district heating and collaborates closely with the commercial company that produces power and heat at the CHP plant in Studstrup. This has inspired thoughts on handling conflicting interests and the potential value of controlling a larger part of the value chain while still seeing the value of including heat from other suppliers.

Connecting more Customers

New district heating customers typically originate from one of these situations:

- City area with individual heating such as oil or natural gas.
- Urban changes and expansions.
- Production industry looking for renewable heat.

From Natural Gas To District Heating

Residential areas heated by natural gas will typically transition to either district heating or individual heat pumps. The district heating company analyses and prepares project proposals, and based on that offer, the homeowners decide whether to connect to district heating. Each project proposal has a minimum limit for proceeding with district heating. The limit is there to safeguard the district heating company making the investments and is set by the company for each separate project, e.g., a 70% connection rate.

Danish district heating companies have focused more on technical matters and the economy than customer interaction. Communication has become a priority due to the attention during the energy crisis and the political decision to transition from natural gas to district heating and heat pumps.

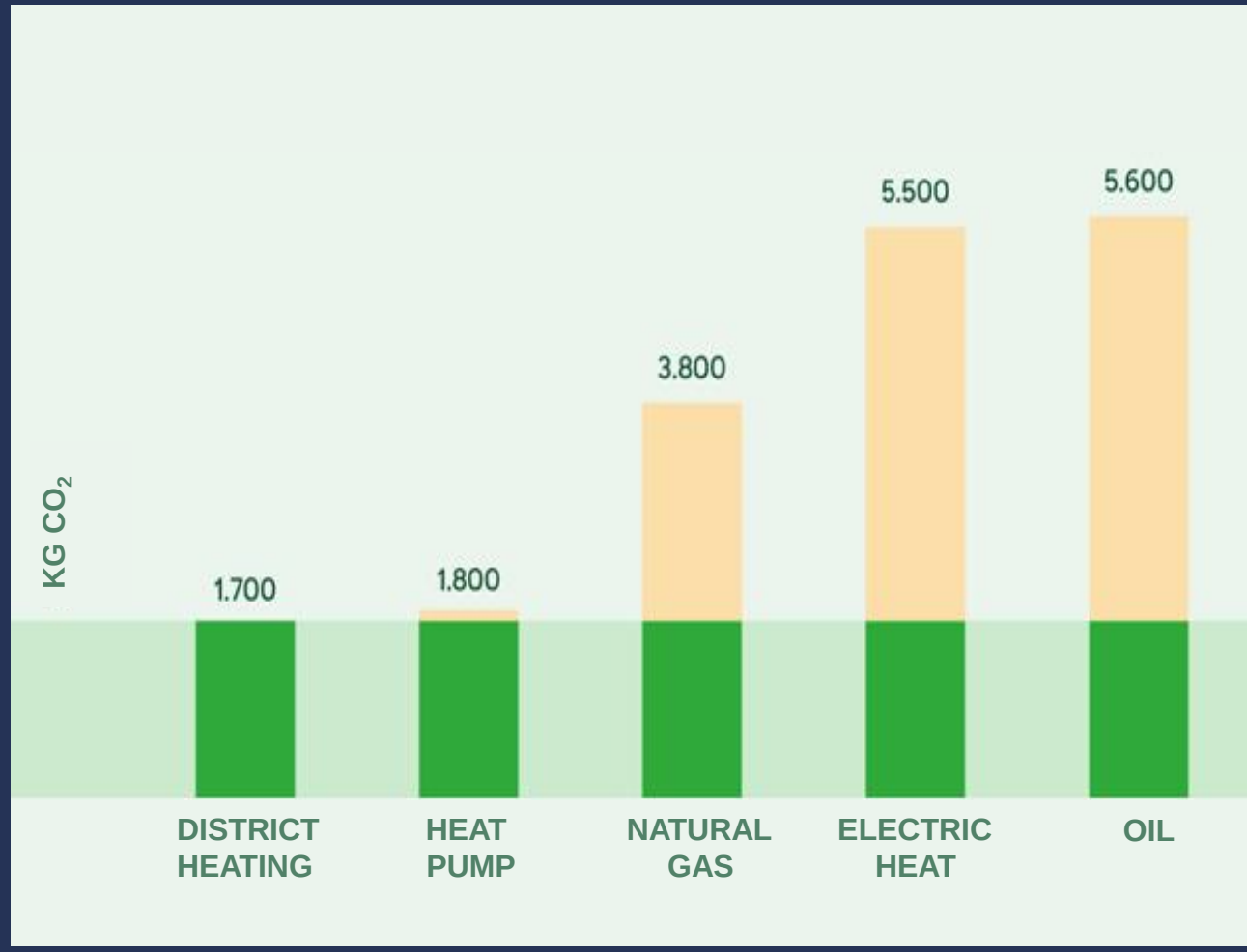
There is no heating with natural gas in Aarhus Municipality, but the neighbouring Skanderborg Municipality has several areas with heating based on natural gas. They asked Kredsløb for help to investigate some towns and potentially offer them district heating. One group (three towns) had a good business case and active citizens advocating for district heating, so district heating will be in operation during 2024. A second group (two towns) had a similar business case and a willingness to connect, but the project had to be developed. The sign-up period was a year later than the first group, and by then, the gas prices had decreased, and the sense of urgency diminished, so the connection rate was too low to proceed. The last group was smaller villages far from the existing grids, so district heating was not feasible.

Convincing People to Connect

Potential customers have legitimate questions about prices, alternatives, and why they must wait for district heating. Kredsløb has a significant part on its homepage dedicated to transparent, timely, and convincing communication with citizens. This includes arguments targeting people considering connecting to district heating or having been offered a “good deal” on an individual heat pump.

- It is cheap, reliable, and good for the environment – and everybody (95%) has it.
- District heating will increase the value of your home.
- It is convenient, invisible, and silent.
- Heat is always there; you don’t have to do anything.
- Prices are stable.
- We have a long history, and we keep improving.

Active support from influential community members and local information meetings are essential to ensuring sufficiently high connection rates. With a reasonable offer in hand, there is a long list of things municipalities and district heating companies can do to convince people to connect.



Urban changes and expansions

In most cases, the best solution for climate and economy is, without a doubt, to connect these areas to district heating. Nevertheless, many interests and people are involved in the processes, and a good final result is no guarantee. Across several steps under different owners, the focus on overall energy efficiency and the “total cost of ownership” approach might be lost.

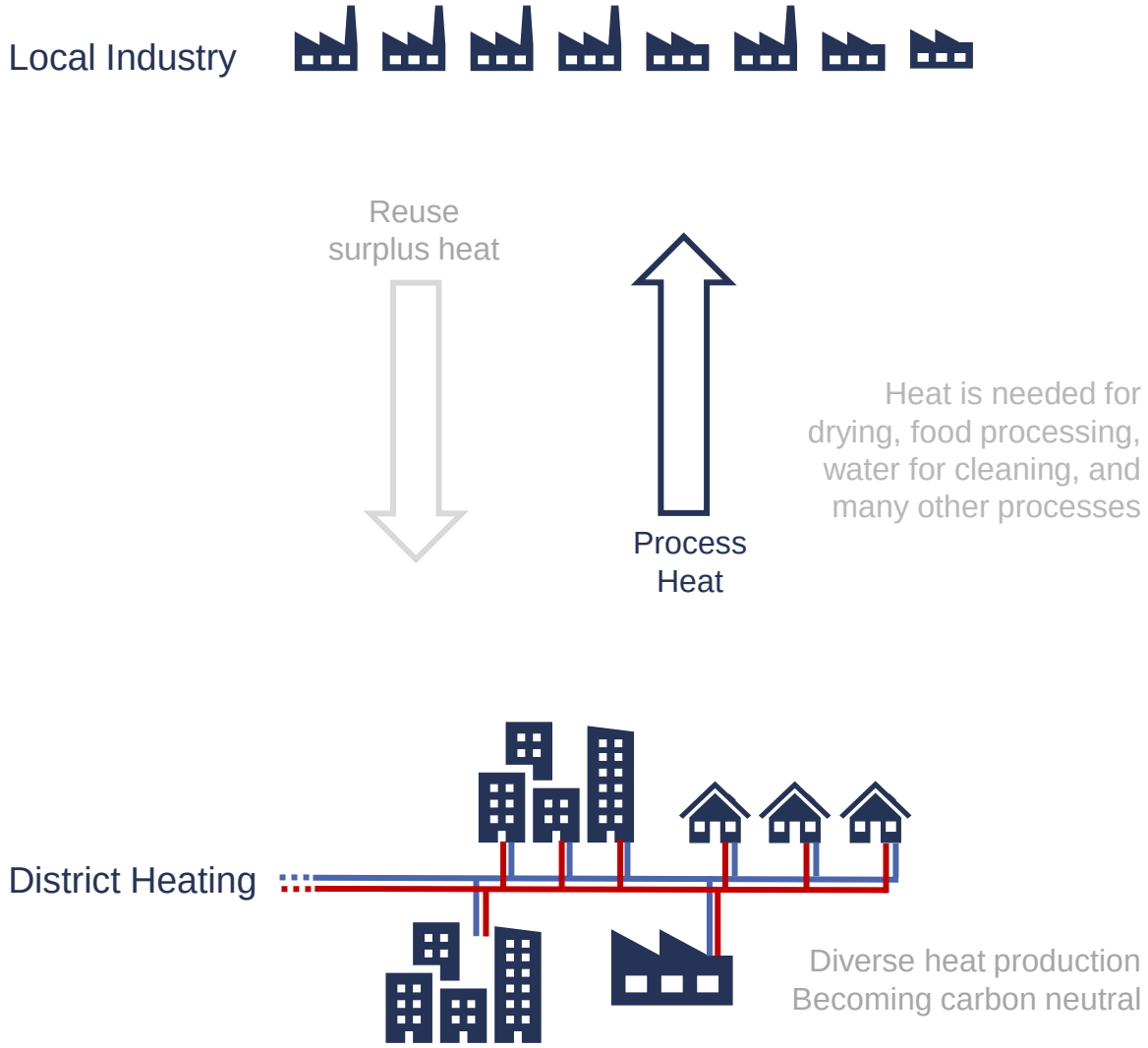
Danish district heating companies are actively in dialogue to motivate owners, developers, and operators to choose the best long-term solutions. Housing associations are often good at this, as they operate the buildings afterwards and, therefore, have invested in smooth operation at lower costs. The sooner the district heating companies can get involved, the better.

Aarhus welcomes more than 5,000 new inhabitants each year, and the city is transforming urban areas and expanding. On average, Kredsløb expands the grid by 20-25 km and connects 1.000 new customers (meters) each year. At the same time, buildings are becoming more energy efficient, so heating demand has been constant overall.

Process Heat for Industry

Reusing industrial surplus heat for district heating is a well-known solution. Perhaps less known is that district heating can support the transition of the production industry, which is struggling to reduce its high carbon emissions. This is still a relatively new solution that is quickly gaining momentum. Solutions have been demonstrated and are being developed further. The climate and economic potentials are enormous, and process heat based partly on district heating is predicted to become a key sector integration solution.

An example from Aarhus is an industrial laundry company that uses many heat-related processes based on natural gas. At the time, district heating was not considered an option as some processes required higher temperatures than district heating could supply. Today, Kredsløb would have taken a more active approach and argued for a combined solution of district heating supplemented with, e.g., high-temperature heat pumps.



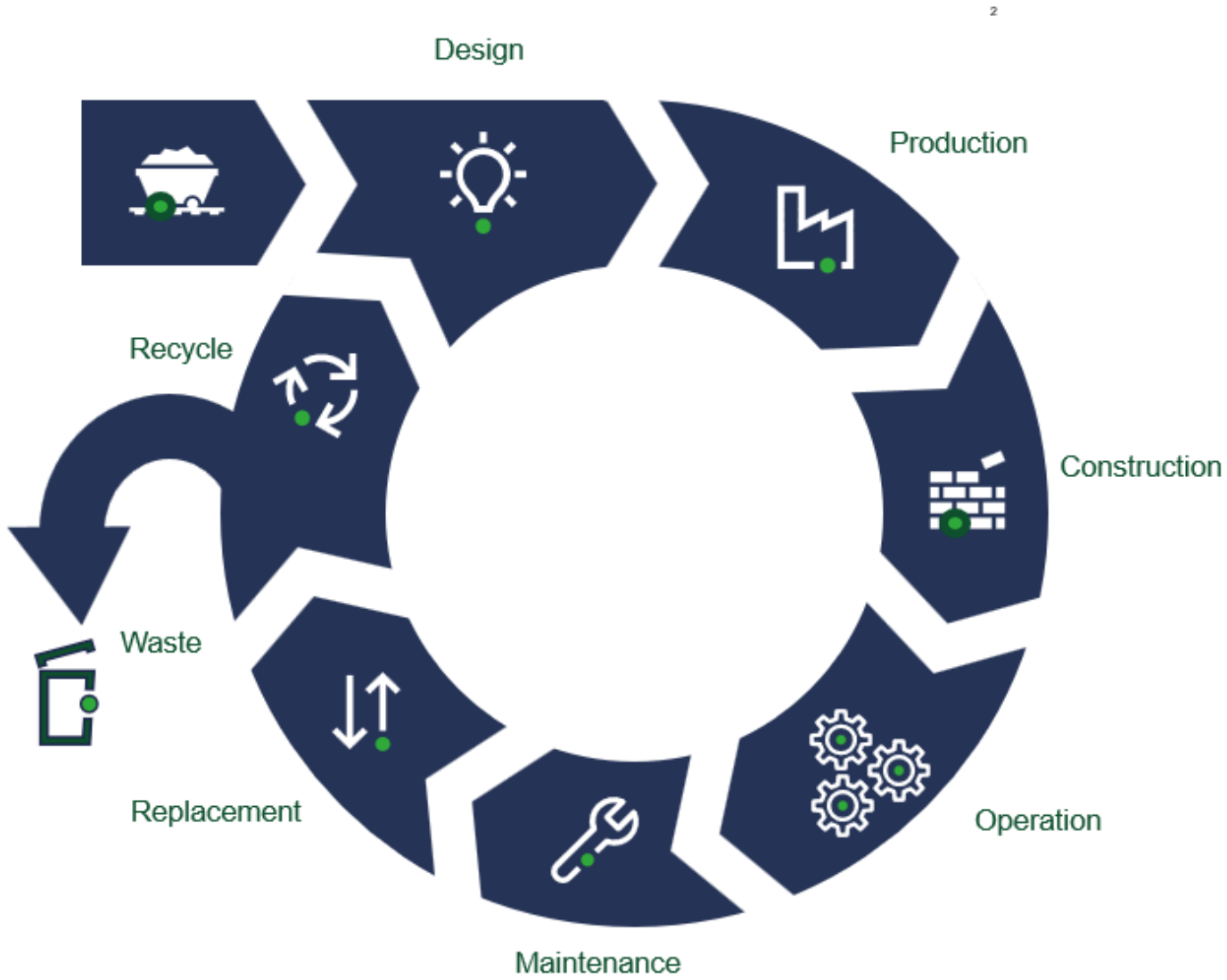
Make Sustainable Choices

From carbon neutral to renewable to becoming sustainable, it starts with the big decision to do it and then the continuous work of integrating it into all decisions.

Looking at the whole picture

The guiding principle of avoiding resource waste and basing decisions on the total cost of ownership approach is a strong starting point. Kredsløb is now working to take this to the next level and look at the whole circular picture, including using sustainable materials, incorporating sustainability in tendering processes, and their role in the chicken-and-egg situation between buyers and suppliers.

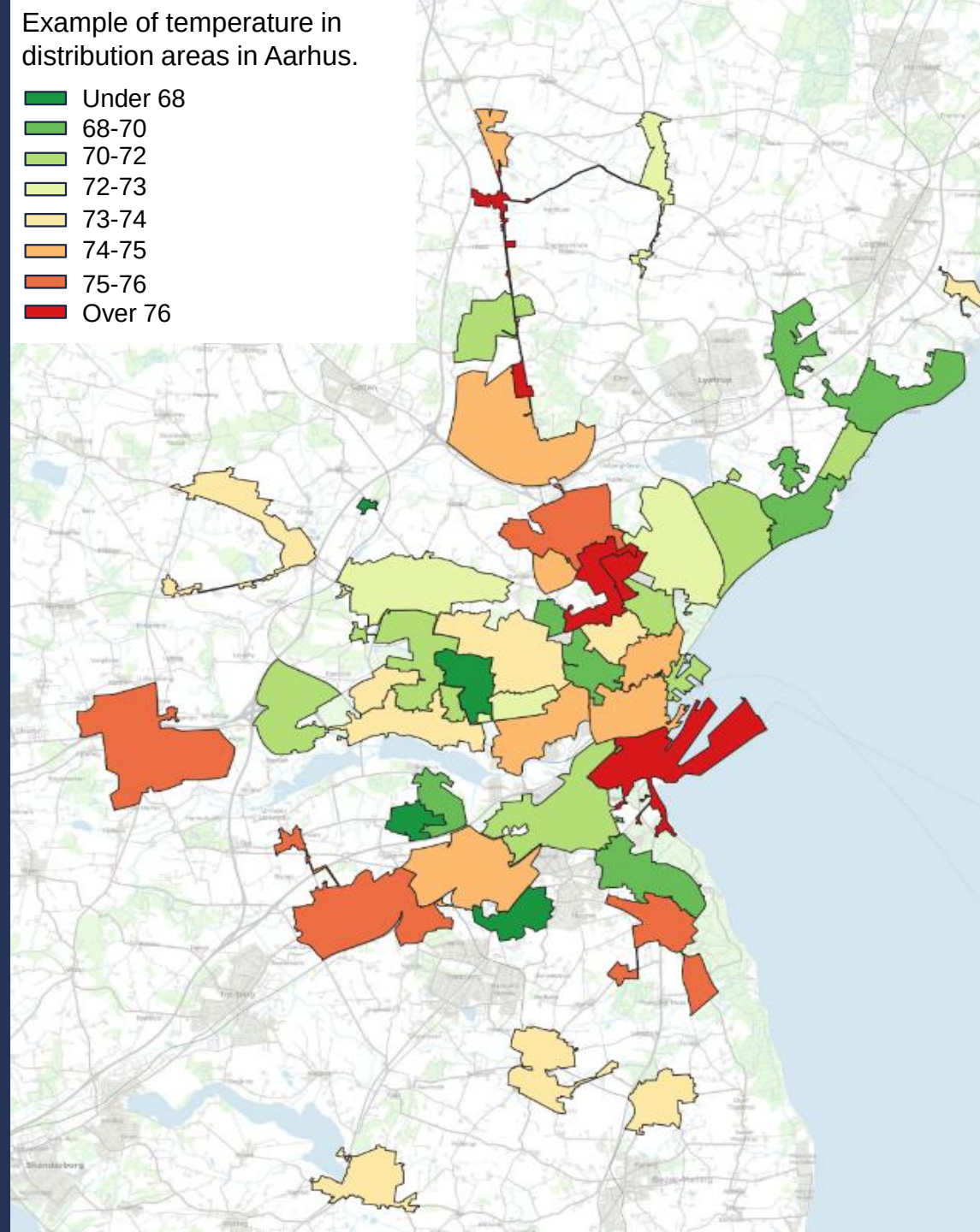
It can be tricky to balance the responsibility to support new and more sustainable products with the responsibility to operate with low risk. When is a product mature enough? The Danish district heating companies have always actively supported the innovation they need for the future. Larger utilities like Kredsløb feel a particular responsibility to collaborate with universities and suppliers to develop and test new solutions and openly share their experiences with everyone.



Temperature Matters

The heat sources for district heating naturally attract more attention than pipes, pumps, heat exchangers, it-systems, and error detection in building installations. However, district heating is unique because energy efficiency in heat production, distribution, and consumption is interdependent. The efficiency of the large-scale heat pumps depends on the temperatures of the grid and heat source. The temperature in the grid relates to the pressure and capacity in the pipes, heat losses, and the heating installations in the buildings. Optimal flows and temperatures differ in summer and winter and even vary depending on the time of day.

Experienced staff and carefully selected measurement points have been the solution to this, and now, this is being supported by solutions based on comprehensive data and new software. The supply temperature to the buildings is set by the heat exchanging station between the transmission system and each distribution area; Kredsløb is working to optimise the overall operation and energy efficiency through the temperature of each distribution area. The efforts are not only based on technical solutions; the tariff sheet includes a motivational tariff to incentivise customers to use the heat more efficiently in the buildings.

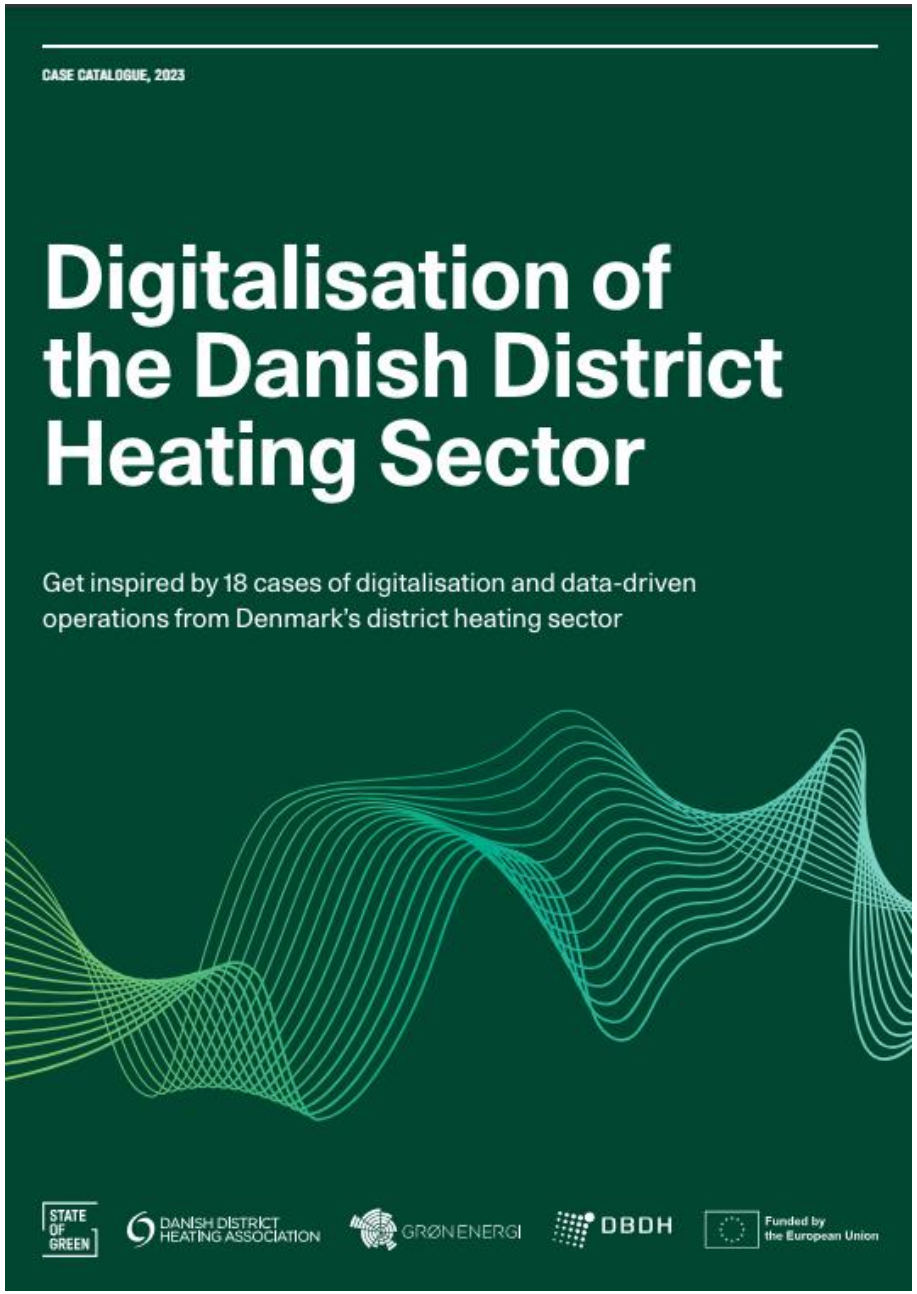


Automation, Data, and Digitalisation

Each meter automatically measures and reports heat consumption to the Kredsløb database to ensure accurate billing and safe data handling. Danish utilities are allowed to use the data to improve the operation of the district heating system. So far, this has helped to reduce grid temperatures, reduce heat losses, improve heat production, alert customers about poorly functioning installations, automate manual processes, detect leaks in the grid, and assess the status of pipes in the ground.

Some of the experiences from the Danish district heating sector have been collected in a case catalogue, and the report includes this assessment for Denmark:

" A conservative estimate is that increased use of data for the district heating sector has a saving potential of approximately € 134 million annually."



More Knowledge

Sharing knowledge and collaborating are two critical factors behind the success of district heating in Denmark.

Find some suggestions for additional information here.

Useful Links

Part of a Bigger Picture

- Go Green with Aarhus - Climate & Sustainability from the Municipality of Aarhus. Read more
- Heat Matters: The Missing Link in REPowerEU, from Aalborg University. Read more
- The role of district heating in the energy system, from the Danish District Heating Association. Read more
- Municipalities and heat planning are key to green and fair heat, DBDH podcast. Listen
- District heating for a just transition and new economic model in Scotland, Hot|Cool article. Read more
- District heating and cooling is a natural part of urban infrastructure in modern cities, Hot|Cool article. Read more
- How architecture can improve new district heating facilities, Hot|Cool article. Read more
- District heating can help unlock the Hydrogen economy in the UK, Hot|Cool article. Read more

Achieved Carbon Neutrality in 7 years

- Short videos with examples and explanations from Denmark, DBDH webpage. See more
- District heating in greater Copenhagen – history and status 2023. Read more
- District heating in greater Copenhagen – 2050. Read more
- How the Danish city of Esbjerg will use sector integration to become carbon neutral by 2030. Read more
- Renewable heating and cooling pathways, from the European Commission. Read more
- Best practices for planning and construction of thermal networks identified in the EU, report for Joint Research Centre (EC). Read more

Useful Links

Heat Source Strategy

- Designing a resilient district energy infrastructure, from Danfoss. Read more
- Catalogues of technology data for energy technologies, from the Danish Energy Agency. Read more
- Inspirational catalogue for large heat pumps in district heating systems (find among downloads), from the Danish District Heating Association. Read more
- The curious case of cost stability, Hot|Cool article. Read more
- Case Hvide Sande – Resilient and sustainable district heating using multiple heat sources, Hot|Cool article. Read more
- Case Hjørring - A strategic approach to locally sourced renewable energy production, Hot|Cool article. Read more
- Districting heating unlocking RE potential in the power system, Hot|Cool article. Read more
- Status of geothermal heat in Aarhus, from Innargi. Read more
- A tour inside a Waste-to-Energy plant, from ARC. Read more
- Circular biomass energy – with citizens heated by their garden-parc waste, Hot|Cool article. Read more
- Integration of district heating with the production of Hydrogen and e-fuels, from the Danish District Heating Association, Grøn Energi, COWI, and TVIS, and. Read more
- Carbon Capture Cluster Copenhagen, from C4. Read more
- Power-to-X synergies across sectors, from Triangle Energy Alliance Read more
- Short introduction to district cooling, from DBDH. Read more
- Large Thermal Energy Storages, from IEA-ES. Read more
- Award-winning example of a new way to use heat storage. Read more

Useful Links

How much does it Cost?

- Heating prices for all district heating systems in Denmark (in Danish), from the Danish Utility Regulator. Read more
- Socio-economic assessment for district heating development in Denmark, from the Danish Energy Agency. Read more

Connecting more Customers

- From natural gas to district heating – Danish experiences on how to get people to connect. Read more
- Annex TS7: Industry-DHC Symbiosis, IEA-DHC. Read more

Make Sustainable Choices

- Perspectives on fourth and fifth generation district heating, from Aalborg University. Read more
- 4G and 5G District heating systems, from Rambøll. Read more
- Lower temperatures, lower CO_2 emissions, and higher profitability, Hot|Cool article. Read more
- Motivation tariff – a key tool to a low-temperature district heating network. Read more
- Case catalogue – Digitalisation of the Danish District Heating Sector. Read more
- Digitalisation in district heating and cooling, from DHC+. Read more
- Annex TS4: Digitalisation of district heating and cooling, IEA-DHC. Read more

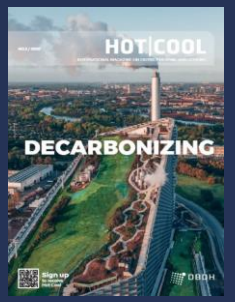
Two Magazines to Know

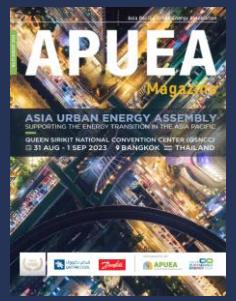
The Hot|Cool Magazine and The APUEA Magazine focus on district heating and cooling. Experts write articles and cover the latest ideas and in-depth knowledge about urban energy. The magazines are free of charge.

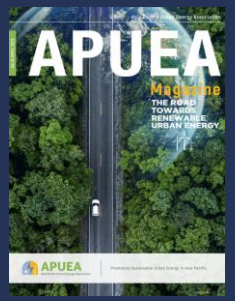
Both magazines share knowledge internationally and welcome both readers and writers to engage in discussions and collaboration about district heating and cooling.

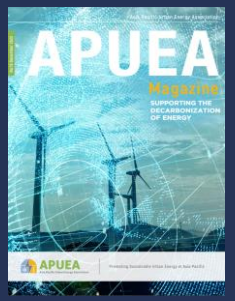
[HOT|COOL Magazine]

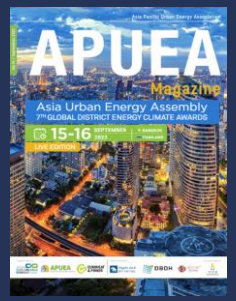
[APUEA Magazine]

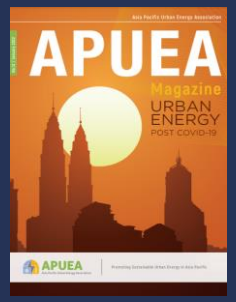






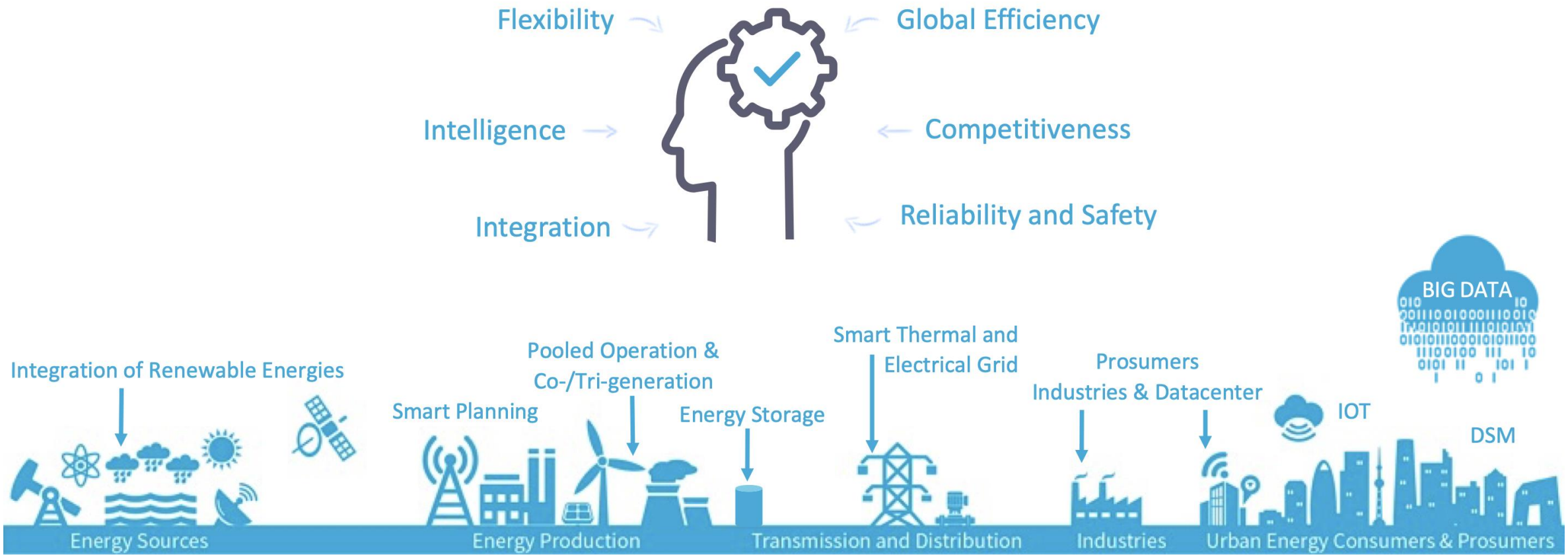






Heat Planning in China

The comprehensive Heat Planning Guideline report offers insights and analyses that support carbon reductions, system integration, and increased energy efficiency. State-of-the-art simulation tools and a well-proven process are applied to a typical Chinese district heating system, and this forms the basis for the analysis, where energy efficiency and heat recovery are in focus. The work combines heat planning experiences and tested technologies from Denmark with technical knowledge about district heating in China to inspire new solutions to the clean heating transition in China. Read more



Sino-Danish Knowledge Platform

The Danish Energy Agency and China Renewable Energy Engineering Institute, in partnership with UNEP Copenhagen Climate Centre, have established a Sino-Danish Clean and Renewable Heating Centre to share and inspire with best practices in energy mapping, heat planning, legislation, technical and real-life applications of clean and renewable heating.

The website is a virtual platform that acts as a repository and virtual collection of relevant materials on the Chinese and Danish heating sectors. This includes case studies, analysis, reports, training modules, etc. The website will be updated continuously with new materials as they are collected and developed.

Under the China Energy Transformation Programme, Denmark and China collaborate on the China Energy Transformation Outlook, CETO, which shows a path to a carbon-neutral energy system in China. In addition to CETO, the website offers a monthly newsletter covering updates on China's energy policies and transition.

Library

The Sino-Danish Clean and Renewable Heating Centre library acts as a repository and virtual collection of relevant knowledge materials on Chinese and Danish heating sectors, including case studies, analyses, reports, training modules, etc.

Access the Library

Experts Panel

As part of the Sino-Danish Clean and Renewable Heating Centre, an expert panel on clean heating has been established that provides inputs to ongoing developments in the cooperation project.

Meet the Experts Panel

Online Training - China

The project “Supporting the clean heating transition in China” included the development of capacity-building materials to support staff members in Chinese organisations, municipalities, and district heating companies. The materials are designed for online training to ensure flexibility for the learner and scalable capacity for the provider. Note that the project only offers a limited number of free licenses for online training. Read more

DISTRICT ENERGY
– Knowledge, Experience, Inspiration

Elevate your expertise with insights from leading international experts from Denmark and China.