DISTRICT HEATING IN COPENHAGEN:
ENERGY-EFFICIENT, LOW-CARBON, AND COST-EFFECTIVE
This booklet introduces the development of the district heating system, the legislative framework, the driving forces involved as well as plans and initiatives for the future.
The district heating system in Copenhagen was established in 1925 and has been developed and expanded since then, so that today the 1,500 km double-piped network provides heat for more than 30,000 customers – approx. 562,000 inhabitants. The system is part of the Greater Copenhagen district heating system, which is one of the world’s oldest, largest and most successful district heating systems, supplying the metropolitan area with energy-efficient, reliable and affordable heat. The district heating system is supplied by heat from combined heat and power (CHP) plants and from waste incineration plants in the region. The yearly heat consumption is approximately 33,000 TJ in the total system, 55% of which is in the City of Copenhagen.

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**Energy-efficient and low-carbon**

Combined heat and power (CHP) production in combination with district heating is one of the most energy-efficient and climate and environmentally friendly ways to produce energy, making it possible to use renewable energy with high efficiency at low prices for the heat customers. District heating is ideally suited to densely populated and built-up areas such as Copenhagen. District heating replaces individual heating and thereby eliminates tens of thousands of chimneys as sources of pollution. The emissions are concentrated at a few CHP-plants equipped with efficient emissions reduction equipment.
The City of Copenhagen and Greater Copenhagen Utility (HOFOR) have been extremely active as the driving forces behind the development of the district heating system in Copenhagen. Following the energy crisis in the 1970s, comprehensive heat planning was launched in Denmark, involving municipalities and energy companies in an intense planning process. The first Heat Supply Act in Denmark took form in 1979. In Copenhagen, the Heat Plan Copenhagen (Varmeplan København) was adopted in 1984 and an obligation for consumers to connect to the network was subsequently introduced.

Massive development

As a result, massive development of the district heating and combined heat and power production (CHP) took place in the Copenhagen metropolitan area in the 1980s. New CHP units were built in two areas of Copenhagen, Amager and Avedøre. In 1984, the municipalities in the region formed the Copenhagen Metropolitan Heating Transmission Company, CTR, and its counterpart in the western part of the metropolitan area, VEKS, in order to facilitate transmission of heat from the large new CHP units to the expanding distribution networks.

A strong regulatory framework

The Heat Supply Act from 1979 enabled municipalities to dedicate certain areas to district heating and make it mandatory for households to connect to district heating. As a result, costs to consumers went down. It was a highly successful initiative in order to save energy and reduce the overall dependence on imported oil.

Environmental concerns as a driver

Socioeconomics and the security of supply were the main concerns when the district heating system was expanded in the 1980s, and from the early 1990s, the environment became a major concern as well. In central Copenhagen, coal fired units at the Svanemøllen CHP plant and the H.C Ørsted CHP plant were converted to natural gas. One of the reasons for this decision was the need to address local environmental issues caused by handling and burning coal in the middle of the city. In 1993, the Danish Government decided that the electricity sector in Denmark should produce electricity from 1.4 million tonnes of biomass, and two of the plants in Greater Copenhagen agreed to participate in the fulfilment of this obligation. Biomass thus became a part of the district heating system.

The current Danish energy policy aims at converting the entire energy supply to renewable energy by 2050

The intelligent and fossil-free energy system

The current Danish energy policy aims to convert the entire energy supply to renewable energy by 2050. Come 2020, renewable energy will cover 35% of the energy supply, and wind turbines will cover more than 50% of the electricity supply. Wind, biomass cogeneration (CHP) and increased energy efficiency are the key elements of this transition. In the future, large amounts of fluctuating energy (especially wind) will require a dynamic new energy system with increased interaction between energy production and consumption and between electricity and heat. New technologies, such as electric heat pumps, electric heaters, geothermal heat and heat storage will be developed with a view to becoming instrumental components of the district heating supply in the long term.
The district heating system in Greater Copenhagen
The Amagerværket Power Station, which was taken over by HOFOR on 1 January 2014. HOFOR plans to fully convert the plant to sustainable biomass.
Cogeneration of heat and power uses around 30% less fuel than the same amount of heat and power produced in separate heat and power plants. Compared to individual heating with boiler units based on oil or natural gas, the Greater Copenhagen district heating system brings about substantial CO₂ emission reductions. Today, district heating results in 50% lower CO₂ emissions than individual gas boilers and more than 60% lower CO₂ emissions than individual oil boilers. This is due to higher energy efficiency and the fact that district heating is increasingly based on renewable energy. In 2013, renewable energy such as biomass and waste constituted 46% of the heat supply of the metropolitan regions. Fossil fuels, predominantly coal and natural gas, account for the remainder.

Biomass and waste
The Copenhagen example demonstrates that district heating is a robust, environmentally and climate friendly form of heat supply which has been able to adapt to changing political priorities. CHP is well-proven and effective when it comes to waste incineration and biomass, too. The Copenhagen district heating system is highly flexible in its daily operation. Optimisation of the heat and electricity production at the CHP plants in the Greater Copenhagen area takes place on an hourly basis, thereby obtaining the lowest possible cost. In the operational planning, the economy is optimised, taking into account security of supply and current framework conditions. Framework conditions include energy taxes and the CO₂-quota system. The load dispatch can choose almost freely among the various production plants due to the integrated structure of the transmission system in the Greater Copenhagen area. Furthermore, the extensive district heating system in Copenhagen enables optimal utilisation of the city’s waste. Waste incineration is included in Copenhagen’s comprehensive waste management strategy, where waste prevention, separation, recycling and incineration are the key elements. As a result, only 1.9% of waste in Copenhagen is deposited at landfills. Around 40% of waste from the City of Copenhagen is incinerated, producing electricity and heat in the process.

Lower heat prices for customers
The consumer price for district heating supplied by HOFOR is competitive compared to other forms of energy. District heating is especially competitive compared to individual oil and gas heating in houses. District heating is also competitive compared to individual heat pumps with the existing taxing and technology development.

Around 40% of waste from the City of Copenhagen is incinerated, producing electricity and heat in the process.
The City of Copenhagen has issued the ambitious Climate Plan Copenhagen 2025, the goal of which is to make Copenhagen the world’s first carbon neutral capital by 2025. One of the elements to attain the goal is a 20% reduction in heat consumption in 2025 compared to 2010. Another element is that heat supply must be CO₂ neutral by 2025. The Copenhagen Climate Plan outlines a number of specific initiatives – supported by HOFOR – in order to attain the goals, including:

- Biomass to replace coal at the Amagerværket CHP plant and Avedøre CHP plant
- Large electricity based heat pumps and heat storage
- Some peak load and reserve plants to be converted to CO₂ neutral fuel
- 360 MW wind turbines are to be established in and around Copenhagen by 2025. The City Council and HOFOR will give Copenhageners the possibility of directly investing in the wind turbines
- The district heating networks are to be continuously modernised in order to reduce heat losses from the pipes
- In the coming years, the role of geothermal energy in the energy system in Copenhagen will be determined. The plan implies a new 65 MW geothermal facility before 2025
- Plastic is to be separated in waste treatment. Plastic contributes substantially to CO₂ emissions when incinerated. Hence, substantial CO₂ reductions will follow if plastic is recycled rather than burned

Energy savings are essential
HOFOR is to contribute to energy savings of more than 3% of the annual district heating sales – every year – in the period 2015–2020. It is the desire of both the government and HOFOR to reduce energy consumption in Denmark. HOFOR ensures savings through its work on several fronts; new district heating customers rather than individual heating, switching from decentralised cooling systems to district cooling,
replacing the old steam heating plants with efficient district heating systems, optimisation of the district heating system with temperature optimisation, subsidies for energy renovation and much more besides. When it comes to energy optimisation and reduction of district heating consumption in existing properties, HOFOR has developed a special system that can contribute to 10% energy savings in Copenhagen buildings. The system consist in remote reading systems and intelligent energy management.

For a year now, a new tool to measure and visualise heat consumption in buildings with district heating has been ready for large-scale implementation. In large buildings, such as residential, office and public buildings in particular, the potential energy savings are huge. In Copenhagen, these buildings account for more than 80% of the total heat consumption. This new tool will replace the current practice where the only monitoring taking place is based on the gut feeling of building managers and an annual heat consumption report.

Above all, the new tool consists of a web-based management tool that monitors heat consumption and analyses it against budgets and outside temperatures. This informs the building manager whether – and where and when – he can optimise the energy consumption on a daily basis, e.g. by turning down the heat in offices at weekends when no one is working.

To motivate the manager to use the data he obtains, the solution also consists of a Heat Label. By means of traffic light colours, this shows whether the yearly heat consumption has gone up (red), stayed the same (yellow), or improved (green).

By passing the success on to large Copenhagen buildings, their energy use can be reduced by 10%. The result is a potential saving of 400 GWh, corresponding to the total energy consumption of more than 20,000 single-family houses in one year.

**CO₂ neutral district heating by 2025**

The Heat Plan Greater Copenhagen (Varmeplan Hovedstaden) Phase 3 from 2014 carried out by HOFOR and the heat transmission companies CTR and VEKS supports the Copenhagen Climate Plan in its quest to become CO₂-neutral. The project includes the entire metropolitan area and is a further development of the Heat Plan Greater Copenhagen (Varmeplan Hovedstaden) Phase 1 and 2 from 2009 and 2011 respectively.

The Heat Plan Copenhagen Phase 3 develops and outlines a scenario for CO₂ neutrality. The scenario sets out how the metropolitan district heating will become CO₂ neutral by 2025. The scenario achieves the CO₂ neutrality using renewables from sustainable biomass, wind power in heat pumps, geothermal heat and waste. The fossil element of the waste has not been further analysed. The work on achieving sustainable biomass is to be continued. Phase 3 has also analysed and reconciled the major investments to be made in the networks and generation over the next 10 to 15 years, including the potential for interconnection with the heating networks in North Zealand.

Additionally, a perspective scenario 2050 has been established to assess the role of sustainable biomass and wind in the district heating supply in the long term – as well as the role of the waste incineration plants. Furthermore, there is focus on the ways in which the district heating system in the metropolitan area can help integrate fluctuating electricity production using flexibility, energy storage and new technologies.

**Sustainable biomass**

Today, biomass is by far the largest source of renewable energy globally. Both in Denmark and in the rest of Europe, a significant increase in the use of biomass for energy production is expected. This brings into focus the discussion of biomass resources, security of supply, commodity prices and sustainability. The debate on sustainability has raised questions about biomass’ competition with food production and whether biomass can, in fact, be considered a CO₂ neutral energy source.

HOFOR works extensively with the assessment of sustainability of biomass, including the requirements that must be made for biomass production, and which biomass resources are available for energy production. This work has been set out in detail in the Heat Plan Greater Copenhagen Phase 3 and will be continued in the coming years.
The Copenhagen district heating system is owned and run by HOFOR.

**Part of a larger system**
The Copenhagen district heating system is part of the larger metropolitan district heating system, which connects four CHP plants, three waste incineration plants and more than 50 peak load boiler plants with more than 20 local distribution companies in one large pool-operated system.

**Close cooperation**
HOFOR and the local heating companies have a long tradition of cooperation, which has been enhanced in the recent years – both in respect of long-term planning and the daily management of the heat supply. HOFOR and the heat transmission companies CTR and VEKS co-own the common load management unit called “Varmelast.dk”, which manages the overall optimisation of the heat production in the region in close cooperation with the production plant owners.

**The steam network**
A quarter of the total heat requirement in HOFOR’s supply area is distributed as steam.

The steam network was originally established in order to supply hospitals and industries in need of high temperature process energy – and once a steam pipeline was established, nearby offices, institutions and blocks of flats were also connected. HOFOR acquires steam directly from the H.C. Ørsted Power Station and the Amagerværket Power Station.
### CHP plants

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<tr>
<th>Plant</th>
<th>Unit</th>
<th>Fuel</th>
<th>Capacity (heating)</th>
<th>Capacity (electricity)</th>
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<tbody>
<tr>
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<td>Biomass, coal, oil</td>
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<td></td>
<td>Unit 3</td>
<td>Coal, oil</td>
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<td>250</td>
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<td>Avedøre Power Station (AVV)</td>
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<td></td>
<td>Unit 2</td>
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<td>H.C. Ørsted Power Station (HCV)</td>
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### Waste incineration plants

<table>
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<th>Plant</th>
<th>Fuel</th>
<th>Capacity (heating)</th>
<th>Capacity (electricity)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>25</td>
</tr>
<tr>
<td>Vestforbrændingen (VF)</td>
<td>Waste</td>
<td>204</td>
<td>31</td>
</tr>
<tr>
<td>KARA/NOVEREN</td>
<td>Waste</td>
<td>104</td>
<td>32</td>
</tr>
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</table>

The major CHP and waste incineration plants in the Greater Copenhagen area.
HOFOR has set the ambitious goal of achieving 100% CO₂ neutrality in district heating by 2025. It will require that fossil fuels, used today in CHP plants and heating plants, as well as the fossil element of waste that is currently incinerated, are replaced by sustainable biomass and, in the longer term, heat pumps, geothermal energy and solar heat. It will additionally require optimisation of the entire district heating system, including conversion of the steam network to a water-based network.

HOFOR acquires the Amagerværket CHP plant and converts it to biomass
HOFOR took over the Amagerværket CHP plant from Vattenfall on 1 January 2014. Today, both biomass and coal are used at the plant. With this acquisition, HOFOR wants to secure a stable heat supply at a reasonable price for customers, in the long term. The purchase will also help to ensure a more sustainable heat and power production in Copenhagen.

Today, it is technically possible to use 100% biomass at several of the units at the Amagerværket CHP plant (unit 1) and at the Avedøre CHP plant (unit 2 owned by DONG Energy). HOFOR will convert the CHP capacity from coal to biomass at the rest of the Amagerværket CHP plant. Furthermore, the rest of Avedøreværket CHP plant (unit 1) will be converted to biomass to fulfill the plan of CO₂ neutrality in district heating by 2025.

Geothermal resources
The development and drive towards renewable energy also includes other energy sources. Copenhagen has a substantial potential for geothermal heat, and in 2005, a geothermal energy demonstration plant went into operation in Copenhagen. The demo-plant is the result of cooperation between four energy companies, including HOFOR. Based on experiences and an up-to-date decision basis, tests are being carried out in order to increase utilisation of geothermal energy in Copenhagen. In addition to this, HOFOR is involved in development projects for heat pumps, electric heaters and solar heat in the district heating system. In the coming years, several heat pump projects will be in demonstration phase. The possibility of heat pumps being a flexible technology in order to integrate a large number of windmills will be in particular focus.

District cooling
Central production of cooling is environmentally and operationally superior to individual cooling in each building based on electricity, and it is cheaper for customers, too. HOFOR has established the first district cooling system in Denmark. The first plant was built in Copenhagen City Centre, and the second plant is in operation close to the City Hall. The district cooling plants use seawater and surplus heat from the power plants to produce cooling for a number of large customers. Future district cooling plants are to be established throughout Copenhagen.

Steam conversion
The conversion of the steam network will benefit the environment and be more energy efficient, mainly because energy losses in the district heating network will decrease. Over the next decade, HOFOR will convert the network in order to abolish steam. By 2021, all customers are to be supplied with district heating based on hot water.
District cooling: Existing and potential areas for connecting to district cooling in Copenhagen.

Current areas: network connection available
Potential areas: future network connection possible
As a utility company, HOFOR has existed under different names for more than 150 years. It was founded in 1857 when the first gas supply plant was built in Copenhagen. At the time, gas was used for lighting. Two years later, the first water works was established, and in the 1860-80s, a sewer system was established in order to improve hygiene conditions in the city. The first electricity production plant was put into operation in 1892, and in 1925, HOFOR started district heating supply based on CHP.

Today, HOFOR is a multi-utility company for the entire metropolitan area. HOFOR as it is today was formed in 2012 in a merger between Copenhagen Energy and the water supply companies in the municipalities of Albertslund, Brøndby, Dragør, Herlev, Hvidovre, Rødovre and Vallensbæk. HOFOR also manages sewerage in these municipalities.

In HOFOR, six different utility sectors are gathered under one roof: electricity, heating, cooling, gas, water and sewage:

- **District heat supply:** HOFOR owns the district heating networks and three peak-load boiler units. HOFOR buys and distributes heat to the district heating customers in the municipality of Copenhagen. Around 98% of heat requirement in Copenhagen is covered by district heating.

- **Power and heat generation:** In 2014, HOFOR purchased the Amagerværket CHP plant, thereby becoming a producer of power as well as district heating. HOFOR also co-owns a small geothermal plant and owns a small solar heating plant.

- **Wind energy:** HOFOR has erected wind turbines at Prøvestenen and Tjørneby, and develops wind power projects at Knuthenborg and Kalvebod Syd.

- **District cooling:** HOFOR produces and distributes district cooling to customers in Copenhagen, initially in Copenhagen City Centre and Kalvebod Brygge.
Town gas: HOFOR produces and distributes town gas to 150,000 customers in the municipality of Copenhagen and neighbouring areas, primarily for cooking purposes. The town gas is partly based on biogas from wastewater treatment.

Water supply: HOFOR produces drinking water at seven regional water works and eight local water works. It supplies drinking water to the municipalities of Albertslund, Brøndby, Copenhagen, Dragør, Herlev, Hvidovre, Rødovre and Vallensbæk as well as nine surrounding municipalities.

Sewerage: HOFOR collects sewage from households and industry as well as rainwater from the roads in the municipalities of Copenhagen, Albertslund, Brøndby, Dragør, Herlev, Hvidovre, Rødovre and Vallensbæk and pipes it to five regional sewage treatment plants.

HOFOR is owned by the municipalities of Albertslund, Brøndby, Copenhagen, Dragør, Herlev, Hvidovre, Rødovre and Vallensbæk. Its turnover is approximately DKK 5 billion a year and it employs around 1,000 people.