

DISCRICT HEATING IN COPENHAGEN: AN ENERGY EFFICIENT, LOW CARBON, AND COST EFFECTIVE ENERGY SYSTEM



District heating has been an important part of the past development of energy infrastructure in Copenhagen and today more than 98 % of the heat demand in the City of Copenhagen is covered by district heating. In a future energy system based on renewable energy, district heating will remain a corner stone. This folder outlines the history behind the development of the system, the regulatory framework and the parties involved as well as initiatives and plans for the future.

Combined heat and power (CHP) production in combination with district heating is one of the most energy efficient and climate-friendly ways to produce energy,

making it possible to use renewable energy with high efficiency at lower prices for the heat costumers.

The district heating system in Copenhagen was started in the mid 1920'ties and today the 1,500 km double-piped net provides heat for more than 30,000 customers - approx. 500,000 inhabitants.

The system is part of the greater Copenhagen district heating system, which is one of the world's largest, oldest and most successful systems, supplying the metropolitan area with energy efficient, reliable and affordable heat.

The yearly heat consumption is approximately 33,000 TJ in the total system. 55 % of this heat consumption is in the City of Copenhagen. The district heating system uses heat from the combined heat and power plants and from waste incineration plants in the region.

District heating is ideally suited for densely populated and build-up areas like Copenhagen. District heating replaces individual heating and thereby eliminates tens of thousands of chimneys as sources of pollution. The emissions are concentrated at few CHP-plants that are equipped with efficient emissions reduction equipment.

MUNICIPALITIES AND ENERGY COMPANIES AS DRIVERS FOR DISTRICT HEATING AND CHP

The City of Copenhagen and Copenhagen Energy have been very active as driving forces in the development of the district heating system. After the energy crisis in the 70'ties, a comprehensive heat planning was launched in Denmark, involving both municipalities and energy companies in an intense planning process. In Copenhagen the Heat Plan Copenhagen (Varmeplan København) was launched in 1984 and the obligation to connect to the network was subsequently decided.

As a result, a massive development of district heating and CHP took place in the Copenhagen metropolitan area in the 1980'ties. New CHP units were planned and build at locations of plants at Amager and Avedøre. In 1984 the municipalities in the region formed the Metropolitan

Copenhagen 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 new large 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 were reduced. It was a very successful initiative in order to save energy and to reduce the overall dependence on imported oil.

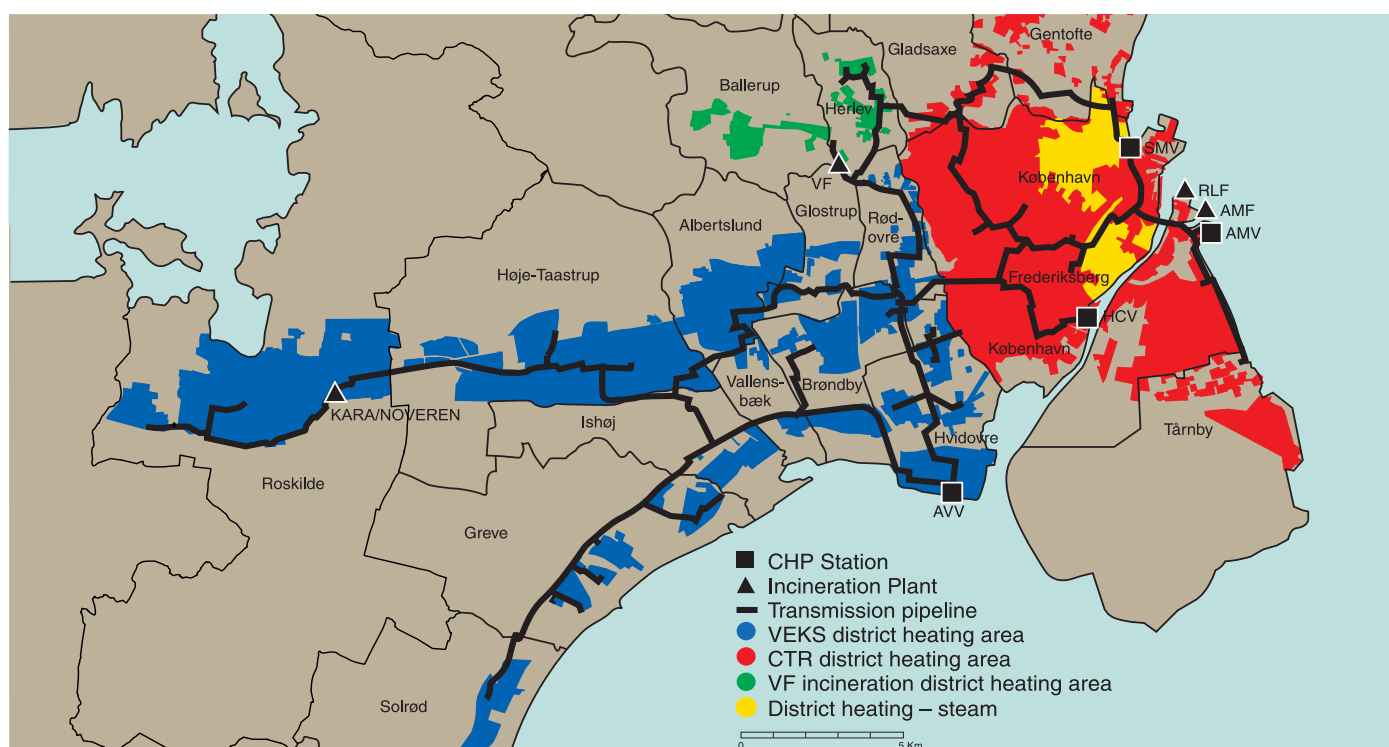
Socio-economy and security of supply were main concerns when the district heating system was expanded in the 1980'ties, and from the beginning of the

90'ties the environment became a main concern as well. In Copenhagen coal fired units at Svanemøllen CHP plant and H.C Ørsted CHP plant were converted to natural gas. Solving local environmental problems caused by coal burning in the middle of the city was also one of the reasons for this decision.

In 1993 the Danish Government decided that the electricity sector in Denmark should produce electricity from 1.4 million tones of biomass, and two of the plants in greater Copenhagen agreed to participate in the fulfillment of this obligation.

Financial incentives

Today increasing biomass use in the CHP plants is supported by subsidies and energy taxes. Electricity production based on biomass is subsidised and heat production based on fossil fuels is taxed heavily. There is no energy tax on heat production from biomass. Combined with the European CO₂-quota trading system, price on fossil fuels and biomass, these taxes and subsidies make CHP production based on biomass more cost-effective than CHP production based on fossil fuels. These incentives further support the use of heat from waste incineration plants with combined heat and power production. Today waste incineration covers approx. 30 % of the heat demand in the City of Copenhagen.



The district heating system in the greater Copenhagen area

CLEAN ENERGY - LOW PRICES

DISTRICT HEATING PROVIDES AN EFFICIENT, FLEXIBLE AND CLEAN ENERGY SYSTEM - WITH LOW CONSUMER PRICES

Cogeneration of heat and electricity production use app. 30 % less fuel compared to 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 bring about very substantial CO₂ emission reductions. It is estimated the system implies 40 % lower CO₂ emissions than individual gas boilers and half the CO₂ emissions of individual oil boilers. In 2008 renewable energy constituted 35 % of the regions heat supply.

Biomass and waste

The Copenhagen example demonstrates that district heating is a very versatile, adaptable form of heat supply. CHP technology is well proven and over time it has shown to be very flexible – it has adapted to different fuels and technologies following changing political priorities over the decades. Today approximately 1/3 of the heat in the district heating system of Copenhagen is based on biomass and waste incineration and 2/3 are fossil fuels.

In 2009 Copenhagen Energy has commissioned a tunnel with heat-pipes from the CHP plant (AMV1) to the city center. AMV1 is able to burn 100 % biomass and will increase the use of biomass markedly.

The Copenhagen district heating system is also highly flexible in terms of switching between production plants and fuels. It is a total optimization of the heat and electricity production on CHP plants in Greater Copenhagen, hour per hour at the lowest possible cost, including energy taxes and CO₂-quota-costs. The heating companies can choose freely among the various production plants due to the integrated structure of the system in Greater Copenhagen. Furthermore, the extensive district heating system in Copenhagen enables optimal utilisation



Amagerværket Power Plant (AMV), owned by Vattenfall. During 2004-9 unit 1 was thoroughly renovated and equipped to burn biomass as well as oil and coal. A geothermal demonstration plant is located at Amagerværket.

of the cities' waste. Incineration of waste included in a comprehensive waste management strategy in Copenhagen, where waste prevention, separation of waste, recycling and incineration are the main elements. As a result only 3 % of waste in Copenhagen is deposited in landfills.

Around 40 % of waste from the City of Copenhagen is incinerated, making electricity and heat in the process.

Lower heat prices for costumers

The consumer price for district heating supplied by Copenhagen Energy is highly competitive to other forms of energy. Annual costs per household are half that of oil heating.

In 2009 district heating costs around 45 % of oil heating and around 56 % of natural gas for a home of 130 m² and an consumption of app. 18 MWh/year.

TOWARDS A CARBON NEUTRAL DANISH CAPITAL

DISTRICT HEATING PROVIDES A POSSIBLE SUSTAINABLE ENERGY FUTURE

The City of Copenhagen has issued an ambitious Climate Plan for combating climate change. In 2009, the city council adopted a plan for reducing CO₂ emissions by an additional 20% between 2005 and 2015. The vision of the plan is to make Copenhagen the world's first carbon neutral capital by 2025.

As a result of the combined initiatives for energy efficiency etc., the City of Copenhagen has already reduced CO₂ emissions from all sectors by more than 20 % over the last 10 years, and now the city wants to pursue even more ambitious climate goals.

Copenhagen Climate Plan outlines a number of specific initiatives in order to reach the goal of 20 % CO₂-reduction in 2015. The energy sector is responsible for

75 % of this goal. The proposed initiatives include:

- Renewable energy replaces coal at Amager CPH plant, Unit 1, which converts 100% to biomass (wood chips). Renewable energy replaces coal at Amager CPH plant Unit 3, leading to a conversion to biomass (wood chips) of at least 40%.
- A possible new combined heat and power station, based on renewable energy.
- New windmills giving Copenhageners the possibility of directly investing in green electricity.
- The district heating network is continuously modernized in order to reduce heat losses from the pipes.
- Heating with geothermal energy is increased six-fold by expanding the demonstration geothermal facility.

- Heating efficiency is improved at waste incineration plants by introducing flue gas condensation units.

Strict energy conservation goals are set for the building sector in Denmark. Reducing energy consumption must be a priority in all renovation and construction projects. Thus all new residential and business neighborhoods in Copenhagen Municipality are designated as so-called 'low energy areas', required to comply with the strictest conservation standards of the national building regulation and must always exceed the minimum requirements of the national standard.

New Heat Plan study for the Greater Copenhagen area

The Copenhagen Climate Plan points in the same direction as the new Heat Plan study for the greater Copenhagen area, Heat Plan Greater Copenhagen, prepared by Copenhagen Energy together with the transmission companies CTR and VEKS. The plan covers the entire metropolitan area and was presented September 2009.

The Heat Plan Greater Copenhagen sets up 4 scenarios for the heat supply system in the metropolitan area by 2025, based on present and future regulatory framework and an evaluation of future technologies. The scenarios result in a doubling of the present share of renewable energy in the heat supply, equivalent to an objective of 70 % renewable energy in the district heating system by 2025. One scenario requires the heat supply to be solely based on renewable energy resources and waste, equivalent to an 85 % CO₂-free system by 2025. If the percentage is to be higher, plastic must be separated from waste before incineration, as the fossil portion (mainly plastic) of waste is not considered RE. This is a task for the waste treatment planning to solve.

The analyses shows it will be both possible and economically feasible to rapidly and massively convert from coal to biomass in the existing CHP plants. Such a conversion should be followed by a gradual long-term conversion to other kinds of renewable energy in the system, as experiences with these technologies are obtained. Utilization of geothermal energy can reduce dependency on biomass in the system.



The scenarios demonstrate that it is feasible to extend the district heating networks by converting apartment buildings and commercial customers in the areas outside the municipality of Copenhagen supplied with natural gas to district heating. Apart from the economic benefits this will also bring about substantially lower CO₂-emissions.

According to Heat Plan Greater Copenhagen, steps should be taken to reduce

bottlenecks in the heat transmission system in the region and to adapt heat production to the seasonal variation of heat consumption. This could for example be done by temporary storage of waste in order to use it at times of bigger value to the system. Other kinds of seasonal storage of heat could be utilized as well. Even with the stricter requirements for energy consumption in new buildings, analyses shows that district heating can be a competitive solution in new urban

development areas compared to alternatives like individual solar heating or individual heat pumps. Heat savings in existing buildings will reduce costs on the supply side – however, due to the high costs, heat savings in residential buildings should be carried out at the same time as other renovations in order to be feasible.

COPENHAGEN ENERGY AND ITS PARTNERS

The Copenhagen district heating system is owned and run by Copenhagen Energy. The system is part of the larger metropolitan district heating system which connects four CHP plants, three waste incinerators and more than 50 peak load boiler plants with more than 20 distribution companies in one large pool-operated system, with a total heat production of around 33.000 Terra Joules per year.

Copenhagen Energy and the heating companies in the region has a long tradi-

tion for cooperation which in later years has been enhanced – both in respect of long term planning and daily management of the heat supply. In 2008 Copenhagen Energy together with CTR and VEKS established a set up for economic optimization of the daily heat production in the greater Copenhagen area, including a new common load management unit: VLE.

VLE manages overall optimization of heat production in the region in close coopera-

tion with production plant owners. This initiative was necessitated by the liberalization and unbundling in the electricity sector that brought along competition among power companies in the electricity marked, including introduction in 2006 of two dominant power producers in the Copenhagen area – DONG Energy and Vattenfall.

A third of the total heat demand in Copenhagen Energy's supply area is distributed as steam. The steam network was originally established in order to supply hospitals and industry in need of high temperature process energy - and once a steam pipe was established, offices, institutions and dwelling houses nearby were also connected. Copenhagen Energy acquires steam directly from DONG Energy and Vattenfall.

CHP Plants		Fuel	Capacity (heat) MJ/s	Capacity (electricity) MW
Amagerværket (AMV)	Unit 1	Biomass, coal, fuel oil	250	80
	Unit 2*	Biomass, fuel oil	166	95
	Unit 3	Coal, fuel oil	331	263
Avedøreværket (AVV)	Unit 1	Coal, fuel oil	330	250
	Unit 2	Gas, biomass, fuel oil	570	570
H.C. Ørsted Værket (HCV)		Gas	815	185
Svanemølleværket (SMV)		Gas, fuel oil	355	81
Waste Incineration Plants				
Amagerforbrændingen (AMF)		Waste	120	25
Vestforbrændingen (VF)		Waste	204	31
KARA/NOVEREN		Waste	69	12

The major CHP and waste incineration plants in the greater Copenhagen area.

*) At present Unit 2 at Amagerværket is not in operation.

RECENT COPENHAGEN ENERGY PROJECTS

THE COPENHAGEN DISTRICT HEATING SYSTEM IS CONSTANTLY DEVELOPED

In 2009 a renovated Unit 1 at Amagerværket (AMV1), owned by Vattenfall, is put into operation and old inefficient CHP units in the city were closed down. As the first plant in Denmark, AMV1 is subject to a requirement of a minimum percentage of biomass-based CHP production. Due to subsidies etc. for biomass-based electricity production, the costs of biomass-based CHP production at AMV1 will be lower than coal-based production. Thus AMV1 will be mainly biomass-fired, with coal as a backup fuel.

Large scale tunnel

At the same time Copenhagen Energy has established a large-scale district heating tunnel from Amagerværket under the harbor to the City. The tunnel is 4 kilometers long with a diameter exceeding 4 meters. It is designed to transport steam and heat from Amagerværket to the steam-based district heating system in the centre of Copenhagen. AMV1 is designed to supply the steam-based system in Copenhagen through this tunnel.

Copenhagen Energy is in the process of converting the steam-based system to a water-based system because it will bring about substantial economic benefits due to improved energy efficiency as well as reduced CO₂-emissions. Therefore the tunnel from AMV1 also contains water pipes. As the steam-based system is converted, the water pipes can supply the new water-based parts in the system and ultimately the steam pipes in the tunnel will be used for hot water as well. AMV1 can be extended with a low pressure turbine thus increasing electricity



Copenhagen Energy District Cooling project in the Copenhagen City centre, 2009.

production at the plant, and allowing AMV1 to produce water-based instead of steam-based district heating.

Geothermal resources

The development/drive towards renewable energy also includes other energy sources. A survey of geothermal resources in Copenhagen has shown substantial potential in the area, and already in 2005 a geothermal energy demonstration plant went into operation. The demo-plant is a result of a co-operation between four energy companies including Copenhagen Energy. It is now investigated how to increase utilization of geothermal energy.

District cooling

Copenhagen Energy is furthermore in the process of constructing the first district cooling system in Denmark in the Copenhagen City centre. The district cooling plant will utilize seawater and surplus heat from the power plants in order to produce cooling for a number of large customers in the city. Central production of cooling will imply both operational and environmental benefits – as well as economic benefits for customers compared to cooling based on electricity.

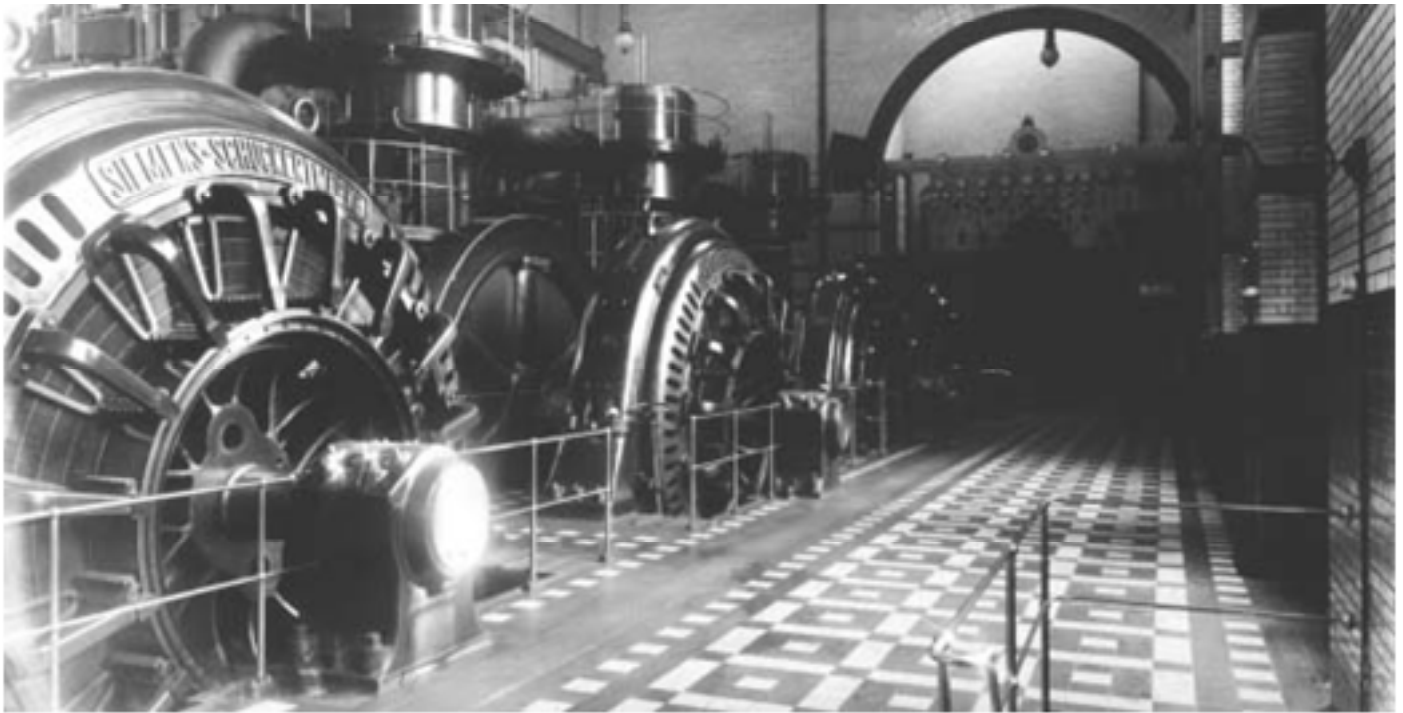


Construction of district heating tunnel under Copenhagen Harbor is the largest construction project in Copenhagen since the metro. The budget is 100 mill. Euro.

COPENHAGEN ENERGY: BEFORE AND NOW

Copenhagen Energy has existed for more than 150 years. It was founded in 1857 together with the building of the first gas supply plant in Copenhagen. At that time gas was used for lightning. Two years later the first water works was established

and in the 1860-80'ies sewerage was established in order to improve hygienic conditions in the city. The first electricity production plant was put into operation in 1892, and in 1925 the company started district heating supply.



The first electricity plant in Copenhagen, Gothersgade Elværk, 1892

Today, Copenhagen Energy is a combined supply company with 5 different supply sectors gathered under the same roof:

- **District heat supply:** Copenhagen Energy owns the district heating networks and 3 peak load boiler units. KE buys and distributes heat to district heating customers in the municipality of Copenhagen. Around 98 % of heat demand in Copenhagen is covered by district heating.
- **District Cooling:** Copenhagen Energy is in the process of increase district cooling in Copenhagen.
- **Town gas:** Copenhagen Energy produces and distributes town gas to 154.000 customers in the municipality of

Copenhagen and neighbouring areas, primarily for cooking purposes.

- **Water supply:** Copenhagen Energy owns 7 water works and produces and supplies drinking water to Copenhagen municipality and 19 surrounding municipalities.
- **Sewerage:** Copenhagen Energy owns and runs the sewer system in Copenhagen.

Copenhagen Energy is organised as a limited company owned by the municipality of Copenhagen. The turnover was 3.7 billion DKK in 2008 and it employs around 700 persons.

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