



Best Practice: District Heating System

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CITY: COPENHAGEN

POLICY AREA: ENERGY, CLIMATE CHANGE

BEST PRACTICE

Copenhagen's **district heating system** provides 98% of the city with clean, reliable and affordable heating. This heating supply system uses waste heat from regional refuse incineration plants and combined heat and power plants (CHPs), distributing heat through a pipe system to customers in the city.

ISSUE

While the socioeconomics and security of the City's heating supply were main concerns when the district heating system was expanded in the 1980's, environmental impacts became a major concern in the following decades.

It was recognized that the district heating process saves energy and substantially reduces CO2 emissions and pollutants. District heating replaces individual heating, eliminating the use of tens of thousands of chimneys.

GOALS AND OBJECTIVES

The City of Copenhagen has set an ambitious goal of becoming the world's first carbon neutral city by 2025. The district heating system, vastly expanded in the 1980's, is one of the many successful projects to help the city achieve its target.

IMPLEMENTATION

Overview

The City's district heating system is part of the regional district heating system, which supplies the metropolitan area with energy efficient, reliable, and affordable heat. As a result of its lack of hydropower resources, Denmark has historically used this type of heating system, and the Copenhagen system dates to the 1920's.

A strong regulatory framework

After the energy crisis in the 1970's, a comprehensive heat planning program was launched in Denmark, involving both municipalities and energy companies in an intense planning process. The 1979 Heat Supply Act enabled municipalities to designate certain areas for district heating and make it mandatory for households to connect to district heating. It was considered a successful initiative, leading to significant energy savings and a reduction in overall dependence on imported oil.

The district heating system

The Copenhagen district heating system is owned and run by Copenhagen Energy. The system is part of the larger metropolitan district heating system that 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. Total heat production is approximately 33,000 terajoules per year.

Copenhagen Energy and the heating companies in the region, including the Metropolitan Copenhagen Heating Transmission (CTR) and VEKS, have a long tradition of cooperation, which in later years has been enhanced – both with respect to long term planning and daily management of the heat supply. In 2008 Copenhagen Energy, 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 cooperation with production plant owners. This initiative was necessitated by the liberalization and unbundling in the electricity sector that allowed for competition among

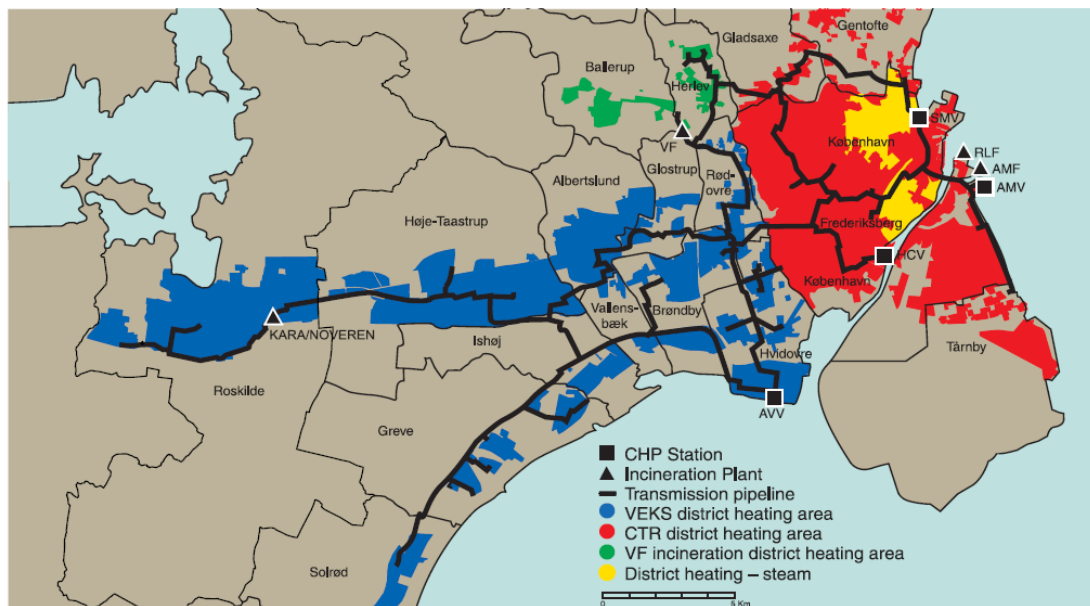
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power companies in the electricity market, including the introduction in 2006 of two dominant power producers in the Copenhagen area – DONG Energy and Vattenfall.

The Copenhagen district heating system is also highly flexible in terms of switching between production plants and fuels. It optimizes heat and electricity production in CHP plants in Greater Copenhagen, hour per hour at the lowest possible cost, including energy taxes and CO₂-quota-costs.

One third of the total heat demand in Copenhagen is distributed as steam. The steam network was originally established in order to supply hospitals and industry in need energy processed at high temperatures. 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. Copenhagen Energy is in the process of converting the steam-based system to a water-based system; the heat loss in a water-based system is lower than in a steam-based system as it is more energy efficient to produce water than steam. The conversion to a water-based system will bring about substantial economic benefits due to improved energy efficiency as well as reduced CO₂ emissions.

The district heating system in Greater Copenhagen is illustrated below.



The district heating system in the greater Copenhagen area

AMVI – large biomass fired CHP plant

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

Large scale tunnel

At the same time, Copenhagen Energy established a large-scale district heating tunnel from Amagerværket under the harbor. 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 center of Copenhagen.

The CHP plant units and the waste incineration plants are described below.

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

Financial incentives

Today, increasing biomass use in the CHP plants is supported by subsidies and energy taxes. Electricity production based on biomass is subsidized, and heat production based on fossil fuels is taxed heavily. There is no energy tax on heat production from biomass. The European CO₂-quota trading system along with biomass 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. Waste incineration currently supplies approximately 30% of the heat demand in the City of Copenhagen. Incineration of waste for heat is one component of 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.

COST

In 2009, district heating cost only 45% of the oil heating cost for a 130,000 square meter home with an annual consumption of 18 MWh/year, including energy taxes. Similarly, district heating cost 56% of the cost of natural gas heating in the same home.

RESULTS AND EVALUATION

Currently, the district heating network covers 98% of the total heating needs of Copenhagen – the equivalent to approximately 50 million square meters.

Compared to individual heating with boiler units based on oil or natural gas, the Greater Copenhagen district heating system brings about very substantial CO₂ emission reductions. It is estimated the system results in 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 region's heat supply.

Heat Plan Copenhagen targets up to four scenarios for the heat supply system in the metropolitan area by 2025, based on the 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 a target 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 renewable energy. This is a challenge for the waste treatment planning.



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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 Copenhagen learns from its experience with these technologies. Utilization of geothermal energy can reduce dependency on biomass in the system.

TIMELINE

- 1979** Heat Supply Act introduced
- 1984** Heat Plan Copenhagen introduced
- 1980s** Massive development of District Heating and CHPs in Copenhagen
- 1993** Decision made by the Danish government to produce electricity from 1.4 million tons of biomass
- 2009** Copenhagen's district heating system provides 98% of the city with clean, reliable and affordable heating
- 2015** Copenhagen expects a 20 percent reduction in overall Co2 emissions
- 2025** Copenhagen aims to be the first CO2 neutral capital in the world

LEGISLATION

Major changes in legislation incorporated within the 1979 Heat Supply Act include:

- municipal heat supply planning, a new natural gas infrastructure and a substantial increase of district heating;
- zoning of district heating and natural gas networks based on overall economic evaluation in Denmark;
- district heating shifts from fossil fuel boilers to CHP and renewable energy; and
- ensuring low cost integration of power, heat, gas and waste sectors in Denmark.

LESSONS LEARNED

The Heat Supply Act of 1979 enabled municipalities to dedicate certain areas to district heating and made it mandatory for households to connect to district heating. As a result costs to consumers were reduced. It was a very successful initiative in terms of energy savings and reducing Copenhagen's dependence on imported oil.

The Copenhagen system demonstrates that district heating is a very versatile, adaptable form of heat supply. CHP technology has proven to be successful and over time it has shown to be very flexible since it has been adapted to different fuels and technologies following changing political priorities over the decades.

TRANSFERABILITY

District heating is well-suited for densely populated and urban areas such as Copenhagen.

District heating in interaction with CHP will be an instrument to secure high energy efficiency in large cities which are densely populated and developed similar to Copenhagen. District heating is also an effective means to increase the share of renewable energy. District heat supplied from both biomass CHP, geothermal heat plants, heat pumps, solar heating and industrial surplus heat can be implemented effectively in the district heating system.



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This report is based on an exhibition from the 2009 Copenhagen Climate Summit for Mayors Future Cities Exhibition. Innovative initiatives demonstrating how cities around the world are combating climate change were on display. Facts and figures in this report were provided by the city of Copenhagen to New York City Global Partners.