



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 and remain 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

In recent years, environmental concerns have been given even more attention, driven by the City's 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 many areas that will 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. Heat is provided from Combined Heat and Power (CHP) plants. As a result of its lack of hydropower resources, Denmark has historically developed the utilization of heat from CHP plants by applying district heating networks, 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 operated by Copenhagen Energy. The system is part of the larger metropolitan district heating system that connects four CHP plants, three waste incineration plants, 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, the '**Varmelast.dk**' (<http://www.varmelast.dk/>).

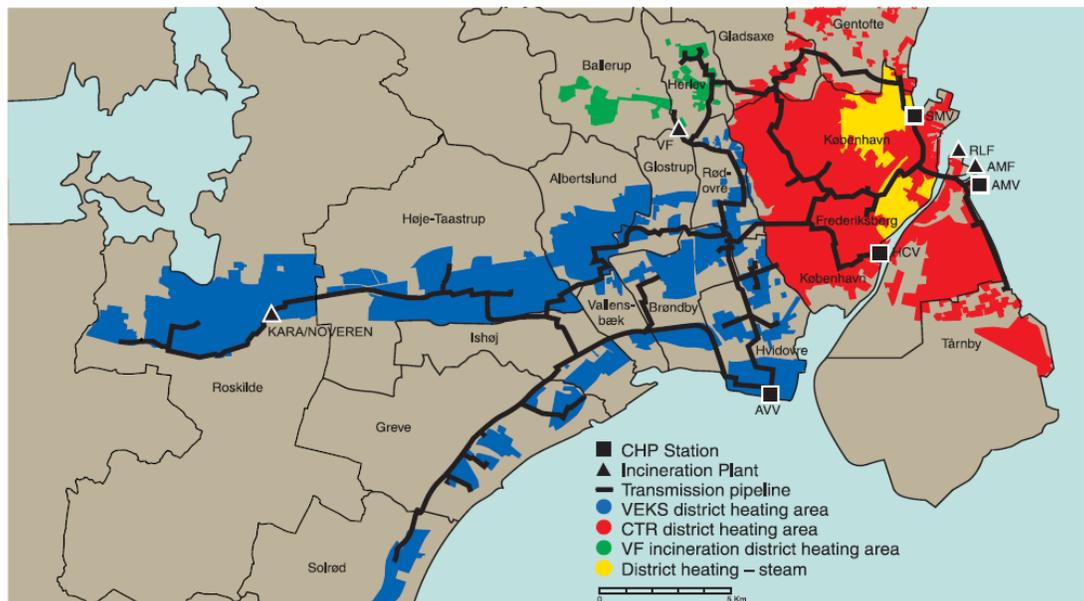
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Varmelast.dk manages overall optimization of heat production in the region in close cooperation with production plant owners. This initiative was necessitated by the liberalization and unbundling in the electricity sector that allowed for competition among 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 induced 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 for process heat 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 as the heat loss in a water-based system is lower than in a steam-based system and 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 in production and distribution 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

AMV1 – large biomass fired CHP plant

In 2009, a renovated Unit I at Amagerværket (AMV1), owned by Vattenfall, was put into operation, and old less efficient CHP units in the city were shut down. As the first plant in Denmark, AMV1 was subject to a requirement of a minimum percentage of biomass-based CHP production. Thus AMV1 is 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.

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

| 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

Heat production based on fossil fuels is taxed heavily by energy tax. Due to exemption from energy tax on biomass for heat production and subsidies to biomass-based electricity production, the costs of biomass-based CHP production will be lower than for coal-based production. In addition, 'saved' CO₂ quotas (the European CO₂-quota trading system) will also improve the competitiveness of biomass-fired CHP. Consequently, 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 larger metropolitan Copenhagen region. Incineration of waste for heat is one component of a comprehensive waste management strategy in Copenhagen, where waste reduction, 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 2011, the cost of district heating is approximately 50% of the alternative cost of oil for a 130 square meter home having an annual consumption of 18 MWh/year, including energy taxes. Similarly, the cost of district heating is approximately 60% of the alternative cost of natural gas heating for 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 using oil or natural gas, the Greater Copenhagen district heating system significantly reduces CO₂ emission: 40% lower CO₂ emissions than individual gas boilers and half the CO₂ emissions of individual oil boilers. In 2010, renewable energy including waste incineration constituted 35% of the Copenhagen region's heat supply. The content of plastics in incinerated waste has doubled since the nineties, and by 2009 it is assumed that only 60% of the waste is organic; the rest being plastics that produce carbon emissions. Increasing the amount of plastics in the waste incineration process therefore affects the overall carbon emissions of the City.

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At present, due to competitive advantages to the consumers, several municipalities around the City of Copenhagen are preparing for substituting individual gas-fired furnaces with district heating.

The different scenarios in the **Heat Plan Copenhagen** (<http://www.varmeplanhovedstaden.dk/english>) show that both from a societal point of view and a company point of view a higher renewable energy penetration is feasible. These scenarios show that it is possible by 2025 to reduce the use of fossil fuels to between 28 and 13 percent. The scenarios furthermore show that there are different ways of integrating more renewable energies into the system.

Analyses show that it is possible and economically feasible to convert from coal to biomass in the existing CHP plants. In the long run, other kinds of renewable energy must be deployed such as geothermal energy. A pilot geothermal plant is already in operation and the utilization of geothermal energy will reduce future dependency on biomass.

Based on **Heat Plan Copenhagen**, the target set out for Copenhagen Energy is to obtain a 100% share of renewable energy and waste incineration heat in the DH system by 2025. The current share of renewable energy is 35%.

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, compared to 2010
- 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.



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District heating, in interaction with CHPs, 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 mean to increase the share of renewable energy. District heat supplied from 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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