Application Global District Energy Award

District Heating and Cooling System in Malmö, Sweden

Malmö from above (Photo: E.ON)

Name of DE systems	District Heating and District Cooling in Malmö
Location	In the municipalities of Malmö and Burlöv, south of Sweden
Owner	E.ON Värme Sverige AB, a private energy utility company, owned 100% by E.ON Nordic
Contact E.ON	Ms Li Lövehed E.ON Värme Sverige AB 205 09 Malmö, SWEDEN Phone: +46 70 207 50 55 Mail: li.lovehed@eon.se Homepage: www.eon.se
Contact City of Malmö	Ms Jennifer Lenhart Malmö Environment Department 205 80 Malmö, SWEDEN Phone: +46 73 3540673 Mail: Jennifer.lenhart@malmo.se Homepage: http://malmo.se/sustainablecity

Background

History

The district energy system described in this application is located in the City of Malmö – the third largest city in Sweden. Presently, there are approximately 290 000 inhabitants in Malmö, a city that has grown consistently over the last 20 years by some 50 000 residents. Malmö has become the growth centre in the South of Sweden and engages in a variety of strategies to support business growth, hosts one of Sweden's youngest universities, as well as taking an active approach to holistic sustainable development, including a focus on energy – in terms of efficiency, source and stakeholder communication.

A critical component of Malmö's focus on energy efficiency can be found in its district heating system, which was originally constructed in1951. First it contained smaller separate units that, over the years, merged together into one large-scale system. Gradually, as the city grew, the district energy distribution system has followed a similar pattern and grown with it.

While originally owned by the municipality, in 1991 it was sold to the energy utility company, *Sydkraft*, which was later sold to E.ON. The private company E.ON currently maintains 100% ownership of the system. However, while privately owned, E.ON engages in close cooperation with the City of Malmö concerning extension of the system, planning, environmental considerations and so on.

In the year 2000, energy and environmental considerations were taken to a new level when E.ON and the City of Malmö worked together to construct a unique district energy system comprised of "100% locally renewable energy" in the Bo01 area of Malmö's Western Harbour. In connection to this, a district cooling system was also incorporated in the development. This system has received global recognition in terms of its systemic approach to energy. Additional information about the Bo01 energy system is described under the heading of *System Success*.

Main production plants for Malmö's District Heating

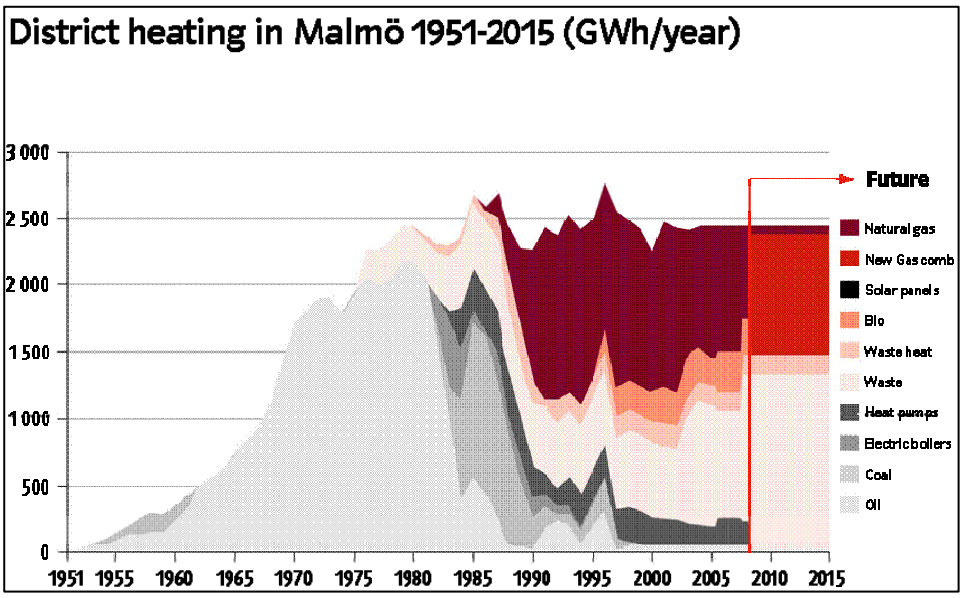
Industrial surplus heat	Heat is bought from *Evonik Norcarb AB,* in operation since 1987. This delivers up to 25 MW_{heat} and also 9 MW_{electr} in own plant.
Refuse incineration – *SYSAV*	Heat is purchased from *SYSAV*, a waste-to-energy plant owned by several municipalities in Southern Skåne. This produces 1 400 GWh per year. In operation since 1973, new incinerators were also built in 2003 and 2008.
CHP Öresundsverket (ÖVT)	A highly efficient Combined Heat and Power (CHP) plant, fuelled by natural gas. Owned by E.ON, ÖVT was inaugurated in 2009 with the capacity of 440 MW_{heat} and 250 MW_{electr}. ÖVT will deliver roughly 3 TWh of electricity and 1 TWh of heat per year.

In addition, there are also peak load and reserve plants. Total power capacity in plants is 1 100 MW, total power connected to customers is estimated to 1 625 MW.

Picture 1. High efficient CHP plant Öresundsverket, inaugurated 2009. *(Photo: E.ON)*

Fuel Mix

The fuel mix supporting the system has changed substantially over the years. During the first decades of the system's operation, the fuel primarily consisted of oil and coal. In the mid 1970s this included refuse incineration, or waste-to-energy. Later, it incorporated surplus heat from industry in the 1980s, as well as large scale heat pumps which captured heat sources from sewage water. A large biomass heat plant has been in use for 15 years, but is now a peak load and reserve plant. Combined heat and power (CHP) with natural gas as a fuel source has been used for 25 years. In 2009, the high efficient CHP plant, Öresundsverket, with natural gas as a fuel, was taken into use. Today the main fuels are industrial surplus heat, refuse incineration and high efficient CHP fuelled with natural gas. Approximately 65% of district heating supplied is today renewable. This progression of the fuel mix has led to a decrease in CO_2 emissions and lower primary energy used.

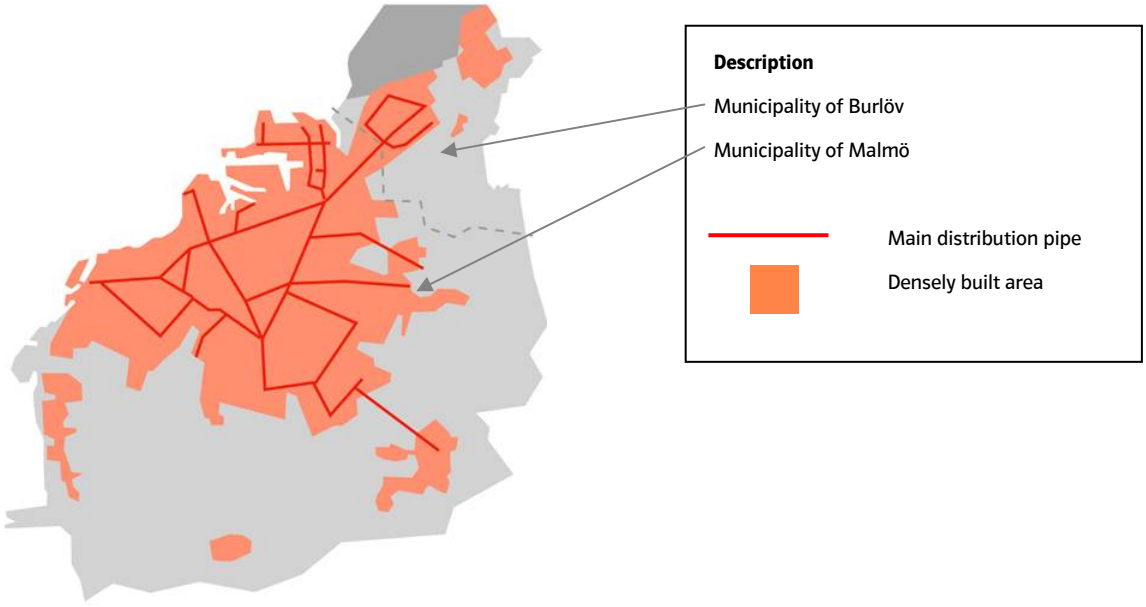


Picture 2. Fuel mix used for district heating in Malmö 1951-2015. *(Illustration: E.ON)*

The District Heating's Distribution Network

The district heating (DH) distribution network has gradually evolved over the last 50 years. The total length today is 550 km, and consequently, the total length of the double distribution pipes is 1 100 km. The age and material utilised differs a lot, as it has developed over the years. Today the most common material is steel with a surrounding insulation and PEH coating. The smallest pipe dimension which supplies a rather small building is 15 mm, and the largest distribution pipe has a diameter of 1 000 mm. The distribution network is well established and carefully constructed; which ensures that the efficiency and the security of supply to customers is close to 100%.

Picture 3. From left: Large distribution pipes in Malmö, pipe storage for ongoing distribution project, pipes are being weld together. *(Photo: E.ON)*



Picture 4. The picture shows a principal drawing of the district heating network in Malmö and Burlöv. *(Illustration: E.ON)*

The district cooling system, in the Bo01 District of Malmo's Western Harbour, is barely ten years old and has a total length today of approximately 6 km. The dominating material used in the system of the cooling network is plastic pipes.

Customers

Today approximately 95% of buildings in DH areas in Malmö are supplied with district heating for space heating and hot water. There is a wide customer base, occupying some 6 000 villas and 4 000 commercial and public buildings. The yearly amount of district heating supplied to customers is today 2 250 GWh. New district heating contracts the past years support the use of up to 20-30 GWh/year.

E.ON's master plan for expanding the system, works closely with and follows the extension planning in the City Malmö in terms of new developments in order to provide district energy to buildings in new expansion areas. District heating is seen as a preferred energy supply by many due to environmental considerations and price.

10 GWh of district cooling is delivered on an annual basis to 30 commercial and public customers. The cooling is principally used in commercial buildings, but district cooling is also used in some residential buildings.

System Success

Higher efficiency and lowered air pollution

When Malmö's district heating system launched over 50 years ago, it was initiated as a possible solution to address the local problems of highly polluted air. By centralizing energy production to a few boilers, instead of burning dirty fuels in each house, it became possible to incorporate better technology, cleaner fuels and higher chimneys to reduce the air pollution. As well as the promise of cleaner air, there were three compelling reasons for customers to change to DH: *cost, convenience and reliability*. All these reasons remain the same today.

If the original reason was cleaner air, in the 1970s DH provided a big advantage, granting Malmö a possible solution to manage the oil crises. DH enables a system to run on a diversified fuel source, which provides flexibility (that comes with a variety of fuel sources) as well as both economical and environmental opportunities. For example, *E.ON* reduced its CO_2-emissions approximately 40% from 1992 to 2008 within the Malmö Network via transforming the production from oil and coal to natural gas and waste-based production.

In addition to the benefits of large fuel flexibility, district heating also enables the use of CHP to make the most efficient use of resources and generates both heat and power. This is shown in the reduction of primary energy use[1] from 0.9 to 0.75 from 1992 to 2008. With ÖVT in operation, the primary energy use in the district heating system of Malmö will be further reduced to approx 0.2.

Öresundsverket (ÖVT) - the bright new natural gas fired CHP – uses state of the art technology to produce 440 MW of electricity and 250 MW of heat. The electrical efficiency is over 58% and overall efficiency is 90%. This is quite efficient, compared to most modern gas fired power plants, where maximum efficiency is about 60%. The very high efficiency of ÖVT is only possible because it is connected to the district heating network of Malmö which also enables production of electricity in two other CHPs (*SYSAV* and *Evonik*). The electricity produced in ÖVT is assessed to reduce the need for imported coal powered generation, with a total marginal effect of approx 1 000 000 tons of CO_2 being saved.

SYSAV - The district energy solution in Malmö takes a holistic approach: 90 % of the municipal waste in Malmö and surrounding areas is either recycled into materials or burned in the SYSAV plant via CHP to create heat and electricity. With resources that would otherwise have been lost, SYSAV feeds the DH network with 1 400 GWh heat (approximately one third of the total heat demand) and produces 180 GWh of electricity. The recourses being recycled into energy are equivalent to an oil use of 100 000 tonnes per year.

Evonik - Another benefit with Malmö's district heating system is the possibility to utilize surplus heat from industry, such as the company Evonik. Their process creates gas as a waste product which is used to produce 25 MW of heat and 9 MW of electricity. The electricity production wouldn't be possible without the heat demand from the district network. The revenues that Evonik generates from selling heat to E.ON Värme Sverige help the industry to remain in Malmö.

Public Private Partnerships in Malmö's Western Harbour

"Public Private Partnerships" have been very important for both the City of Malmö and E.ON in terms of collaboration, cost savings and taking a holistic approach to the energy sector. In addition, so-called PPPs in the energy sector have also benefited other key stakeholders, including developers, architects and real-estate owners, in order to learn from and develop small scale solutions in relation to specific environmental characteristics within the large scale district heating system.

The first and most progressive example of PPP in a large-scale development and DH system is the Bo01 area in the Western Harbour, where a unique 100% local renewable concept was constructed by E.ON for approximately 1 000 residential units in 2001. The concept is premised on using local conditions for energy supply from renewable energy in the form of solar, wind and water. A large wind power generator of 2 MW, placed in the Northern Harbour in Malmö, and 120 m^2 solar cells on one building in the area, produce electricity for the housing and for the heat pumps as well as other pumps and fan installations in the buildings for their use. Heat is produced by 1 400 m^2 solar collectors that are placed on ten of the buildings. Heat is also gained from an aquifer in the area with the help of a large heat pump. The aquifer is a natural water storage in the bedrock that enables seasonal storage of heat and cold, respectively. The heat from the summer is saved for the winter and is made available with help from the heat pump for the district heating system. Cold from the winter is saved and is provided by a district cooling system that provides comfort cooling during summer. Besides renewable energy provision, the goal for energy use in the building is set according to the quality program that was adopted for the area at maximum 105 kWh per square meter of use area and year, including electricity for domestic appliances. This is substantially lower than prevailing building norms at that time.

Creating a 100% local renewable solution with both local heating and cooling networks would have been much more difficult without having the existing infrastructure working as a buffer. During the summer, surplus heat from the Bo01 area is sent to the rest of Malmö through the district heating net. In winter, when too little heat is generated locally, heat is imported the same way. Averaged over the course of a year, production and use are in

1 Calculated according to *Swedish District Heating Associations´* procedure. Standard SS-EN 15316-4-5 describes how the primary energy factor (PEF) is calculated.

balance and the area is self-sufficient without the need of an over dimensioned system or extra reserve capacity. Energy sold and delivered to customers within this concept goes under the label "100 % locally renewable".

Picture 5. The Bo01 area in the Western Harbour is supplied by the unique energy system "100% locally renewable energy", designed and constructed by E.ON. The systems´ components are: wind power, solar cells, solar panels and an aquifer in cooperation with a large heat pump. *(Photo: E.ON)*

Following the learning and spirit of collaboration first heavily undertaken during the development of the district energy system used in Bo01, the City of Malmö and E.ON continued to work together in other districts built in the Western Harbour, the so-called "Flagghusen" and "Fullriggaren" developments. In these developments solar collectors on the buildings are suggested to be combined with district heating and energy efficient building standards (in some cases passive house standard). Experiences from the various developments in Malmö's Western Harbour demonstrate that by early cooperation with builders, architects and the municipality, it is possible to integrate a more long-term and environmental friendly energy solution which incorporates (for example) solar collectors in modern architecture, by emphasizing their function rather than attempting to hide them. Thereby solar collectors become important symbols in terms of sustainable energy solutions.

The total area of solar collectors connected to the district heating network in Malmö is today approx 4 400 m² whereof 2 600 m² is located in the Western Harbour's original renewable project as well as the adjacent project Kockum Fritid. The connection of solar panels to the existing infrastructure has demonstrated the possibility to incorporate energy generation on the buildings themselves, as opposed to separate buildings. Nevertheless there are still some system developments which are needed before it is possible to offer solar district heating solutions to a broader group.

Market actions

District heating in Malmö is a success story from many aspects. That E.ON delivers 2.2 TWh annually to more than 10 000 customers is perhaps not so impressive, but this same number also provides more than 90 percent of the residents in Malmö with their daily demand of heating and hot water!

The district heating customers in Malmö vary significantly; there are customers representing small households with not more than 5 MWh of annual use, as well as municipal residential companies with 250 000 MWh

consumed annually. The largest single point of delivery is the University Hospital with an annual usage of 40 000 MWh.

Picture 6. Typical small-scale and large-scale DH customers´ installation. *(Photo: E.ON)*

Despite this large variation in customer size and probably the same variation in the expectations of E.ON as a supplier, it seems the district heating in Malmö provides the large customer pool what they want. As a proof of this, E.ON has witnessed that the demand for district heating is higher than ever before.

E.ON struggles to be the customers' natural choice. In 2003 E.ON started to measure the district heating customer satisfaction annually. The results from these measurements led to activities to improve customer satisfaction, using a PDCA model. The results for Malmö demonstrate an improving trend since the beginning of the measurements, table 1 below.

Table 1. Table describing business customers´ satisfaction index concerning DH in Malmö over the years 2003-2008.

E.ON Business customer - Malmö	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Customer satisfaction index (NKI)	43	48	46	53	57	57

In 2005, the Swedish District Heating Association[2] introduced *Reko Fjärrvärme*, a quality assurance for customer relations. The application from E.ON for the District Heating in Malmö was sent in the same year and was approved in 2006. *Reko Fjärrvärme*, among others, puts requirements on the process for price adjustments, transparency on price constructions as well as financial data and business conditions. It also states conditions for communication with customers, for example, should annual customer meetings be held.

E.ON began annual public customer meetings already in 2004, before *Reko Fjärrvärme*. In August 2009 E.ON welcomed more than 1 000 customers in a combined customer meting and power plant opening. Additionally, a Customer Council in cooperation with The Swedish Property Federation South[3] has been in operation since 2006.

In 2004 E.ON started to apply a new pricing for the district heating in Malmö. This means that the price is set to always be competitive, against the best alternatives on the heating market. The price changes once a year and E.ON informs the customers at least 60 days ahead. E.ON also aims to support a stable price development, as the company recognises that all this is appreciated by customers, as well as providing district heating a unique advantage, in comparision to more traditional energy sources such as oil and electricity.

2 Svensk Fjärrvärme, a trade organisation for companies in Sweden which generate district heating, combined heat and power and district cooling.

3 Fastighetsägarna Syd, regional association of the largest property owners' organization in Sweden.

For almost two years E.ON has installed hourly metering on district heating and cooling for all Business-to-Business customers. In essence, E.ON measures the hourly consumption and collects data on a daily basis. This provides customers excellent possibilities to work with energy efficiency. E.ON also developed different tools, like EnergiDialog® and E.ON DataExport® to support our customers with information concerning energy consumption as well as learning how to monitor energy use.

Another popular product E.ON offers is customer service and maintenance. By offering cost effective installation service to customers, the installations are more efficient and the amount of energy used can be reduced. That saves both costs and environment at the same time, as the customer gets more satisfied with his district heating supply. That is the kind of win-win solution E.ON and more than 25% of its customers like!

E.ON has always considered communication with customers very important. Today E.ON uses, besides the bill, separate letters, the official E.ON homepage (www.eon.se), a local homepage for district heating in Malmö (www.eon.se/varme-malmo), electronic newsletters, postcards, telephone calls and personal meetings in a mix to offer the best suitable communication for each customer and his needs.

Being a district heating customer to E.ON in Malmö also means that you are doing a good cause for the environment. Presently some 65% of the production is counted as renewable, which is a tremendous development from 1975 in which the corresponding figure was 0%. This is one of the great advantages with district heating, since the distribution network serves as baseline and the fuel can change. When we have managed to increase the percentage share of renewable production, it has made a difference for all our customers and in the end also for the City of Malmö.

Conclusion

The City of Malmö and E.ON, as the primary energy provider in Malmö, have a long and productive history of working together, in terms of communication, energy provision, environmental considerations as well as specific components of the energy system – including an increase in renewable energy, energy efficiency, as well as the broad reach and environmental benefits of the district energy system. In Malmö, public and private sectors work together to minimise environmental impacts, to create housing and city districts that function in the long-term with a better energy profile – reducing environmental impact and incorporating steadfast design and durability.

In a variety of partnership projects, financial, aesthetic and environmental elements work together to achieve the greatest possible results in terms of harnessing the benefits of environmental, economic and social aspects of energy provision. E.ON and the City of Malmö have learned a lot and made good partnerships, which can be applied to further joint projects. Effective and active cooperation makes for excellent results and provides valuable experience to put to use in coming projects in the future development of Malmö.

Environmentally, this has paid off: In Malmö, total CO_2 emissions from energy production, transport and industry will be reduced 50% (1980-2020). Current total CO_2 emissions in 2008 were 4.4 tons per capita. Target CO_2 emissions include a 25% reduction by 2012 compared to 1990 levels, and to achieve 100% renewables by 2040. With strong partnership and communication, and building on the effectiveness of the existing system; the City of Malmö, together with key actors, such as E.ON, hope to reach this goal.