RENEWABLES IN DISTRICT HEATING AND COOLING
CONTENTS

BIOMASS
Maribo-Saksøbing (Denmark)
Forssä (Finland)

GEOTHERMAL
Ferrara (Italy)
Decin (Czech Republic)

FREE COOLING
Stockholm (Sweden)

SOLAR
Rise (Denmark)
Almere (The Netherlands)
Crailsheim (Germany)

WASTE INCINERATION AND INDUSTRIAL SURPLUS HEAT
Vienna (Austria)
Grüssen Pratteln (Switzerland)
Lindesberg (Sweden)
INTRODUCTION

The district heating infrastructure optimises use of renewable energy sources in satisfying urban heat demands. It creates an opportunity to combine a large spectrum of renewable fuels and ‘free’ energy inputs, such as surplus heat from electricity production, from waste incineration and from industrial processes. District cooling is emerging as a complimentary energy efficient tool for providing comfortable and reliable indoor climate during summer.

District heating and cooling will be instrumental in increasing the share of renewable energies on a large scale. In particular the sector provides:

• an infrastructure - compared to single technologies - allowing the development of a holistic approach to heating and cooling needs;

• significant know-how in dealing with renewable energies;

• access to a large number of heat customers enabling large scale use of renewable energies for heating and cooling purposes.

The local nature of district heating and cooling (DHC) provides a great flexibility to optimally combine locally available renewable and fossil-free energy sources.

This brochure illustrates the variety of renewable energy sources used in district heating infrastructures to warm and cool human living spaces.
STRAW IN DENMARK

RES source: straw
Heat capacity: 9 MW
Electric capacity: 20 MW
Operator: Energi E2
Support scheme: mainly through taxation on fossil fuels

Straw is a fuel available locally in any agricultural zone. In Denmark 11.9 PJ of straw was used in 2003, amounting to 1.4% of gross energy consumption. Straw is used as a supplementary fuel (co-firing) in large-scale combined heat & power (CHP) plants and as the sole fuel in smaller CHP plants or in boiler stations. Waste heat from the CHP plants and the heat produced in the boiler stations are used in district heating.

One example of a small CHP plant based on straw is Maribo-Sakskøbing CHP plant. The plant was commissioned in 1999. The electricity produced equals the consumption of around 10,000 households, whereas the heat produced covers 90% of district heating supplied in Maribo-Sakskøbing. The 40,000 tonnes of straw used by the plant are delivered by local farmers. The ashes from the combusted straw are then returned to the farmers, to be used as fertiliser.

Straw is very efficient energy source with 89% of the energy used. Out of this, 29% goes to electricity production and 60% goes to heat. This very efficient use of the fuel provides clear environmental and efficiency benefits. The emission of CO2, SO2 and NOx is considerably reduced through the combined production on electricity and heat. A further advantage is that straw emits less sulphur and nitrogen than fossil fuels like coal and oil. A final advantage is that straw is CO2 neutral since the carbon dioxide emitted is equal to the carbon dioxide it consumed while growing.

The heat produced is sold to two district heating utilities in the twin towns of Maribo and Sakskøbing, around 140 km south of Copenhagen.

District heating offers many environmental benefits to the Danish society. Around 60% of all households are connected to the heat grids. Three-fourths of the heat supplied is waste heat from CHP. Further 12% comes from waste incineration, 6% is biomass burned in boilers and 3% is industrial waste heat. The remaining 4% is mainly natural gas, but also oil, used in peak load and spare capacity boilers. The average annual cost for heating a standard house with district heating is one-third lower than heating with oil, and one-fifth lower than heating with natural gas.

Further information about energy in Denmark can be found at:
Energi E2 www.energie2.com
Danish Energy Authority www.ens.dk/sw1212.asp
Center for Biomass Technology www.videncenter.dk
Forsaa is a city of 19 000 inhabitants located 100km west of Helsinki.

Until 1996, district heat was generated from heavy fuel when a new CHP plant using biofuels started operation. The plant uses as main fuels industrial food residues obtained from sawmills in the surroundings, and forest chips collected locally. The plant uses as peak and reserve facilities two heavy–oil fired heating stations. The plant uses local renewable fuels and provides a secure supply of heat and electricity to the city; it covers all heat supplies of the city and two third of its electricity needs.

In Finland where the market share of district heating is 50% of the residential heat market, wood and peat represented in 2003 respectively 9.7% and 19.9% of input fuels to district heat production.
FERRARA, ITALY

RES source: geothermal
Geothermal well capacity: 14 MW
Peak boiler run on natural gas: 66 MW
Municipal waste incineration CHP plant: 8 MW thermal, and 3,44 MW electricity
Space heated volume in 2003: 4 million m³
Operator: Ferrara district-heating company

The geothermal district-heating network of Ferrara is based on a low enthalpy resource. Two wells in the surrounding of the city are extracting a quantity of water of 400 m³/h. The 100°C water is then delivered through a heat exchanger to the network.

The district operator uses geothermal to both warm houses and delivers hot water. It also provides cooling through the use of absorption chillers. In addition to geothermal, the network relies on a cogeneration plant burning municipal waste, and peak gas boilers when the demand is very high (e.g. winter times).

According to the European Commission’s *Blue Book on Geothermal Resources*, the potential of geothermal energy in Europe for district heating is significant. Geothermal as low-enthalpy resources offers an effective way to substitute fossil fuel based production of heat.
The project of using geothermal energy in Děčín started in the early 1990s. The heat producer in Děčín, the company Termo, used warm water from boreholes as pre-heated drinking water.

Energy in Děčín is ‘concealed’ in a vast underground lake from which water with the temperature of 30° C flows out through natural overpressure of 20 metres of a water column to the ground from the depth of 550 metres. The borehole yield is 54 litres a second. By means of heat pumps, geothermal water is used for generating thermal energy. After cooling down to 10° C and simple treatment it meets the requirements for quality drinking water and is supplied to the municipal water reservoir in the volume of approximately 1 million m³ a year.

The central source of Termo Děčín consists of heat pumps, gas cogeneration units and gas boilers. The basic load is covered by heat pumps and cogeneration units. The passage of the water from the borehole is difficult to adjust and the source is supplemented by a heat reservoir. The limited flexibility of using geothermal water from the borehole also precludes intermittent operation of heat pumps and motors, as is otherwise common with CHP plants.

Network water of the return pipe with the temperature of approximately 55° C is first heated up by means of a heat pump system to the temperature of about 72° C. Subsequent further heating up to about 90° C is ensured by the heating output of motors. Electricity generated through cogeneration primarily serves for driving the heat pump compressors and other circulation pumps of the source and the distribution network. If output above 9 MWt is necessary, further heating up to a maximum of 110° C and the remaining necessary output capacity is provided by peak boilers using natural gas, which can also serve independently as a backup source for covering the entire requirement of the network during outage of heat pumps or motors. The hot-water distribution network has the nominal parameters of 110/65°C. In comparison with the hot-water system with the temperature of 130°C, this solution allows for better use of heat from heat pumps.

The total annual heat supply from the source is approximately 280 TJ. One-third of heat generation should be covered by geothermal heat. The total efficiency of the source expressed as the share of heat supplied to distribution and the calorific value of consumed natural gas in an annual aggregate ranges between 120 and 130%.

CO2 savings in comparison with heat generation merely from natural gas is roughly 10,000 tonnes a year.

FREE COOLING IN SWEDEN

Operator: Fortum
Customers: 8 million m²
Production: 500 GWh
Capacity: 270 MW

Environmental benefits: Emissions of CFC and HCFC dropped by 60 metric tons. CO₂ emissions from conventional cooling is 280 g/KWh compared to 60 for the Stockholm DC network.

The development of district cooling started in Stockholm in the 1990s. The build up of the network was progressive, based on customers’ demand. Now the production reaches 500 GWh.

The phase out of refrigerant gases released by the traditional cooling systems was the main driver for the development of the project. Since the network has reached a mature stage, emissions of CFC and HCFC dropped by 60 metric tons. The amount of cooling produced and distributed by Fortum in Stockholm represents a reduction of 80%, if it had to be produced with electricity.

The renewable dimension lies on the use of deep cold seawater extracted from lake Malaren, pumped and used in the network to cool buildings.

The Stockholm scheme consists of different systems ranging from 3 to 228 MW. The largest system is in the central part of Stockholm. The second largest is the Kista system, designed for 50 MW.

All over Europe, demand for comfort cooling has dramatically increased over the last decade. As it is traditionally met by electricity, this surge for cooling is putting strains on electricity networks and deteriorating local environment through release of CFC/HCFC. As shown in this example, district cooling can bring solutions, with renewable possibilities, to meet this demand for comfort in an innovative manner.
RISE, DENMARK

Renewable energy source: solar and biomass (wood pellets)
Solar installations: 3600 m² solar panels
Heat storage: 4000 m³
Biomass boiler: 800 kW
Operator: Rise company
Support scheme: mainly via taxation on fossil fuels

In 2000, a new plant started operating in Rise, located in the island Aroe. The plant serves the energy demand of 115 buildings in the city, including institutional buildings and flats. The objective of the project was to reach 50% of heating on solar. The capacity of the heat storage corresponds roughly to 25 hours of peak load of the boiler. The solar installations also run during the wintertime.

During the planning of the project, special attention was paid to the return flow temperature from the building installations. To ensure the lowest possible return flow temperature all the heating installations were carefully balanced, fitting the necessary valves on radiators and setting these valves to the lowest possible flow. The result is a return flow in winter of 30 degrees and 36-40 in summer time.

The low temperature made it possible to install smaller main pipes and to achieve a very high efficiency for both the heat storage and the solar heating plant.

ALMERE, THE NETHERLANDS

Renewable energy source: solar panels 8000 m²
Additional fuel: gas
Heat capacity: total of 120 MW (two units of 60)
Electric capacity: total of 120 MW (two units of 60)
Operator: Nuon
Support scheme: investment support

The city of Almere is a new city in the Netherlands near Amsterdam built on the bottom of the old “Zuiderzee” after its conversion into a “Polder”. The biggest part of Almere, around 35000 house-equivalents is supplied with district heat. In the newest part of the city, a sun island will be built and solar panels will be integrated to the district-heating system. The total island has 8000 m² sun collectors to produce hot water.

The island will produce heat for around 2700 houses and offices at a total amount of around 4,5GJ per house. The project is the third biggest similar project in the world.

For further information you can contact milieubeleid@almere.nl or nuon@warmte.com
CRAILSHEIM, GERMANY

Renewable energy source: solar
Solar installations: target of 10 000 m².
Heat capacity: 
Electric capacity:
Operator: Stadtwerke Crailsheim
Support scheme: feed-in tariffs

Out of the total energy production in Germany, 7% originate from renewable sources. Among them solar energy is steadily growing with an output of 270 MW.

The solar project in Crailsheim, to be completed in 2009, is one of the four groundbreaking projects in Germany, selected as an excellent example of how to use solar thermal energy on a large scale. In this project, the city of Crailsheim cooperates with the Institute for Thermodynamics and Thermal technology, the Institute for Solar – and thermal technology (both of the University of Stuttgart); and HGC Hamburg Gas Consult GmbH.

In a first step, an area of 1040 km² of photovoltaic devices was installed on already existing buildings and now distributes heat across 10 km into a newly built area. The objective is to cover 10 000 m².

In the second step of construction in 2005/2006, the first collector sub field will be installed on a wall for noise protection, the others on buildings. Additionally, a long run heat reservoir with a storage capacity of 20 000 km³ will be built. The final step of construction, taking place between 2007 – 2009, will conclude with the assembly of the remaining collector fields on the wall for noise protections, covering a total of 7000 m². Then, the installation is expected to cover 50 % of the heat demand in the newly built area “Hirtenwiesen II”.

The entire costs of the project, 7 million euro, are shared between the Ministry of Economy of the state of Baden Wuerttemberg, the environment Ministry and the City of Crailsheim

Further information about the project can be found here:
http://www.stw-crailsheim.de
Reneable energy sources: waste incineration and surplus industrial heat
Share of waste in total district heat supply: 22%
Share of surplus industrial heat in total district heat supply: 8%
CHP: 75% of heat produced in CHP mode (industrial heat included)
    Heat capacity: 2.828 MW
    Electric capacity: 1623.6 MW
    Heat production: 5.633.386 MWh
    Power production: 5.838.175 MWh
Operator: Fernwärme Wien
Support scheme: feed in tariffs for CHP electricity, various taxation measures

The district heating network of Vienna supplies around 240,000 dwellings and 5000 industrial customers with district heating energy for space and water heating purposes. Waste and cogeneration accounts for 97% of the heat output.

 INCINERATION OF WASTES
Apart from an effective treatment of waste in a controlled manner and its attached benefits compared to landfilling, waste incineration enables to increase the sustainability of energy systems via the substitution of fossil fuels. The district heating network in Vienna is connected to four installations: three units of municipal waste and one dealing with hazardous waste.

Around 60% of the waste output of the population of Vienna is treated in incineration installations. This represents 475,000 tonnes a year that are used to produce energy. The heat output from waste incineration accounts for 22% of total district heat production.

The biodegradable part of wastes represent around 65% of municipal waste of Vienna. Given the contribution of waste incineration to the objectives of the Union, it should be clearly recognised as energy recovery.

 INDUSTRIAL SURPLUS HEAT
Another form of renewable supply of energy is the use of industrial surplus heat. At European level, the huge potential is still very much unused. Use of surplus heat should be definitely encouraged and recognised as renewables as these energy flows would be wasted, without the district heating network.

In Vienna, the use of the surplus heat of the OMV refinery is used in the district heating net. The refinery produces a number of products from crude oil.
Still, there are also by-products that are not currently used – even when they have a significant energy content. To dispose of these products they have to be burned. Given the proximity of dwellings in the neighbourhood of OMV, it was made possible to build a district heating pipe to the refinery to make use of this otherwise wasted energy.

The district infrastructure makes use in these energy flows that would otherwise be lost with significant gain in terms of sustainability.

**AN EFFICIENT AND SUSTAINABLE SUPPLY OF ENERGY**

In Vienna, the base load for district heat is ensured with waste. During colder time of the year, CHP installations are running. Only for peak demand heat-only-boilers are used. 97% of heat needs are based on heat from waste incineration and CHP. Added to the low losses in the system, it is estimated that the energy savings compared to in-house individual oil boilers are about 68%.

A recent study of the Austrian Federal Environmental Agency states that the CO2 emissions of Fernwärme Wien per MWh used energy (means that net losses and house losses are considered) are about 132 kg CO2. Comparing this figure to 256 kg CO2 / MWh when running an average gas boiler displays the high environmental benefits of district heating for the city.

Fernwärme Wien plans to commission a biomass plant next year, a new plant running on biogas as well as a new waste incineration plant, and considers the repowering of a CHP installation.

With an increasing supply of sustainable heat, the future is definitively green for the Viennese!

More information: [http://www.fernwaermewien.at](http://www.fernwaermewien.at)
WASTE HEAT FROM SLUDGE INCINERATION IN GRÜSSEN PRATTELN, SWITZERLAND

Benefits for the customer:
- High reliability due to an optimised, efficient heat supply
- Professional operation by a competent energy service company
- Minimal investment
- Contribution to environment protection due to the use of heat which otherwise would be wasted

Starting point
The idea to use the heat which is generated as an inevitable by-product when incinerating the sludge produced in ARA Rhein AG was taken up by Elektra Baselland (EBL) in 1999. On the grounds of a feasibility study an economically viable heat supply concept was developed and implemented from 2002. The construction itself took two years.

Concept
On the site of ARA Rhein SA a heating plant was built that supplies heat to the whole district heating system. The system is conceived as a hot water plant producing feed-water at 130° C. This is used by industrial customers, such as the Coop production and distribution centre, who need process heat for the operation of their facilities.

The waste heat, extracted from the sludge incineration plant of ARA Rhein AG by means of a heat exchanger, covers the largest share of the yearly heat demand of all customers connected to the network. In times of peak demand, additional heat is produced in fuel oil boilers. Once completely exploited, the use of waste heat will substitute the use of one million litres of fuel oil.

In case of unexpected interruptions, the decentralised heating plants installed at the site of the Coop production and distribution centre can ensure autonomous supply.

For more info please see http://www.ebl.ch
Consumption of fossil fuels in the district heating system reduced by approximately 96%

Reduction of CO2 emissions by around 96% and NOX emissions by approximately 79%.

**Project description**

Lindesberg is a town of 23,500 inhabitants, located 200 km north of Stockholm.

At the end of the nineties, Linde Energy started discussions with Assi Doman, a company manufacturing cardboards, on the use of surplus heat to supply flats and family houses in Lindesberg, Vedevåg and Frövi at a later stage.

The project is based on a unique solution where high-temperature surplus heat can be supplied for most part of a year with no supplementary heat source requirements. The heat is transported to Lindesberg over an 18-km long transmission pipeline.

**Reduction of use of fossil fuels**

The heat supply from Assi Domän will meet all the annual heat demand with an exception of approximately two weeks per year - peak load to be covered by the a boiler. The project results in a considerable reduction of fossil fuels use in the district-heating system operated by Linde Energi - by approximately 96% while the use of electrical energy for heat production decreases by approximately 85%.

The figure 1 at the end shows the changes in the use of energy sources including the district heat systems of Lindesberg and Vedevåg when production requirement is 84,000 MWh per year.

**Reduced Environmental Impact**

The 82,000 MWh supply from Assi Domän covers approximately 98% of the heat demand in Linde Energi’s district heating system. This implies an annual reduction in use of LPG by 4200 tons and use of fuel oil by 200 m³. Furthermore, the heat pump is taken out of operation. This leads to reduced use of electricity and CFC media. The project reduces Linde Energi’s carbon dioxide (CO2) emissions by around 96% and NOX emissions by approximately 79%.
The project results in considerable environmental advantages. In actual figures, the following environmental benefits have been achieved annually for the existing district-heating systems in Lindesberg and Vedevåg:

- Emissions of carbon dioxide (CO2) are reduced by 13 350 tons
- Emissions of nitrogen oxides (NOX) are reduced by 10.4 tons
- The use of electricity is reduced by 11 000 MWh

Comparison of the situations with and without surplus heat utilisation shows large environmental improvements in the district heating supply to Lindesberg and Vedevåg.

Further benefits will be achieved when the project expands to Frövi. This examples illustrates the benefits of the district heating infrastructure to make use of resources that otherwise would be wasted, and the huge benefits in terms of energy savings and emission reductions.