District Heating
- Danish experiences
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The history of Danish district heating

Denmark is not least known for Scandinavian design and the fairy tales of Hans Christian Andersen. But Denmark is also one of the most energy efficient countries in the world. The widespread use of district heating (DH) and combined heat and power (CHP) is one of the most important reasons why it has been possible to increase energy efficiency and reduce carbon emissions over several decades – a small fairy tale in its own right.

The first combined heat and power plant in Denmark was built back in 1903. It was a waste incineration plant which made it possible to handle waste in an environment-friendly way, and to provide electricity and heat to a new hospital. Thereby, the plant solved two problems at the same time.

Towards fuel efficiency

During the 1920’s and 1930’s, a collective district heating system was developed based on waste heat from local electricity production. District heating also supplied some urban areas with heat and accounted for around 4 % of the Danish heat supply. From here on, district heating from combined heat and power expanded in the larger Danish cities and in the 1970’s, around 30 % of all homes were heated with the use of district heating systems.

At the time of the energy crisis in 1973/1974, energy consumption per capita had risen to very high levels. This made it evident that it was necessary to save energy – including energy for space heating – to decrease the dependency of imported fuels and to reduce the consumers’ heating expenses. Therefore, it was decided to expand the fuel-efficient combined heat and power system to not only the larger cities, but also to medium and small-size cities in Denmark.

Photo: CHP production efficiently utilizes fuel, because excess heat from the generation of electricity is used in district heating systems instead of merely releasing it into the sea or air.
Modern district heating in Denmark

Today, 63 % of heating in private Danish houses is provided by district heating – not only for space heating, but also for hot tap water.

Denmark has six large central DH areas with a total heat production of approximately 60 petajoules (PJ) per year. There are also around 400 smaller decentralised DH areas with an annual heat production of app. 75 PJ.

In 2013, the production of district heating in Denmark amounted to 134 PJ. 72.8 % of all district heating was produced in cogeneration with electricity (CHP), thus saving around 30 % of fuel compared with separate generation of heat and power.

Figure 1 shows the development over the last two decades in district heating production by type of production plant.

As this figure shows, DH production from especially small-scale CHP units has developed significantly over the years. Today, Denmark has around 670 centralised and decentralised CHP plants.

Figure 1: District heating production by type of plant
Main characteristics of Danish district heating

Denmark’s relatively large central DH areas typically consist of a number of distribution networks interconnected by a transmission grid. Heat is produced at a variety of different plants including large extraction plants (based on coal, biomass or natural gas), municipal waste plants, surplus heat from industry, and peak load boilers.

An example of a large central DH area is the Greater Copenhagen DH system, as shown on next page in figure 3. It is by far the largest system in Denmark supplying approximately 35 PJ of district heating annually. The distance from the eastern to the western part of the system is approximately 50 km.

A variety of decentral areas
The smaller decentral DH areas are typically areas consisting of a single distribution network supplying no more than 1,000 consumers. Heat is produced by one base load unit and one or more peak load and reserve units. The base load unit is typically a natural gas CHP unit, a biomass boiler (e.g. straw or wood chips), or a municipal solid waste plant. The peak load and reserve boilers are typically simple boilers based on oil or natural gas with low investment costs. Some plants install these years supplementary solar heating or electric boilers. In recent years, the share of renewable energy in district heating production has increased. This is partly because some CHP plants in the large DH areas have changed from using fossil fuels to biomass. Figure 2 shows the development in district heating production with regard to fuel composition over the last two decades.

Who owns the plants?
With regard to ownership of plants in Denmark, there are various forms. The largest plants are owned by large energy companies, while smaller plants are typically owned by production companies, municipalities, or cooperative societies.

Common for all DH areas in Denmark is that the supply is driven by the actual demand. Consumer installations include variable flow and measurements of actual demand which means that the consumers have an incentive to save heat. Payment for heat is most often divided on a fixed part (per installation) and a variable part (per gigajoule of consumption).

![Figure 2: Fuel composition for district heating, percentage of distribution 1990-2013](image-url)
The necessity of heat storage

One very important element of both the central and decentral DH/CHP areas is that all CHP areas in Denmark have heat storages. This means that the CHP plants can optimise their cogeneration of electricity and heat according to the demand of electricity, and still be able to supply heat when needed.

It also means that CHP plants can decrease their production when there is plenty of electricity in the system, and that they can increase their production when there is a need of electricity in the system. When the corresponding heat production is higher than the heat demand, the heat is simply stored in the heat storage – and when the corresponding heat production is lower than the heat demand, heat is taken from the heat storage.
Public heat planning and the current market setup

Denmark passed its first heat supply law in 1979. The law made local authorities responsible for identifying the potential for public heating in their area.

The law of 1979 set the ball rolling and from it, other successful policies followed. Planning regulation was certainly the most important factor in the early stages of development, effectively creating the market, after which financial incentives were introduced to ensure the on-going economic viability of DH/CHP.

Today, all centralised CHP plants and most decentralised CHP plants sell electricity at the market price. Therefore, they must aspire to optimise their production according to the market price of electricity on the spot market, where prices are set for each hour. This means that CHP plant operators aim at producing most electricity and heat in cogeneration when electricity prices are high. Likewise, they try to minimise their production when electricity prices are low. This is done by active use of the heat accumulators in the system.

Subsidies for decentralised plants
In addition to the income from electricity sales on the spot market, most of the decentralised CHP plants receive a subsidy. Originally, the subsidy was granted as a feed in tariff with three different tariff levels depending on the time of delivery, but today it has been converted to an annual amount which depends on the market price of electricity.

With regard to taxes, all Danish DH producers have an incentive to use biomass as these fuels are excluded from heat taxes, whereas heat taxes are imposed on the use of fossil fuels. Furthermore, CHP producers receive an addi-

Investment costs versus operating costs
The establishment of DH systems requires large investments in infrastructure compared to individual heat supply options, especially because of the large investment costs in DH networks. On the other hand, the cost of operating a DH system as well as the environmental impacts are in many cases significantly lower.

This is particularly the case if heat is produced by an energy-efficient CHP unit or if heat is produced by utilising waste heat from an industrial plant, e.g. a steel plant.

The life-cycle viewpoint
When evaluating the feasibility of district heating, it is important to consider a period of years. From a "life-cycle cost" viewpoint, district heating is in many cases the most feasible solution – of course depending on among other things the heat demand and the heat density in the specific area.

The necessary infrastructure investments are in many cases paid back after some years by lower annual operating costs. The same can be said about high quality DH components which are more expensive up front than low quality components – but in many cases they are paid back by lower maintenance costs.

It should be taken into consideration that DH networks have a technical lifetime of typically 40-50 years.
The future role of district heating in Denmark

The Danish district heating system is expected to play an important role in reaching two large future political goals:

• In 2020, wind turbines shall cover 50% of the domestic electricity supply
• In 2035, all electricity and heat supply shall be based on renewable energy.

The fulfilment of the first target increases the challenges of balancing wind power in the power system. When introducing large amounts of wind power in the system, there will be times in which the production from wind turbines covers only a minor part of the electricity demand. Similarly, there will be hours during which the production from wind turbines covers a very large part or even exceeds the electricity demand.

Different technical measures can improve the flexibility of the DH/CHP system and can help integrate wind power:

• Heat storages
• Electric boilers and heat pumps
• Bypass of turbines.

Denmark, CHP plants can decrease their combined heat and electricity production when there is much electricity in the system from wind turbines and still be able to supply heat.

By using electric boilers and heat pumps, DH plants can use electricity for heat production (instead of producing electricity).

By bypass of turbines, a CHP plant can avoid generating electricity when there is excess electricity in the system. Instead, it can produce only heat with the same efficiency as a heat-only boiler. The flexibility of the DH/CHP system is therefore an important aspect with regard to wind power integration.

The fulfilment of the second target – which has to do with renewable energy – will require a conversion of all electricity and heat generation to renewable energy by 2035. In that respect, district heating has a big advantage because it is flexible with regard to fuels.

By use of heat storages, which are already common in
Project approval of heat projects in Denmark

This section provides a brief overview of the regulatory process, responsibilities and requirements when approving district heating projects in Denmark.

The Danish district heating legislation is set out in the Heat Supply Act that regulates the heating sector and provides local authorities (i.e. municipalities) with the power to engage in local heat planning, make decisions on energy infrastructure and which resources is to be prioritized. The legislation and guidelines to the legislation is developed by the Ministry of Climate, Energy and Building and the Danish Energy Agency, but the actual implementation of the legislation and policies is the responsibility of the local municipalities.

The Danish approach to heat regulation provides a clear division of authority where local decision-makers have full authority over local heat system designs, but they do so by relying on a centralized policy and a technical framework provided by the national level. This ensures that district heating projects are in line with the overall national ambitions with regards to the development of the heat sector, but at the same time the evaluation and decision on a concrete heat project is undertaken by a local authority with detailed knowledge of local urban development, heat demand and any other relevant local considerations.

Main principles of the initial Danish Heat Supply Act from 1979:

- Local authorities/municipalities are responsible for the approval of new heat supply projects.
- Local authorities/municipalities have to make sure that project with the highest socioeconomic benefits is chosen.
- Production of heat must, if possible, be produced as combined heat and power.
- The collective heat supply price must offer consumer prices based on “true costs”, meaning that the heat price cannot be higher or lower than the actual heat production costs.

The Danish Heat Supply Act has also established specific zones of heat networks throughout the country. Within each zone a specific heat supply is promoted through the Danish heat legislation.

The zones are as follows:

- Natural gas supplied through the natural gas grid
- Decentralised district heating
- Centralised district heating
Municipal heat project approval process

When the owner of a building wants to supply a building with heating or renovate an existing heat unit and the building is within an area or zone dedicated to natural gas or district heat, the supply has to be approved by the municipalities. When a district heating company wants to build new production capacity, a transmission line or supply a new area with district heating this also has to be approved by the municipality. The approval process is usually a matter between the district heating company and the municipality but can also involve the natural gas company and a consultant on one or both sides.

The typical process is as follows:

• Initial dialog between municipality, the district heating company, building owner(s), the natural gas company and in some cases a consultant. The purpose and objective of this dialogue is to define the scope of the project and to define the reference project scenario for the analysis.
• The district heating company submits the project proposal to the municipality.
• 4 weeks hearing period among the stakeholders that is directly affected by the project proposal.
• Adaptation of the project proposal according to comments submitted during the hearing period.
• City council approves or rejects the project proposal.
• 4 weeks opportunity for appeal for the stakeholders directly affected by the project proposal.
• Implementation of the project.

When the district heating company or the owner of a building submits a project proposal to the Danish municipal authorities the following documentation has to be included in the application:

• The proposed project’s relation to other relevant legislation.
• The project’s relation to other municipal plans e.g. for new development zones or local preservation areas.
• Description of the area to be supplied and technical specifications of the installation, e.g. capacity, fuels, security of supply and other technical issues.
• Time schedule for the implementation of the project.
• Description and account of the applicant’s consultations with other stakeholders.
• Economic impact for the consumers, i.e. effect on heat prices.
• Basic business cost-benefit analysis for the project/district heating company economy but also an analysis of energy-related and environmental aspects.
• Socio economic evaluation of relevant scenarios.
The main approval criteria is the socio economic evaluation and only projects showing the best net benefit to society are prioritized. However, the other information mentioned above, is important in order to give the municipality the full picture of the proposed heat project.

A socio economic analysis ensures that all societal costs of the heat projects are included and the analysis is always a comparison between two or more alternatives. Taxes are excluded and externalities, such as cost of emissions, are included. The project alternatives are always evaluated over their entire expected technical lifetime. If the technical lifetimes of different technologies are not the same, scrap values or reinvestments are included in the analysis.

So, while companies that invest in energy projects typically make their own internal business case, municipal authorities and district heating companies are only allowed to pursue projects with a high value in socio-economic cost-benefit analysis.

The socio-economic analysis has to be based on a methodology and on data supplied by the Danish Energy Agency. The data consist of forecasts for future energy prices, costs of emitting certain pollutants and other considerations that are necessary for a full accounting of the socio-economic analysis of a project. By comparing different projects based on comparable data sets it is ensured that the project showing the best socioeconomically benefit is chosen.

The Danish Energy Agency is responsible for maintaining a national provides catalogue and data on:

• Future fuel prices
• Future electricity prices
• Externalities
• Cost and technical specifications of different heat production units

These data helps municipalities and heat companies develop accurate costs estimates which strengthens the planning and approval process. However, if the heat company that applies for a project approval has more accurate local data, these data have to be used instead of the data from the Danish Energy Agency. For instance, this is always the case with regards to heat prices, when applying for projects in existing district heating areas.
Real examples of the benefits from District heating and cooling

This section provides examples of district heating case studies.

The first two summarises the process and the results, with regards to the environmental and the socio economic analysis, from two specific Danish projects that have been approved by the local authorities. One example is the development of heat supply to a new building area and the other example describes a heat project in an existing district heating area.

The next cases focusing on the current transition to low temperature district heating and the potentials in district cooling.
Nordhavn is a new development area in Copenhagen. There are some existing buildings in the area but the majority of the heat demand will be from buildings that are built from 2014 and onwards. In the development plan for the city of Copenhagen, this area is defined as an area for low-energy buildings. This means that all new buildings will have to be built in accordance with the strictest energy performance requirements in the Danish building code (The 2020 Building Standard). The area is expected to have 864,000 m² of heated floor space in 2060. The surrounding areas are supplied with district heating.

**Project proposal**

The project proposal consists of an analysis of the three different heat demands – low, medium and high - supplied with either district heating, ground source heat pumps or air source heat pumps. An earlier study has shown that it was not socio economically feasible to establish a separate district heating network for new development areas and therefore this scenario was excluded from the analyses.

Based on previous studies the municipality decided that the high heat demand was the most realistic scenario and the following results therefore represent that scenario. The following shows the NPVs of the main costs for the high heat demand scenario.

The different relevant analyses are as follows:

1. The project: The entire area is supplied with district heating from the existing network.
2. Reference 1: The entire area is supplied with air source water
3. Reference 2: The entire area is supplied with ground source heat pumps

<table>
<thead>
<tr>
<th>NPV of costs (million EUR)</th>
<th>District heating</th>
<th>Heat Pumps - ground</th>
<th>Heat Pumps - air</th>
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<tbody>
<tr>
<td>Investment:</td>
<td>30:</td>
<td>49:</td>
<td>38.5:</td>
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<tr>
<td>Fuel:</td>
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<td>10:</td>
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<td>Q&amp;M:</td>
<td>3.2:</td>
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<tr>
<td>Electricity sales:</td>
<td>-18.8:</td>
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</table>
Results from socio-economic analysis
The district heating solution proved the best overall NPV and was chosen as the best alternative. Even though the fuel cost of the district heating solution was the highest of the three different options, the overall cost of the district heating solution was lower when seen over the 25 years period covered by the analysis. Therefore, the district heating solution was approved by the municipality of Copenhagen and the district heating network is currently being expanded into the Nordhavn area.

The environmental analysis were conducted for all the years (2013-2037) included in the analyses, but because the results vary from year to year, the year 2037 was chosen to illustrate the environmental impact on the energy system.

The district heating option results in a reduction of CO2 emission whereas NOx emissions are slightly increased when compared to the alternatives. When the overall environmental impact assessment is done by comparing the cost of the emission the district heating scenario has a benefit of 194,000 EUR. The main reason for this is that the district heating is supplied from CHPs and in a Danish context; the electricity that is co-generated with the district heat will replace coal-based electricity. In other words, if the CHP that supplies district heat for the new area did not exist then the electricity would instead have to be generated by a coal-fired condensing power plant. So, when you compare the district heating scenario with the reference you find that the former will have fewer total CO2 emissions.

Read more here: http://stateofgreen.com/en/profiles/danish-energy-agency

| Cost of externalities in year 2037 (million EUR) | District heating | Heat pumps - ground | Heat pumps - air |
| CO2 : | -225.000| 85.000: | 93.000: |
| SO2 : | 0 | 0 | 0 |
| NOx : | 33.000: | 13.000: | 13.000: |
| Total : | -194.000: | 13.000: | 106.000: |

Photo: By & Havn - Ole Malling
Heat supply in an existing area – Køge Harbour – Køge City

Køge City, located just south of Copenhagen, has a population of 35,000 and the current heat supply comes from individual natural gas boilers, where the gas is supplied by the natural gas grid. At the harbour there is a wood-chip fired CHP plant that supplies heat for industrial purposes as well as electricity to the power grid.

**Project proposal**
The project proposal submitted to the municipality of Køge was an analysis of two scenarios 1) the proposed project and 2) the reference scenario.

1. The project suggested retrofitting the existing CHP plant to supply heat to a district heating network and thereby substitute the natural gas boilers with a district heating network. Furthermore, the project included an investment in a heat storage, which would enable flexible production at the existing CHP plant.

2. The reference or baseline scenario was that the individual natural gas boilers would eventually be replaced by individual heat pumps, electric boilers and/or solar thermal solutions.

**District heating supply options**
A number of different alternatives could be taken in to consideration but in Køge it was clear from the beginning that the socio-economically most feasible solution would be retrofitting of the existing CHP plant.

A number of different biomass solutions could be considered but as the screening below shows, retrofitting the existing CHP plant is the best solution based on a number of parameters.

<table>
<thead>
<tr>
<th>Technology screening based on data from DEA Technology Catalogue</th>
<th>Retrofit the existing wood chip fire CHP</th>
<th>New straw fire CHP</th>
<th>New wood chip fired CHP</th>
<th>New wood pellets fired CHP</th>
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<td>Environmental impact</td>
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</tbody>
</table>
Defining the reference scenario
The reference scenario assumed that the heat consumers would not replace their individual natural gas boilers before the end of their technical lifetime and therefore the replacement would take place gradually during the project period. In Denmark there is a policy to phase out oil and natural gas from the heating supply and this means that the new individual heat supply in the reference scenario would be based on renewable energy sources. However, earlier studies have already shown that the socio-economic benefits of large scale direct-fired biomass boilers are higher than using individual renewable energy heating units. Therefore, the option of individual household biomass boilers was not included in the screening.

Under these considerations the reference scenario was defined such that the current individual gas boilers will be replaced by individual heat pumps, electric boilers and/or solar thermal solutions.

Results from socio-economic analysis
The socioeconomic analysis showed that the proposed project, when compared to the reference scenario, had a positive NPV of 12 million EUR. Therefore, the project could be approved by the municipality of Køge and the district heating company is currently building the district heating network and retrofitting the existing CHP plant. The project will be fully implemented by January 2015.

The analyses of the environmental impacts during the entire project period (2011-2031) showed that the proposed project would reduce emissions by as much as 254,733 tonnes CO2 compared to the reference scenario. The project however also increases SO2 emission by 90 tonnes and increases NOx by 17 tonnes.

The overall environmental impact assessment is done by comparing the cost of the emissions. The total value of the CO2 emission reductions for the entire project period is 32.1 million DKK and the cost of the SO2 and NOx emissions are 6.4 million DKK. This means that even though there are additional emissions related to the project the total cost of externalities for the project are positive.

Photo: Køge Kyst P/S
Transition to low temperature district heating

Low-temperature district heating is realistic and will provide energy savings and reduce dependence on fossil fuels.

Today in Denmark, the use of low temperatures in district heating systems is becoming a reality. A number of Danish district heating companies have started to realize projects that make it possible to reduce the temperature significantly; in some cases down to around 50/25°C. In the long run, even lower temperatures may be possible. The group of companies undertaking the research have recently published a report on the results.

In the Copenhagen suburb Albertslund (which was planned and built during the 1960s) some 2,000 town houses will be completely renovated and converted to low-temperature heating. The old district heating network will be replaced with a new one designed for 50/25 °C. To date, 544 houses have already been converted and now run at low temperatures (See fig. 1 below).

The report (in Danish) describes a number of different methods by which the reduction in temperatures may be achieved and covers a range of different building types and ages. Of course, each network and building type is different and will require a different solution, but the purpose of the work is to use the trials carried out to develop plans for widespread reduction in temperatures over time. This article will summarise some of the results of the study.

Broad cooperation

The project is carried out in cooperation between five district heating companies: Albertslund Forsyning, AffaldVarme Aarhus, Bjerringbro Varmeaværk, Silkeborg Forsyning, Gentofte Fjernvarme, Arbejdernes Andelsboligforening Aarhus (AAB a cooperative housing society), Aalborg University represented by the project “fourth-generation district heating” and COWI.

The project highlights examples of temperature reduction,
either already implemented or planned. The aim of the study is partly to describe what is currently going on within this field and partly to suggest new ways of reducing temperatures.

Obviously, this transition must take place in a way that allows consumers time to adapt to the new conditions. Therefore it may be necessary to include measures to ease transition, such as the possibility to raise the supply temperature locally if needed. It was not the intention of this work to analyse the economic aspects, but merely to collect and process the knowledge and experience gained with a view to informing future development.

Initiatives and results

In the report, a number of results from test operations on small and large scales have been collected. Some of the key results are outlined below:

• 75 detached houses from the 1970s in the Copenhagen suburb Høje Taastrup, where under floor heating was already installed, were converted to low temperature operation. The local distribution system was replaced with up-to-date twin pipes, and today the average flow temperature is 55 °C. The heat loss was reduced from some 40% to 13%, corresponding to an annual saving of 555 MWh.

• A similar initiative was undertaken in Tilst - a suburb of Aarhus. This test included eight detached houses located on the same residential street. In this case, the houses had an existing radiator system, which remained in place. However, the local distribution system was replaced with twin pipes. The first results indicated that minor modifications of some house installations and some upgrading of insulation in a few houses had to be done to achieve adequate comfort levels. The flow temperature previously was 70-80 °C and, as a result of the project, it is now 60-65 °C. The heat loss in the distribution system to the eight houses dropped from approx. 28 % to 12 %.

• Silkeborg District Heating Company has successfully introduced TERMIS TO (Temperature Optimisation)
in the company’s total pipe network (224 km of main pipes and 317 km of branch pipes). The system adjusts the flow temperature automatically to the lowest possible temperature to meet the requirements of the 10,500 consumers. This initiative has resulted in a considerable reduction in flow temperatures for the majority of hours, even during the winter months. In this case no attempts have been made to reduce the guaranteed temperature delivered to the customers. So far, the annual heat loss from the network has been reduced by 6,000 MWh, corresponding to about 8.5%.

- A similar initiative was taken in Bjerringbro District Heating Company, where the flow temperature was decreased by an average of 7 °C.
- The district heating companies in the towns Skanderborg-Hørning and Middelfart carried out full-scale trials to optimize the return temperature. Here they used a software solution that makes it possible to continuously monitor and record each individual customers return temperatures. This allows identification of installations that could improve the operation conditions. The district heating companies will approach the owners of these installations, and suggest solutions that will reduce operational costs. The resulting lower return temperatures will improve the overall system operation.
- Gentofte District Heating Company will utilise waste heat via a heat pump to be installed at the local Hospital. The heat pump will provide approximately 12% of the heat required in winter by a nearby group of terrace houses where the existing gas supply is to be replaced with low temperature district heating. During the conversion from gas to low temperature district heating it is expected that some minor modifications to the radiator installation have to be carried out within the dwellings to ensure that comfort levels are maintained.

- In the town Odder, a new test project consisting of 5-10 houses will be provided with district heating water as low as 30-40 °C. To avoid issues with legionella, the hot water supply will be boosted to 50 °C using a small electrical immersion heater.
- In the outskirts of Aarhus there are two additional projects using low temperature:
  - In Hjortshøj, AAB has built 23 low energy double houses with 46 low energy dwellings each designed for a heat consumption of 4.01 MWh pr. year. Floor heating is installed, and three local air to water heat pumps supply district heating water at 35 °C. Hot water is provided by plate heat exchangers supplemented by local electrical heaters.
  - In Geding an existing district heating network will lower its flow temperature, and the 23 detached houses will have a new heat exchanger unit for hot water supply. In this case the unit will enclose a small heat pump to raise the temperature of the hot water supply.

**Future actions**

The discussions in the project group focused on what actions are required to reach a general and substantial lowering of temperatures in the long term. It was agreed that the district heating companies have to take the initiative when it comes to influencing developments in the desired direction.

A key action for the district heating companies will be to
create a development plans for the long term. This work must include providing consumers with the necessary knowledge to renovate their buildings according to future demands, so that they can adapt to lower temperatures. The technical demands issued by the district heating companies must be adjusted and in line with what is technically achievable whilst also being realistic for the owners.

Some areas may require a longer transition period than others, as necessary adaptations will vary with the age and type of the building. In Albertslund the change is enabled by supplying the new sections of the network to serve the converted buildings via local shunt installations, where return water is mixed with the water from the ordinary flow line. Once all buildings in the wider area are converted, a separate line with low temperature from the heating station may be established. Using the shunt installations, it is possible to temporarily increase the temperature should it be required in a particular area.

**Outlook**

As mentioned above, development and demonstration of various solutions is now progressing with a view to creating action plans for 100 percent transition to low temperature district heating. We do not as yet have the final solutions for any system, so there is still work to be done. Therefore it is important that further ideas are developed and tested.

Close community engagement will be essential to make plans for the buildings and for the heat supply fit together in the long term. Particular attention should be paid to ensuring that customers return to the network at a low temperature, since those who currently return at a high temperature could encounter problems when flow temperatures are lowered.

Overall it can be concluded that to achieve future-proof solutions with lower temperatures, it is important that the whole ‘chain’ from the source of energy, through the network to the building’s envelope is involved in a coordinated effort that provides optimal solutions. It requires a great effort by all involved. However, the district heating companies have to be proactive in this development, if low temperature district heating is to succeed.

By Hans-Henrik Høgh, Albertslund Forsyning and Theodor Møller Moos, Senior Project Manager COWI

Keeping cool under the CO2-pressure

The increased demand for air conditioning and cooling has led to higher electricity consumption in many cities. In our effort to provide low carbon cooling, we have built the first two district cooling networks. They are based on free cooling from seawater abstraction, along with running surplus heat from the district heating network through absorption cooling and traditional compression chillers. The project is expected to save 14,000 tonnes of carbon dioxide per year.

Peak summer temperatures in Copenhagen can reach 35°C and are expected to rise by 2 – 3% by 2050 – with average daily temperatures also rising. Consequently, the demand for traditional air conditioning is increasing. Dependency on electricity-based cooling appliances can create unsustainable electricity demand and overreliance on fossil fuels. Traditional air conditioning systems are expensive, noisy and utilise a lot of space. Additionally, there is currently excess surplus heat within the district heating system during summer months when demand is low. The solution was to develop a 'District Cooling' system to complement the highly successful District Heating system.

District Cooling is the centralised production and distribution of chilled water, partly cooled with cold seawater. It is distributed via underground insulated pipelines to commercial and industrial buildings to cool the indoor air. The plant is designed around three different methods of cooling making it very flexible and highly energy-efficient, depending on the temperature of the seawater.

In the city of Changchun - capital of the Jilin Province situated in north-eastern China - the citizens can breathe in cleaner air. A district heating project, which was constructed by Danfoss, results in 10% savings in coal usage, amounting to 28,000 tons a year. This means 10% less CO2, SO2 and NOx emissions. District heating plays a major role in supplying indoor heating and domestic hot water to the people of Changchun, and Danfoss has been a key partner for Changchun Heating Group Ltd in bringing the district heating technology up to modern high standards, thereby saving money and reducing greenhouse gas emissions.

China focuses on energy efficient technologies
China is one of the world’s largest energy consumers and carbon dioxide emitters, only surpassed by the USA. Due to the economic development and integration to the world economy, China’s energy consumption has grown rapidly in recent years. Faced with substantial energy and environmental challenges has made the Chinese government focus on energy efficient technologies and district heating has been encouraged for several decades. According to the International Energy Agency, (2007), China’s district heating area has increased from over 276 million m2 in 1991 to over 1.100 million m2 in 2000, and exceeded 2.500 million m2 in 2005, with an annual growth rate of 17%.

Two new district heating systems
The project covered two new district heating systems for the Yutan development area situated 15 kilometers from...
the city center of Changchun. In the city development areas, new residential buildings as well as offices and public buildings have been constructed. With the construction of the two new district heating systems (one for the northern part of Yutan and one for the southern part), heat supply for an area of 6.44 mil m2 has been ensured. The total system capacity is 380.7 MW heat, of which 169.2 MW heat is needed for the northern area and 211.4 MW heat for the southern area. The district heating network has been converted from a constant flow system to a variable flow system, where the main booster pumps have been equipped with Danfoss frequency converters. This means that heat is supplied according to the actual need, and residents in the city can get heat 24 hours a day.

State-of-the-art technology
Danfoss District Energy - the leading supplier of automatic controls and systems for district heating applications - signed the final agreement to deliver 40 district heating substations on December 4th 2008 with Changchun Heating Group Ltd. The 40 Danfoss district heating substations in various capacities from 3 MW to 10 MW are equipped with high quality and state-of-the-art components. All substations can be remote controlled and via the SCADA (Supervisory Control and Data Acquisition) system; the actual data can be evaluated and optimum operation of the district heating network and substations is ensured.

Danish mixed credit loans support development of DHC in China
One of the tools Chinese government approached to prevent an increase of SO2, CO2 and NOx emissions was to support external financing of District Heating and Cooling (DHC) projects. Nordic countries like Finland, Sweden and Danmark were the countries China went to in order to get DHC know-how and experiences. Due to this approach and the expected market growth the Danish government has had big focus on China as a strategic partner with concern to energy efficiency and DHC for more than 10 years. And many district heating projects have been realized during the years with Danish funding.

Demand for 50% Danish
With the request of minimum 50% of Danish content and resources used in the 10 million EURO project, Danfoss District Energy produced the 40 state-of-the-art substations at locations close to the Danfoss Group headquarters in Denmark. All substations along with their accessories and spare parts were put in 47 40-foot containers and shipped by sea via Hamburg, Germany to the Chinese harbour city Da Lian. From there trucks transported the substations to Changchun, where the installation started in autumn 2007.

The final acceptance certificate was signed by Danfoss District Energy, the official buyer CMC International Tendering.

Conclusion
As a result of this project the sky above Changchun city is now brighter and the air is cleaner. In numbers the project has achieved a 10% reduction of CO2 emissions, amounting to approximately 58.300 tons a year, 320 tons SO2 a year and 58 tons NOx a year.

Read more on Danfoss’ profile at www.stateofgreen.com
Danish Energy Agency

The Danish Energy Agency is responsible for handling all national and international agreements and tasks linked to the production, supply and consumption of energy in Denmark. The Agency also deals with efforts to reduce emissions of greenhouse gases, and oversees the legal and political frameworks for reliable, affordable and clean supply of energy in Denmark.

The Danish Energy Agency’s Global Cooperation collaborates with China to combine sustainable future energy supplies with economic growth. The initiative is based on four decades of Danish experience with renewable energy and energy efficiency, transforming the energy sectors to deploy increasingly more low-carbon technologies. The Danish Energy Agency is very happy with the collaboration with China’s National Energy Conservation Center.

The agency is part of the Danish Ministry of Energy, Supply and Climate.

Read more at www.ens.dk/en/policy/Global-cooperation

State of Green

State of Green is a public-private partnership founded by the Danish Government, the Confederation of Danish Industry, the Danish Energy Association, the Danish Agriculture & Food Coun~cil and the Danish Wind Industry Association with the aim of sharing Danish green solutions internationally. State of Green is not-for-profit and your one-point access to green solutions and companies from Denmark. State of Green’s website is available in English and Chinese.

Read more at: www.stateofgreen.com/heating-and-cooling

Danish Board of District Heating

The Danish Board of District Heating (DBDH) is a private organisation promoting district energy for a green city development. DBDH represents the leading players within the Danish district heating sector.

This includes:

- Heat and combined heat and power production companies and waste incineration companies
- Heat transmission and distribution companies
- Private consulting companies, R&D institutions and training institutes
- Manufacturing companies of plants, systems, components and products for the sector
- Contractors.

DBDH implements conferences, seminars and exhibitions with the purpose of making consolidated experience available worldwide. Furthermore, DBDH develops and maintains cooperative agreements with district heating organisations abroad for the purpose of exchanging information related to all aspects of district heating.

You can read more about DBDH at www.dbdh.dk