A remarkable district heating system

By Mr Per Rimmen
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Odense, the third largest city in Denmark, is known for its efficient district heating system, and a heat price which is among the lowest in Denmark. Around 75 % of the heat are sold to one-family houses, which are much more expensive to supply than large apartment buildings. It is therefore remarkable that the heat price can be among the lowest, considering that in many countries it is impossible for the district heating to be competitive, especially in districts with one-family houses.

The district heating company is owned by the municipality of Odense. The city council acts as a board of directors of the company. The 53,000 consumers (buildings) that are supplied represent 97% of the population in the municipality. The company's natural aim is to provide the consumers, and thereby the population living in the buildings, with sufficient and reliable heat at the lowest possible costs. All profit made by the company is used to reduce the tariff.

A typical family in a 150 m^2 one-family house pays annually DKK 8,500, including taxes and VAT. This corresponds to 0.6 % of the price of the house or 1-2 % of the annual family income and is 30 % lower than the alternative of individual oil or gas boiler.

What is the reason for this successful market share? Is there any secret? There are many reasons for the success, but one of the most important is that we have very simple and cheap district heating substations to connect the 53,000 buildings, which are supplied. The internal heating systems in the buildings are directly connected without heat exchangers and, most importantly, without a mixing loop. Moreover, all meters are cheap mechanical flow meters - not heat meters. In fact, there are no heat exchangers in the heating circuits of the system at all, except a few, which separate the special heating tubes in the green houses. This is even more remarkable as the whole directly interconnected heating system, from power plant to the radiators of 53,000 consumers (buildings), includes 1600 km of pipes, with dimensions from 25 to 1000 mm, 150,000 m^3 of circulating water and pressure levels up to 25 bar. Only the hot tap water is heated in each building substation via heat exchangers or hot water tanks in order to ensure high quality of the water to the consumers and in the closed heating circuit. We definitely have no open systems, which are typical in the NIS countries.

Let us look in greater detail at the main reasons for the low heat price and the most important preconditions for the large and directly interconnected heating system:

The district heating system started in Odense in 1929 utilising the low cost surplus heat from the local power plant and it has gradually developed subject to commercial conditions.

The heat supply law from 1979 and the integrated heat supply and urban planning have moreover boosted the development in the last 20 years. District heating today supplies 100% of all heated buildings in the 95% of the city's urban areas suitable for district heating.

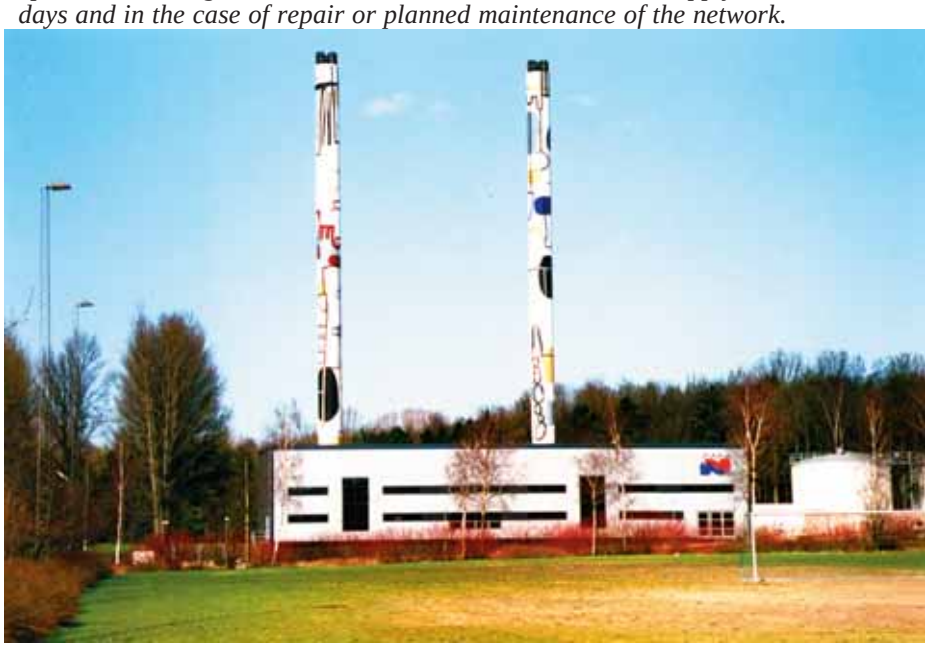
The heat production is still based on CHP - 20 % come from a CHP waste incinerator, 75% come from a new coal fuelled extraction CHP plant and only 5% come from peak load boilers distributed in the network. Consequently, the heat production is based on low-grade fuels, and the fuel consumption is around 3 times smaller than it would have been if the heat were produced in heat-only boilers.

A 15,000 m^3 pressureless heat accumulator tank at the CHP plant has been in operation since 1975. It was the first heat accumulator in Denmark. Now heat accumulators in the range from 1,000-50,000 m^3 are a natural part of any modern CHP plant. The accumulator maintains the pressure of the system and allows the CHP plant to operate in power-only mode in 2-4 power peak hours, while the accumulator provides all the heat. In other words, the heat extraction does not reduce the capacity value of the power plant.

Apart from the 53,000 buildings, the district heating system supplies two neighbouring towns and a number of greenhouses, spreading on an area of about 150,000 m^2. In total, 5% of the heat production is sold to the other municipalities and 30% to the greenhouses.

The temperature level is very low. The normative design temperature is, in principle, 120°C. However, the maximal operational supply temperature is 95°C, due to the pressureless accumulator. On the coldest day, the normal maximal supply temperature from the CHP plant is around 90°C, which is sufficient to provide a suitable supply temperature directly to the radiator thermostatic valve at the other end of the network. In summer, the supply temperature is around 78°C. This is sufficient to produce hot tap water at 55°C to most consumers, whereas thermostatic regulated bypasses ensure that the consumers at the end of the network are also provided with a district heating temperature of at least 60°C. The return temperature to the CHP plant is around 40°C in the winter and 42°C in the summer. The low temperatures reduce the fuel

Peak load back-up boiler plant fuelled by light oil situated in the outskirts of the network. It is not staffed and it can be started by remote control. It is seldom in operation, but it guarantees the consumers a reliable heat supply on the coldest days and in the case of repair or planned maintenance of the network.



A typical consumer substation to a one-family house in the show room of the district heating company. The consumers are able to ask for advice before they decide to invest. The flow meter and valves in the left corner below belong to Odense District Heating Company, whereas the heat exchanger for hot tap water, the differential pressure valve, and other components belong to the consumer.

consumption for the production of heat in the combined production and the heat losses.

The flow meters in the consumer substations are simple mechanical flow meters owned and maintained by the Odense DH company, but the consumer reads the meter and reports the result to the consumer department. The board has considered replacing all the flow meters by heat meters, but found that it would not serve the interests of the consumers. It would be very expensive and would not introduce a more reasonable share of the costs among the consumers. The flow balance of the system shows that 42 mio. m^3 are circulated whereas only 35 mio. m^3 are measured at the consumers. The difference is mainly due to the re-circulation in thermostatic by-passes, as mentioned above. Only a minor part is due to faults of meters and not registered consumption in low load periods.

The tariff includes 3 cost based price components:

- A fixed annual meter-fee per consumer
- An annual fee per m^3 of heated building volume to cover the fixed costs
- A variable fee per consumed circulated m^3 flow

The fixed meter-fee and the variable fee are the same for all consumers, whereas the fee per m^3 building volume includes a discount to large consumers. Thereby the one-family houses pay a higher average price, which reflects the fact that it is much more expensive to supply the small consumers. This tariff structure encourages the consumers to save heat and to reduce the return temperature.

As all other Danish DH companies, Odense DH company pursues an active and transparent information policy towards consumers. In publications and during campaigns, consumers are offered advice on how to use the heat wisely and save heat and flow. The consumer can also contact companies and ask for a visit of an expert.

Many of the old concrete ducts are still in operation many years after they have been paid back and they are only replaced with pre-insulated pipes when non-profitable. A strategy is developed (see *News from DBDH* 4 1995, page 22, Rehabilitation of district heating pipe network in Odense) for replacement of pipes, taking into account investments, heat losses, costs of repair, water losses and the inconvenience of disruptions.

The water loss of around 180 m^3/km pipe/year is high compared to Danish conditions, but still very low compared to water losses in Eastern Europe and NIS. It should, however, be taken into account that the make-up water is produced efficiently at a high quality at the CHP plant and that it replaces the losses in all consumer installations, thereby preventing internal corrosion of these installations.

There is a risk that radiators could burst and water could leak into the buildings, due to the direct system. However, experience shows that this happens very rarely (once in every 10 years) and the costs of the damage are far lower than the savings. This low risk is mainly due to 3 factors:
water quality.

The success and the low heat price are not a pretext for the company for doing nothing. New possibilities for saving costs are analysed and implemented. A fresh example is our decision to remove the heat exchangers between a 25 bar transmission line measuring 15 km and the distribution system in the neighbouring towns Munkebo and Kerteminde, which are supplied from the system. The decision was made on the basis of detailed water hammering analysis with a computer simulation system called SYSTEM RORNET, and various measures have been implemented on the basis of the analysis to prevent water hammering, including 5 m^3 air vessels.

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