

# Maximal utilisation of the market forces in the heat sector



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One of the hot issues in the energy sector, in Denmark as well as abroad, is the maximal use of the market forces for improving the efficiency and reducing the costs. In the gas and electricity sectors in most countries, a strong regulation is being implemented on that part of the supply that has a natural monopoly, and a total liberalisation of the other activities is also being carried out. But what about the district heating sector? How can the market forces be utilised to make the DH sector more efficient and competitive? We have encountered several very theoretical ideas, which however do not take into account the special characteristics of the DH system and its divergence from the electricity and gas sectors.

During the last 20 years, we have in the Copenhagen region established and operated a district heating system based on a maximal utilisation of the principle of market forces to the benefit of the consumers. Although the situation seems monopolistic (one supplier and one consumer), the established technical system and the tariffs, which have been agreed upon, ensure a daily operation based on the principles of market forces. Company monopolies often result in a technical monopoly situation, where the total costs are not minimised. Therefore our experience and the lessons we have learned could be a model for other large district heating systems. The district heating network is a very strong natural monopoly, which needs to be regulated in order to ensure efficiency and the lowest possible prices. At the same time, however, a modern district heating network operated with variable flow is a precondition for the maximal competition and use of the market forces in the heating sector in any city. In bigger integrated district heating systems all heat sources can compete, but the

competition will only be to the benefit of the consumers if these are united as a single buyer.

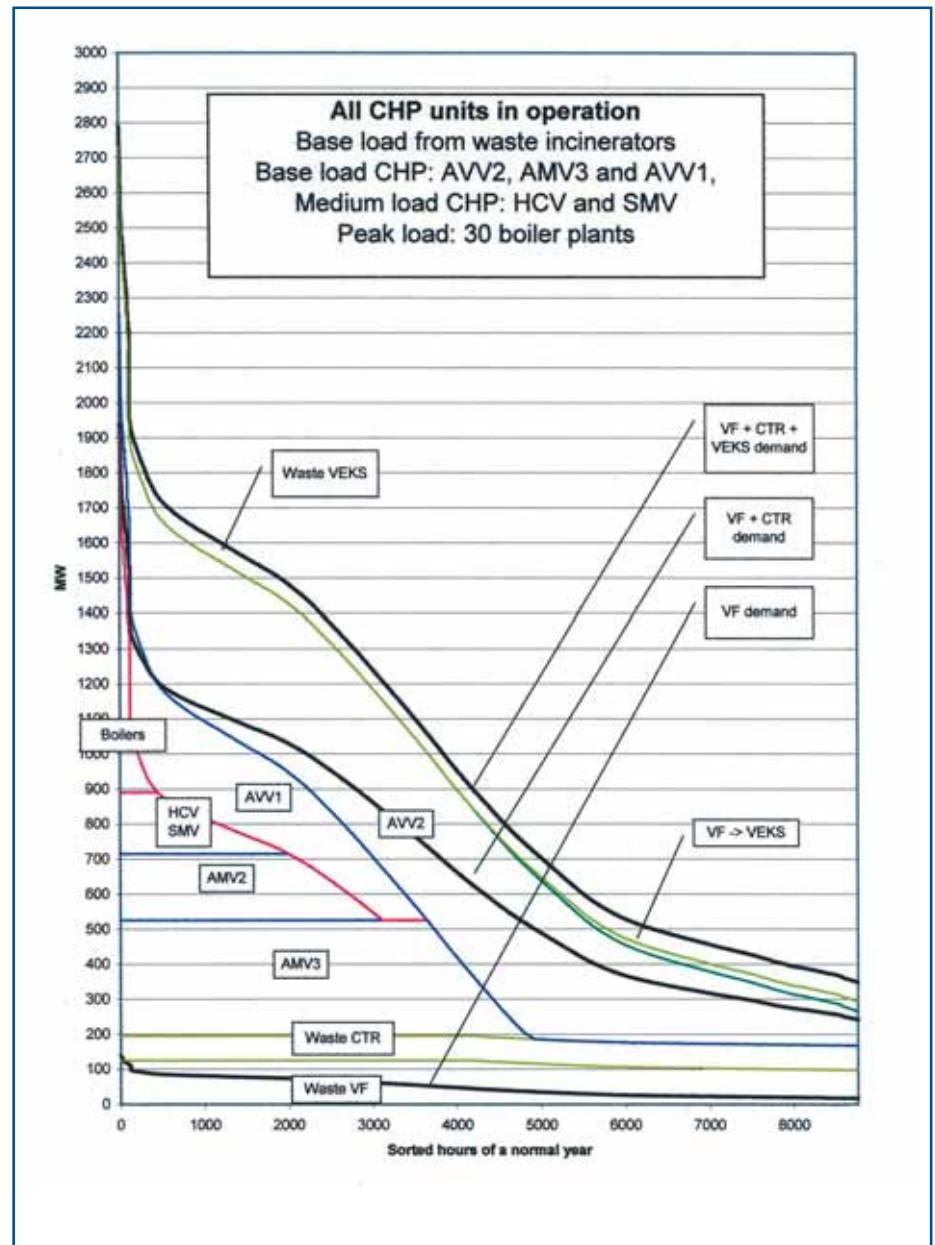
## The technical side of the Copenhagen DH system

Twenty years ago, the DH supply in the Copenhagen region was divided into more than 20 individual distribution systems mainly heated by heat-only oil-fired boilers. The cheapest and most efficient heat sources (such as surplus heat and heat from CHP plants) could only supply a minor local part of the total system, due to the lack of connecting pipes. When new CHP units were to be constructed in

the region, it was decided to establish a bigger interconnecting transmission system, opening for a situation with "competition" between the various producers of heat.

Today all the distribution networks and all heat production plants in the region are integrated in the most economical way. This integration is mainly achieved through the heat transmission system, but also by transferring capacity and flexibility of some of the main distribution systems. The main data of the integrated DH system with optimal load dispatch are as follows:

Load dispatch of the heat production.



- 155 km heat transmission system with 5 main booster pump stations
- 75 heat exchanger stations from transmission to distribution, in total 2,200 MW
- 265 MW from 4 waste incinerators (3 with CHP)
- 1,040 MW from 4 coal-fired CHP extraction units
- 540 MW heat supply capacity from 1 gas/biomass-fired CHP extraction unit including 2 integrated gas turbines
- up to 175 MW surplus capacity from 2 gas-fired back-pressure CHP plants, which mainly supply the old steam system in the city center
- 44,000 m<sup>3</sup> heat accumulator (one more under construction)
- 20 distribution systems
- 50 million m<sup>2</sup> of heated floor
- 26,000 TJ of annual heat production (27% from waste incineration, 72% from CHP units and 1% from heat-only boilers)

It is important to notice that all district heating networks are operated with variable flow. The heat supply to each building substation is regulated by the demand of the consumer, and the hydraulic conditions (direction of the flow and differential pressure) in the network can therefore shift, depending on the direction from which the heat is produced. We might say that the variable flow system is a precondition for competition between the connected heat production plants in the network. This differs significantly from the constant flow system that we see in the former centrally planned economies, where one production plant technically had a monopoly of the production to the whole network. In other words, the DH system with variable flow opens for competition between all types of heat sources and fuels available in the geographic area of the network. On the other hand, establishing an integrated transmission system is only practically possible in a regulated market, due to the big investments and the long-term economical aspects.

Looking back on the 20 years of operation of the entire DH system in the Copenhagen region, we can conclude that the competition principle has been a driving force of the system:

- The heat has been produced in the most optimal way hour by hour, year by year, giving first priority to production plants with the lowest variable production costs. Under normal operation, a heat-only boiler will not start operation until all the more competitive CHP units are fully utilised.
- The heat capacity from a production plant has only been utilised if it has been competitive in the longer term,

taking into account all fixed and variable costs of the production as well as the costs of interconnection to the network.

- The optimisation of the production from the CHP plants has taken into account the response of the power system, e.g. by closing some of the CHP units in periods with cheap hydropower and switching to back pressure production in periods with high prices on power.
- The DH distribution systems supply almost every building in each DH district. New districts are only being supplied with DH and connected to the system if, in the longer term, the DH price has proven to be competitive compared to alternative supply of individual natural gas boilers.
- The various service activities, such as special maintenance, consultancy services, supply of equipment and loans to finance investments have, in general, taken place on the basis of a large degree of competition, taking into account the interest of the owners (the municipalities) and the consumers.

#### **The organisation of the overall heat market in the Copenhagen DH system**

A special feature is that the totally integrated DH system in the Copenhagen region is split on many organisations. The transmission system is operated by 2 heat transmission companies, CTR and VEKS, owned by the municipalities they supply, and the distribution systems are operated by 20 distribution companies owned by the consumers or the municipalities.

CTR and VEKS, each having a control and monitoring center, staffed all 24 hours, co-operate to purchase the heat to all the consumers as cheap as possible hour by hour. Consequently CTR and VEKS have the monopoly in providing the heat from all available plants (including their own) in their regions and to sell it to all distribution companies at pool price. We might say that the companies act on the heat production market and in the region for supply of fuels as one single buyer acting on behalf and to equal benefit of all consumers. Only in this way can the market forces be utilised to the maximal benefit of all the consumers as a whole.

The company structure where the ownership of the transmissions companies lies at the municipalities, combined with the regulatory setup, secures the transfer of the entire profit from the operation of the companies to the consumers paying for the heat.

The power utility Energy E2 is the owner of all CHP plants in the region. CTR and VEKS co-operate with Energy E2 to optimise the load dispatch between the CHP plants, taking into account the situ-

ation in the electricity market. The heat price basically equals the real production cost of heat production compared to power-only production (plus an additional benefit to the power company after a 12 year pay-back period of the transmission system). In periods with low electricity prices, CTR and VEKS pay an additional fee to compensate for possible losses that arise due to Energy E2 operating the CHP plant.

On one hand, special tariffs agreements with the waste incineration plants make sure that the surplus heat (according to regulations household waste has to be incinerated) is always utilised, and, on the other hand, that the heat price never exceed the price of the alternative heat production.

As regards the total capacity from all production plants, CTR and VEKS collaborate to utilise the available production plants in the region whenever these are competitive and suitable for spare capacity and peak capacity.

As regards the heat sale to buildings, the distribution companies propose projects to supply new districts, mainly urban development areas, and have to demonstrate that district heating is more competitive than individual natural gas boilers. The municipalities have an obligation to initiate such projects, and the authority is obliged to approve or reject project proposals in accordance with the heat supply law under the supervision of the Danish Energy Authority. In this way, there is a fair competition between district heating networks and natural gas networks in the planning stage. Once a DH project is approved for being the most competitive, the district heating company will have the monopoly of supplying heat for at least the project's life time, and normally all buildings will be connected.

#### **CTR acting on the market**

CTR is responsible for the heat supply in the central part of the system, corresponding to approximately 60% of the total heat production. Besides collaborating with VEKS, the power utility company Energy E2 and the municipalities, CTR acts as an independent company, serving the objectives set out by the 5 municipalities that own CTR, namely to provide a reliable heat supply in an environmentally friendly way and at **the lowest possible costs** to the distribution systems in the 5 municipalities.

To meet the objectives, CTR utilises the market forces whenever this is an advantage:

- In the long-term development planning, CTR simulates the heat supply and costs 15-20 years ahead and analyses the most competitive alternatives for improving the system, for

a new base load capacity and for a new peak and spare capacity. The result of long-term planning may be a long-term contract with a heat producer or it may be an investment project for CTR, e.g. a new peak load boiler plant.

- In the shorter term, CTR establishes daily production plans in collaboration with VEKS and Energy E2 in order to guide the control centers in operating the most competitive heat production.
- The control center is in operation and staffed 24 hours a day, and the heat is dispatched in the most economical way. The operation takes place 100% automatically with no manual interaction. Operation staff is only necessary in case of mechanical failure.
- All investment projects and supplies have been executed in open tender, mainly as individual contracts of supply, works and special services in order to maximise the competition and lower the costs.
- CTR is a slim organisation of 24 employees, including 8 engineers in the control center, only dealing with the core business of operating the transmission and the pool operation. All other services are outsourced to private or public companies, using the market forces in the interest of the owners and consumers.
- All loan agreements are based on strong competition on the international market. In fact, all the 350 million USD investments of CTR have been financed by the most favourable international credits. Apart from a

good tender, the precondition was that the project be feasible, that the consumers pay and that the municipalities guarantee with all their assets.

Naturally CTR focuses very much on how to improve the efficiency and to cut down prices on the supply of heat, by analysing the costs, e.g. by using benchmarking key figures and other statistical data. The market forces are recognised to be one of the important mechanisms in lowering the costs of heat production and services.

The way of using market forces for providing the cheapest capacity and heat can be illustrated by the following case:

The Carlsberg Breweries' old production plant is situated close to one of the distribution systems. In the beginning, this distribution system was supplied by only one heat exchanger and could therefore use a local peak and spare boiler thanks to the development of the distribution system. Also CTR needed to invest in new peak boiler capacity to meet the increasing demand, as all options for renting existing boiler capacity in the region had been utilised. Carlsberg had a 20 MW boiler capacity available and a surplus of free steam, which had to be condensed and cleaned for environmental reasons. A long-term evaluation showed that it would be profitable to interconnect Carlsberg to the network, and the parties agreed that:

- The local distribution company would invest in the connection pipes, mak-

ing it possible to connect new consumers situated between the existing network and the brewery.

- CTR would rent the 20 MW boiler capacity.
- CTR would pay all variable costs of heat ordered from the boiler plant.
- CTR would purchase all excess heat from the process at a low competitive price.
- Carlsberg would invest in a heat exchanger and the necessary installations on the primary site.
- CTR would invest in necessary installations on the secondary site such as pumps, heat meters etc.

The savings compared to the alternative of investing in additional boiler capacity and in buying the heat at the second cheapest plant could easily pay back the investment in the pipe connection, thereby reducing the heat price for CTR. Also for Carlsberg Breweries this was a profitable agreement as the project solved an environmental problem and as the revenues could pay back their investments.

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*The district heating system in the Copenhagen region.*

