Bioenergy for district

Today, almost 120 district heating plants in Denmark are straw- or wood chip-fired, and a further 35 relatively old coal-fired heating plants have replaced the coals with wood pellets. Straw used to be the favourite fuel, but nowadays an increasing number of plants choose to use wood chips. In Denmark there is a tendency for biomass-fired heating plants to become smaller and smaller, as the market for large plants has nearly been saturated. The latest invention is the so-called neighbour heating plant, where farmers or major institutions supply heat to their neighbours.

By Morten Tony Hansen

In Denmark more than 50 per cent of the demand for heating is met by district heating. Approx. 70 per cent of the district heating is produced at combined heat and power plants, and in addition a large number of smaller plants produce heat only.

The Danish Centre for Biomass Technology has recently summed up the number of biomass-fired district heating plants put into operation in Denmark between 1980 and 1999. In total, 119 biomass-fired plants have been commissioned, including 65 straw-fired plants and 54 chip-fired plants. Today, the number of biomass-fired heating plants is actually slightly lower, i.a. because several plants have been converted into combined heat and power plants.

Most of the straw-fired plants were commissioned in the last half of the 1980's (see figure 6). Throughout the 1990's, activities within the straw area have been considerably lower, at just under two plants per year on average, especially by the end of the period. The increase in the number of wood chip-fired plants has been more evenly distributed over the period, but there was increased activity in the mid-1980s and the first half of the 1990s.

70 of the 119 commissioned district heating plants have been converted from a different fuel to straw or chips (see figure 7). The remaining 49 plants have been new plants built on a green field site, i.e. plants at towns where there has not previously been a district heating network.

The share of new plants and converted plants clearly shows that conversions have taken place during the 1980's, whereas an increasing number of new plants have been commissioned between the mid-1980's and the mid-1990's. In the last half of the 1990's practically all plants commissioned were new plants. Since 1992 there has been no conversion of district heating plants into straw-fired plants, whereas several plants have been converted into wood chip-fired plants.

Smaller plants

The new plants are typically much smaller than converted plants. As regards wood chip-fired plants, the average new plant size is about 2 MW, whereas the converted plants are more than twice as large. As regards straw- fired plants, the difference is slightly smaller with new projects at an average of approx. 3 MW and converted plants at about 5 MW.

However, the trend is ever-smaller plants. On average, new plants from the 1990's are only half as large as new plants from the 1980s.

Reasons

The increasing focus on biofuel at district heating plants in the beginning of the 1980's was due to the heavy increase in fossil fuel prices after the second oil crisis in 1979. Later in the 1980's the Danish government introduced taxes on fossil fuel, and this helped sustain the interest in biomass-fired heating plants.

The market was developed on the basis of a large number of oil- and coal-fired heating plants with established district heating networks. Investment in a central boiler station alone could convert these plants into straw- and wood-fired plants. As this market was filled, new district heating networks were increasingly built in connection with the central boiler station.

From straw to wood chips

The price difference between straw and wood chip has been decisive in the choice of fuel. For a long time the price for straw-based heating was approx. DKK 30/GJ, whereas the corresponding price for wood chips was typically DKK 45/GJ. It was only natural to choose straw.

However, the market for wood chip-firing has been favoured in various ways. The technological development introducing flue gas condensation resulted in improved exploitation of the fuel, and at the same time the wood chip price declined; partly due to more efficient forestry, and partly due to the crisis in the cellulose industry in 1991.

Apparently, the 1989 legislation prohibiting the burning of straw in the fields has not had any significant influence on the choice of fuel at the district heating plants.

Wood pellets

The situation concerning wood pellet-fired heating plants is special, and consequently they have not been included in this assessment. These plants, approx. 35 in total, switched from coal to wood pellets in the beginning of the 1990's. The switch was made over a very short time span as a result of a coal tax increase. In the majority of cases the switch was merely a minor conversion of the boiler system. There have been practically no new projects using wood pellets as fuel.

The future

In Denmark the market for conversion of heating plants into biomass-fired plants has nearly reached saturation.

In the future we will mainly see conversion into biomass-fired combined heat and power (CHP) plants. Some biomass-fired heating plants will start producing electricity as well as heat, and in addition there will probably be a number of natural gas-fired CHP plants that will convert to biomass. Today there are already several viable solutions based on steam turbines and gasification plants, but the technology required to exploit this market is still being developed.

As regards new plants, only small towns are left by now, so the main development is expected to be based on so-called neighbour heating plants, i.e. plants where farmers or major institutions supply heating to their neighbours.

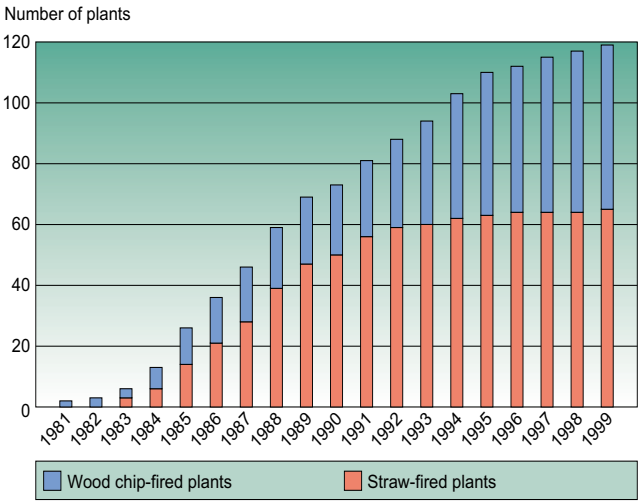

Figure 6: The development in straw- and wood chip-fired district heating plants in Denmark between 1981 and 2000.

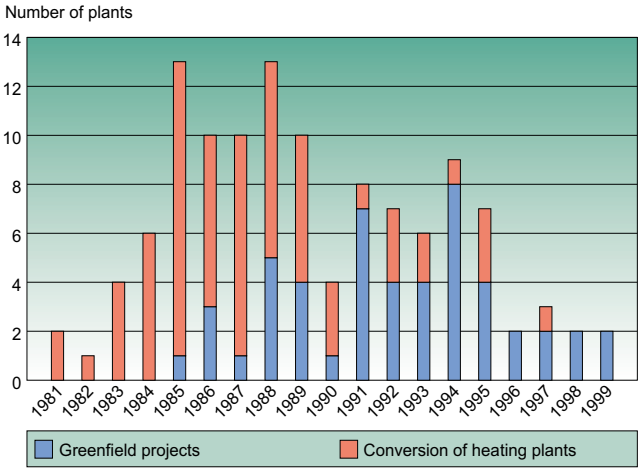

Figure 7: The share of new projects and conversion of heating plants between 1981 and 2000.

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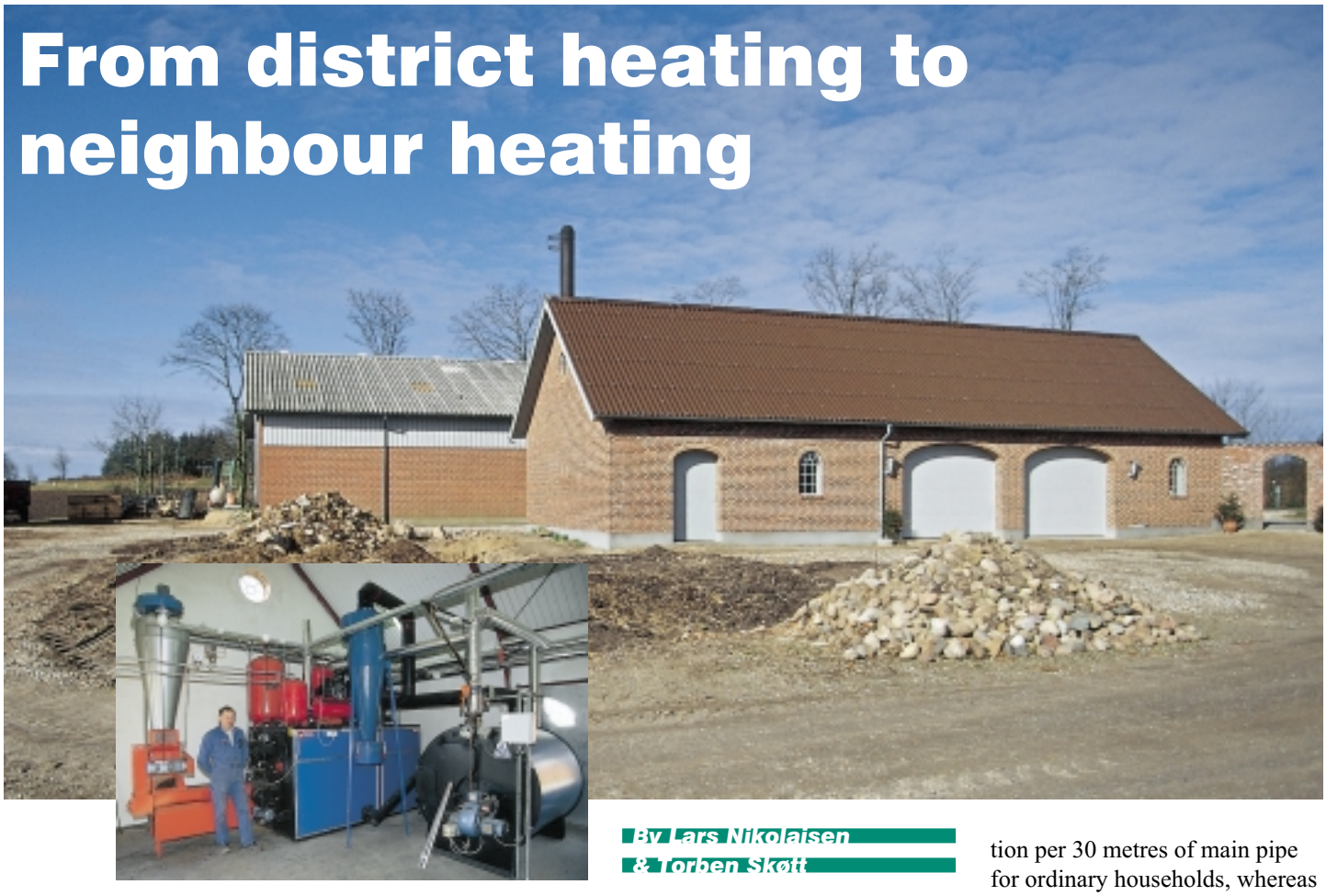
From district heating to neighbour heating



Frede Nielsen from Hårup near the town of Brædstrup is one of many farmers who have chosen to invest in an extra large straw-fired boiler, supplying his neighbours with heat and making use of a large amount of his 300 tonnes of straw per year.

In Denmark the market for district heating plants has nearly been saturated. By now, only the very small towns have not been covered, and in this case conventional district heating plants are a costly solution. Instead, a market is emerging for so-called neighbour heating - a scheme where farmers invest in a larger straw-fired boiler than they need and sell the surplus heat to their neighbours. In some cases this can reduce the cost of a heating plant by 50 per cent.

By Lars Nikolaisen & Torben Skøtt

A neighbour heating plant is a farm- or institution-based boiler that supplies heat to the farm itself and to one or more neighbours. The system consists of a biomass-fired central heating boiler and a district heating network that distributes the heat to the neighbours.

The biofuel boiler is dimensioned to supply 70-80 per cent of the heat required for the coldest winter period. This ensures optimum heating economy in the winter as well as in the summer, when the only heat production required is for hot water supply and compensation for network loss. During the coldest part of the winter this system is complemented by an oil-fired spare boiler, which also supplies heat in case of biomass boiler production interruption.

To ensure a sufficient sale of heat in relation to the size of the pipe network, the households connected must be located relatively close to each other. On average there must be one connection per 30 metres of main pipe for ordinary households, whereas a slightly longer distance is acceptable in case of major consumers.

In this scheme the lower value of the heat sale is 600 MWh/km main pipe. In comparison, the energy density in existing towns with district heating and 175-300 households amounts to 900 - 2,000 MWh/km main pipe.

What are the costs?

Table 1 shows a number of estimates of the initial costs of straw-fired plants. However, they should only be regarded as indicative, as individual projects may vary considerably. The costs will normally be lower for wood chip-fired plants and even lower for wood pellet-fired plants.

In order for people to find it attractive to participate in a neighbour heating project it is vital that their heating costs decline or at least remain the same compared to oil-based supply. Therefore, it is very important that the preliminary calculations are exact

enough to ensure that budgets are met. Finally, the price should always be paid at a rate that reflects the plant's actual fixed/variable cost ratio.

Farmer supplies heat

Some years ago, the local authorities tried to implement a district heating project amounting to just over DKK 10m in the village of Sdr. Nissum close to the North Sea. This was a tall order for a town with only 130 households, and eventually the entire project was abandoned.

Today the local primary school, sports centre, rest home and 70 of the households are supplied with heat from a straw-fired heating plant. However, the supplier is not the local authorities but one of the farmers in the area, Mr Henry Toft, who was born in Sdr. Nissum and runs a large farm just outside the town.

"Originally we only planned to supply heat to the school, the sports centre and the rest home", says Henry Toft. "We didn't believe that the private households were interested, but as news about our agreement with the local authorities spread, we were approached by a number of people who would like to participate in the project. In a matter of weeks, 56 households had signed up, and today the number is 70".

In the mid-1990's, Henry Toft sold his cattle and focused entirely on crop production. With 430 hectares of land he has a considerable amount of straw at his disposal, and it has been very hard to sell it at a reasonable price.

Straw-based heating at half the price

Farmer Henry Toft from the village of Sdr. Nissum has built a straw-fired heating plant at half the cost of a conventional district heating plant.

Today, Henry Toft takes 600-700 large bales per year for the heating plant, so the amount of straw to be ploughed in is very limited. In the future this amount will probably decrease even more, as several electrically heated households in the town have now also shown an interest in being connected to the straw-fired heating system.

Neighbour heating at half price

Henry Toft's straw-fired heating plant has cost DKK 5.5m, including the grid and the individual consumers' heating installations. Costs have almost been halved compared to the project abandoned by the local authorities.

The Danish Energy Agency has provided a grant of approx. DKK 1.3m, and the rest has been financed through a 10-year loan from the local bank.

The price for district heating has been calculated to offer consumers typical savings of DKK 1 - 2,000 per year by replacing oil-based heating with straw-based heating. The price is tied to an oil price of DKK 4.20 per litre with a max. fluctuation of 10 per cent to either side. In addition, the individual consumers have paid a token amount of DKK 600 to be connected to the heating plant.

Henry Toft believes that there are may reasons why the project has become so profitable.

"We were offered a good price from Lin-Ka Energy - the main contractor on the project. We have spent no money on consulting and building inspection, and compared to a normal district heating project our facilities are relatively modest, as they consist of a straw barn with an integrated central boiler station. As there are no employees, we have no need for toilets, shower facilities, canteen or office". The whole business is run from the farm house, where Henry Toft's wife, Birtha, keeps the accounts.

Henry Toft spends between 30 minutes and one hour a day operating the plant. Most of this time is spent moving straw bales onto a straw conveyor. The straw is automatically transported to a shredder and into the boiler.

Plant size	100 kW	200 kW	400 kW	800 kW
Price, boiler plant	DKK 200,000	DKK 300,000	DKK 400,000	DKK 900,000
Price, boiler house	DKK 70,000	DKK 70,000	DKK 90,000	DKK 120,000
Price, straw storage facilities	DKK 1.000 - 1.100/m^2			
Price, main pipeline	DKK 1.000 - 1.200 kr./*metre*			
Price, service pipe	DKK 10.000 - 15.000 kr./*consumer*			
Price,household installation	DKK 10.000 - 15.000 kr./*consumer*			

Table 1: Typical initial costs of a straw-fired neighbour heating plant.

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