The International
District Energy
Climate
Awards 2011

# District heating system - Nyborg, Denmark

**The system:**

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|---|---|
| Company name: | Nyborg Forsyning & Service A/S |
| System: | District heating |
| Location: | Nyborg, Denmark |
| Owner: | Nyborg Forsyning & Service A/S |

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**Executive Summary**

The town of Nyborg is a middlesized Danish provincial town located at the island of "Fuen", with a population of approximately 17,000.

For years the local multi utility company *"Nyborg Forsyning & Service A/S",* colloquially named *"NFS A/S",* has supplied the town of Nyborg with $CO_2$-neutal district heating.

*"NFS A/S"* serves approximately 7,700 district heating customers in the town of Nyborg and a small neighbouring town, named Ullerslev, in an area of 9,072 square kilometres. Annually 200,392 MWh is distributed through 202 kilometres of pipes.

From the establishment of the district heating system in 1964, the planning has been farsighted and today the community as well as the environment benefits from it.

Through decades the system has kept up with the growth of the community, managed to adjust the challenges of the global energy crises in the seventies and has during ongoing maintaining served the consumers with an economic and reliable heat supply.

For more than 35 years development of the district heating system has focused on increasing harnessing of surplus heat in the production of district heating, with a successful result.

Through a well establish co-operation between *"NFS A/S"* and two chemical plants located in the town of Nyborg, the district heating supply takes off the surplus of waste heat produced on the plants - enough to supply 87% of these provincial towns.

*"NFS A/S"* stands out from many of the district heating suppliers in Denmark, in recycling this amount of surplus heat from industrial companies.

**Contents**

**The history of district heating in the municipality of Nyborg**

On the first of October 1964 the heating supply of the town of Nyborg entered a new era, as the first boiler on a brand new district heating plant was lit.

During the next decade a number of district heating plants were established and the distribution network was extended to keep abreast with the growth of new neighbourhoods.

One plant established was built in combination with a new incineration plant to channel the surplus heat from the burn off energy into district heating. A constructive way to counter the increasing waste problem in the industrialized society. The plant was operated for 26 years before it was shut down in the early nineties for environmentally and economical reasons.

The global energy crises in the seventies gave occasion to rethinking, how to supply the heating plants with fuel. An alternative to mineral oil was needed. The experiences with surplus heat made the municipality of Nyborg pay attention to the new establish and rapidly expanding chemical plant, named *"Kommunekemi a/s"*.

Negotiations with the company about a long-term solution of providing heating for the town began and turned out positive. Soon a heating plant was set up at the location of the chemical plant, to purchase the surplus energy produced, when disposing of the chemical waste. The future main energy source in the district heating supply was found and the co-operation has been fruitful for everyone.

Since another chemical company, named *"Koppers Denmark A/S"*, has been added as supplier of surplus heat, as well as the local purifying plant is providing surplus heat when buring off biogas produced in the digesting tank.

Today 87% of the energy used to supply the town of Nyborg and a small neighbouring town with district heating, comes from surplus heat. Only an insignificant quantity of heat is produced on the boilers of the heating plants.

From the very beginning the municipality had worked out masterplans for the district heating supply and in this way formed the basis for developing the distribution of district heating.

Until 2001 the district heating supply was managed by the municipality of Nyborg. To counter the legislation for distributors of energy the existing departments for district heating, water and refuse disposal was evolved into a multi utility company and named *"Nyborg Forsyning & Service A/S"*, colloquially named *"NFS A/S"*.

*"NFS A/S"* was established as a limited company owned by the municipality. In 2007 *"NFS A/S"* took over the district heating in a small neighbouring town due to a new structure of the Danish municipalities.

Today the district heating networks in both towns has been connected by a new transmission line, which opened in November 2009.

## The production units

The district heating system consists of seven heating plants. Six are located in the town of Nyborg and the seventh in a small neighbouring town, named Ullerslev.

In practice two of the plants work as heat exchangers for the surplus heat, which is regained from two chemical plants in the town of Nyborg. The rest of the heating plants are supporting the production of district heating when needed.

The total rated effect of the boiler capacity is 95.2 MW, which makes each boiler produce an average of 15.9 MW. Altogether this is enough to produce district heating for the entire area supplied. Despite the boiler capacity, only a part is used when peak load, as the majority of the district heating is produced on surplus heat. The total annual production of the seven heating plants in 2009 was 222,573 MWh.

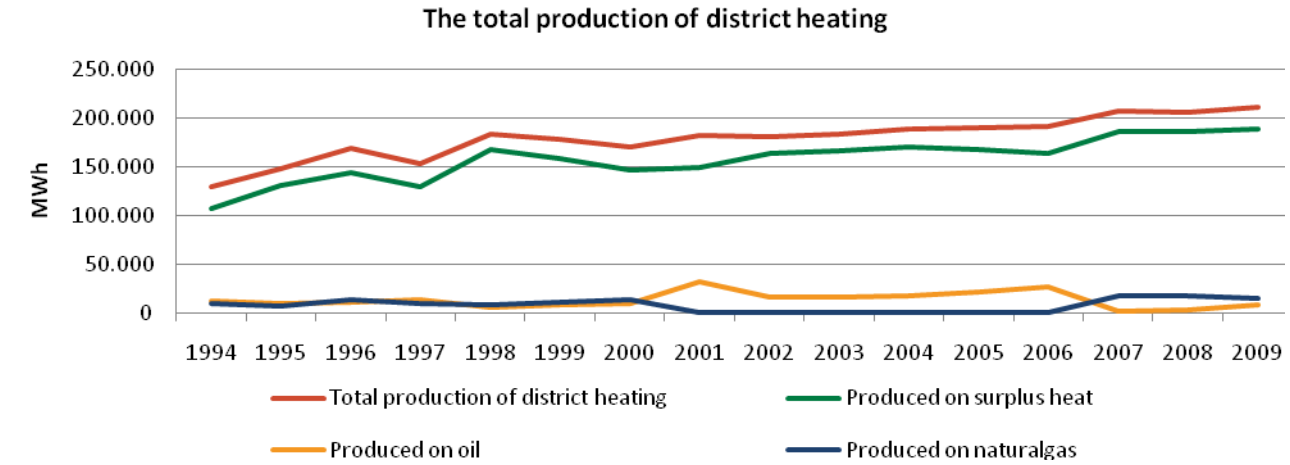



*Fig. 1: The share of district heating produced in the period 1994-2009 divided on energy input. Only a small quantity of heat is produced by the boilers on the heating plants.*

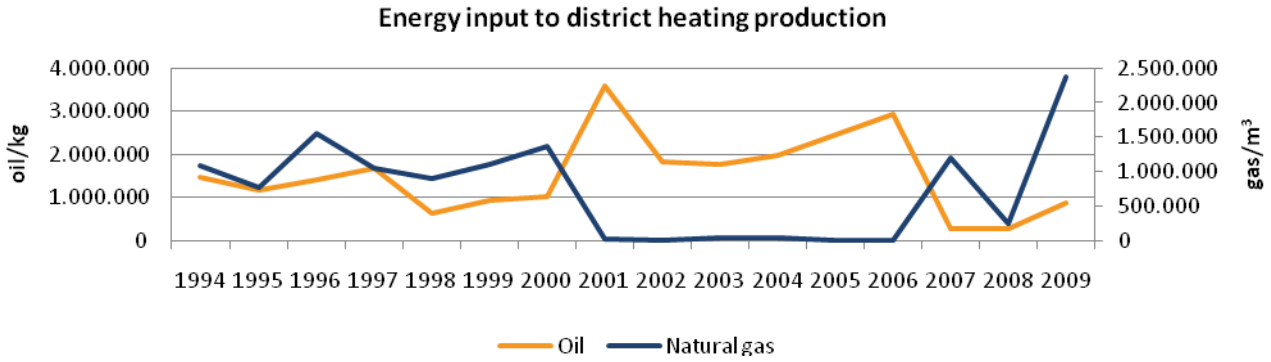



*Fig. 2: The consumption of respectively oil and natural gas in the production of district heating.*

The construction of the five first plants took place in the period 1964-1975. Of these plants, two were build with the purpose to take of surplus heat from respectively the incineration plant and the plant for handling chemical waste.

The plant built in combination with the incineration plant was in use for 26 years before it closed down in 1996. At that time the plant was no longer up-to-date and it was getting harder to comply with the requirements for emissions.

To compensate for the loos of surplus heat from the incineration plant, the first build heating plant was extended to become a combined boost and peak load plant in 1995. With this, it was possible to compensate for the loss of surplus heat from the incineration plant, by taking of a larger quantity of surplus heat from another supplier.

In 1975 a new plant was taken in use. This plant was built at the location of the chemical plant *"Kommunekemi a/s"* and was to become of most importance. Compared to the capacity of today the original equipment was poor.

To begin with the plant was equipped with a boiler and two heat exchangers, each at 5.5 MW, to receive the steam energy from the incineration at the chemical plant. During the following decades the plant was undergoing several changes.

The first time in 1982, then a 10 MW heat exchanger was added. In 1986 the purchase of surplus heat was increased and a counter pressure steam turbine with 4 MW was fitted in with a condenser, which is able to deliver 20 MW district heating. At the same time the pump capacity for circulation the water in the distribution network was increased to 650 $m^3$/h and a water treatment installation as well as a hydrophore were installed.

In 1990 the purchase of surplus heat was increased again and the original 5.5 MW heat exchangers were replaced with two 12 MW. Because of the heavy operating strain these heat exchangers only lasted for 6 years. In general the use of steam in the heat exchangers has been challenging and it has been difficult to find a suitable material to stand the wear.

A replacement at the plant in 1996 coincided with the planning of a new gas turbine at *"Kommunekemi a/s"* for providing the heating plant with more steam energy. To counter this, an extensive rebuilding of the heating plant was necessary. The capacity of the new heat exchangers was doubled and a new 200 KW/1000 $m^3$/h transfer pump was fitted in and the general size of pipes were increased.

During the years a lot of efforts have been put into this heating plant. Of all the challenges met in maintaining the district heating system, the greatest has been to harness the steam energy coming from *"Kommunekemi a/s"* into district heating.

The basis in the production of district heating is always to use the available surplus heat before starting up the boilers.

This is not without complications, as the production on *"Kommunekemi a/s"* is not proportional to the customers demand for heat. Therefore it requires a lot of optimizing on a daily basis to meet the demand. Another challenge is to obtain the right temperature, because the energy received to the heating plant, comes as steam. The ideal situation would be receiving the energy as hot water, which suit perfectly for heat exchangers.

In the early nineties another supplier of surplus heat appeared, when the purifying plant in the town of Nyborg was changed from being mechanical to biological. The heat from burning off the biogas, produced in the digesting tank on the purifying plant, was channelled into the nearby heating plant on the locating of *"Kommunekemi a/s"* and used for district heating.

In 2005 the transmission pipes for channelling heat to the district heating system was renovated. The efficiency was improved and by 2009 the purifying plant delivered 1.696 MW, which is twice the quantity as in the start.

The newest heating plant was constructed in 2000 and has been another great success within lowering the use of primary energy and reducing the $CO_2$ emissions.

*"NFS A/S"* had spotted a potential in using the surplus heat from the production at another chemical plant in the town of Nyborg, named *"Koppers Denmark A/S".* The chemical company used major quantities of both water and electricity, when cooling the hot water from the production in a cooling tower. A co-operation between *"Koppers Denmark A/S"* was established on the same principle as the co-operation with *"Kommunekemi a/s"*.

After building a new plant with 3 heat exchangers, the cooling tower was closed down and the surplus heat was harnessed into district heating. The consumption of water and electricity was eliminated, to the benefit of everybody, but mostly the environment.

Compared to the challenging process of harnessing the surplus heat from *"Kommunekemi a/s"*, this project was simple as the surplus heat comes as hot water.

In 2007 the last heating plant came by, then *"NFS A/S"* took over a combined heat and power plant in the neighbouring town of Ullerslev. This plant was establish in the sixties as a heating plant, but was rebuilt in 1983 to become the first gas driven power/heating plant in Denmark. In 1995 the engine was replaced by a new 3.145 MW.

The increase of this plant and the belonging distribution network to the existing district heating system shows in most of the graphs with a rise from 2007.

| Central | Boiler/MW | | | | | | Pump/m3/h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Summer 2008 | | | | | | Summer 2008 | | | | | |
| | Peak | Average | Peak | Average | Peak | Average | Peak | Average | Peak | Average | Peak | Average |
| | APR-JUN | APR-JUN | JUL-SEP | JUL-SEP | APR-SEP | APR-SEP | APR-JUN | APR-JUN | JUL-SEP | JUL-SEP | APR-SEP | APR-SEP |
| No. 1 | 34.96 | 12.33 | 15.19 | 6.37 | 25.08 | 9,35 | 783 | 279 | 381 | 170 | 582 | 225 |
| No. 2 | 0 | 0 | 2.28 | 0.02 | 1.14 | 0.01 | 0 | 0 | 61 | 0 | 31 | 0 |
| No. 3 | 0 | 0 | 0.40 | 0 | 0.2 | 0.00 | 0 | 0 | 32 | 0.06 | 16 | 0 |
| No. 4 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 |
| No. 5 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 |
| No. 6 | 3.47 | 1.42 | 1.75 | 0.87 | 2.61 | 1.15 | 75 | 35 | 46 | 26 | 61 | 31 |
| No. 7 | 3.65 | 2.63 | 4.07 | 2.83 | 3.86 | 2.73 | 83 | 58 | 102 | 65 | 93 | 62 |

| Central | Boiler/MW | | | | | | Pump/m3/h | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Vinter 2008/2009 | | | | | | Vinter 2008/2009 | | | | | |
| | Peak | Average | Peak | Average | Peak | Average | Peak | Average | Peak | Average | Peak | Average |
| | OCT-DEC | OCT-DEC | JAN-MAR | JAN-MAR | OCT-MAR | OCT-MAR | OCT-DEC | OCT-DEC | JAN-MAR | JAN-MAR | OCT-MAR | OCT-MAR |
| No. 1 | 42.69 | 25.28 | 46.24 | 33.6 | 44.47 | 29.44 | 1000 | 658 | 1000 | 772 | 1000 | 715 |
| No. 2 | 7.41 | 0.05 | 6.97 | 0.6 | 7.19 | 0.33 | 239 | 0.33 | 202 | 14 | 221 | 7 |
| No. 3 | 4.33 | 0.04 | 11.18 | 0.49 | 7.76 | 0.27 | 141 | 1.34 | 364 | 16 | 253 | 9 |
| No. 4 | 0 | 0 | 4.45 | 0.22 | 2.23 | 0.11 | 0 | 0 | 129 | 7 | 65 | 4 |
| No. 5 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0 | 0 | 0 | 0 | 0 | 0 |
| No. 6 | 4.22 | 2.56 | 4.7 | 3.4 | 4.46 | 2.98 | 96 | 63 | 107 | 78 | 102 | 71 |
| No. 7 | 3.17 | 2.04 | 2.8 | 1.87 | 2.99 | 1.96 | 86 | 54 | 59 | 43 | 73 | 49 |

*Fig. 3: Key diagram for the capacity of the heating plants. In Denmark the heating season is October to March/April. Central no. 1 is connected to the chemical plant "Kommunekemi a/s" and the purifying plant. Central no. 7 is connected to the other chemical plant "Koppers Denmark A/S" and no. 6 serves the neighbouring town of Ullerslev.*

The district heating system is supervised by the computer system *"SCADA"*, which operates on a basis of reference points placed in the system. Based upon the information coming from these reference points, it is possible to control the heat produced from the heating plants.

The first priority is always to use the surplus heat form the chemical companies and the purifying plant. If needed, boilers can be lit and switched off automatically, so they only are operating when necessary. When regulating this, the boilers which cause least emissions, are lit up first. By using the *"SCADA-system"* $CO_2$ emissions are reduced and the use of energy is optimized.

The *"SCADA-system"* was implemented in 1988. "*NFS A/S"* was the first district heating supplier in Denmark to try out this new technology. The project by implementing the system was financially supported by the EU with 35% of the total cost.

It took 4 years to implement the system. Until 2001 the Sattcontrol-system, were used, but was replaced in 2001 by the iFIX-system. This system has the advantage of being compatible with all PLC´s. An ongoing work in the maintenance of the system is renewal of the PLC´s.

Another ongoing work is to maintain the boilers. To make this simple, a metre has been installed on each boiler with the purpose to identify potential problems in the operation like fouling.

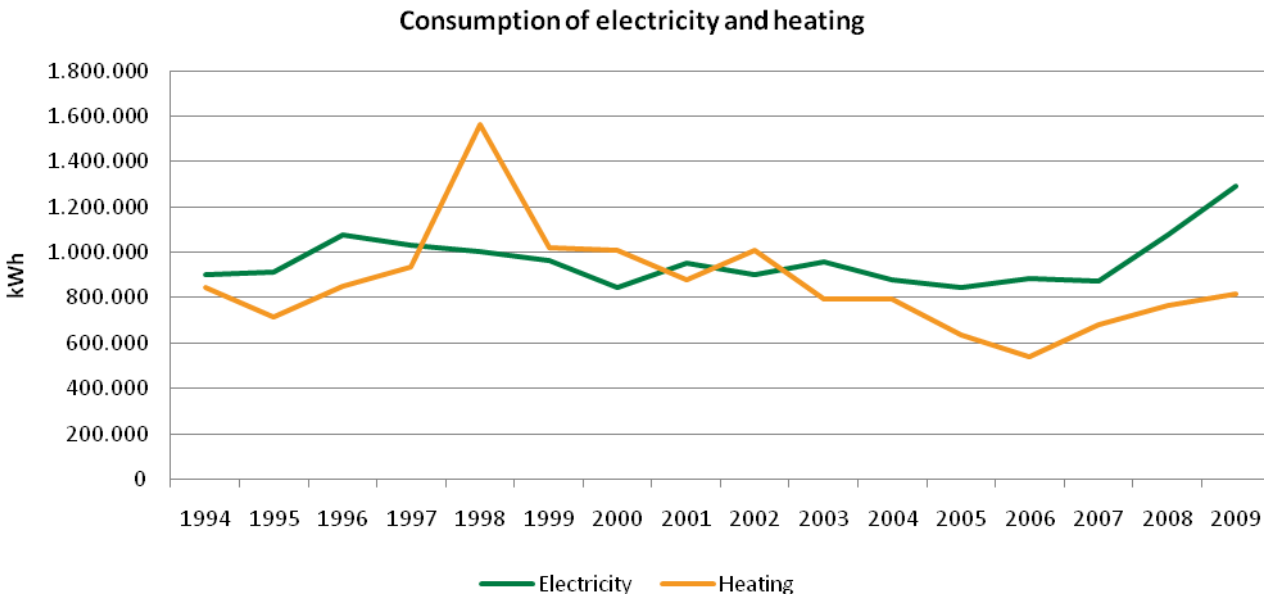
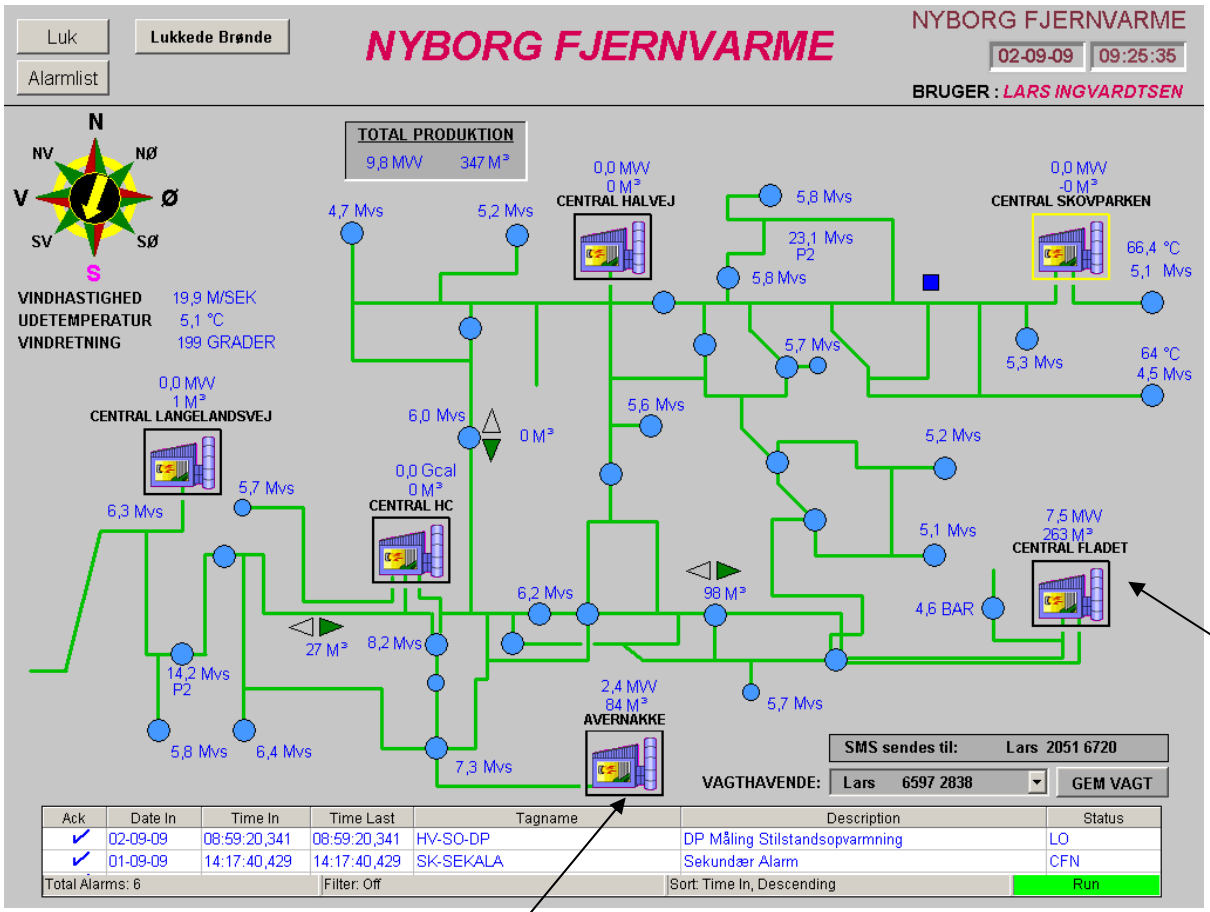



*Fig. 4: The consumption of electricity and heating. The electricity is used for production and distribution of district heating. The heating keeps the oil in the tanks fluid and are used for the boilers too.*




The heating plant connected to *"Koppers DenmarkA/S"*.

The heating plant connected to the purifying plant and *"Kommunekemi A/S"*

*Fig.5: A screen dump from the operation system that supervises the district heating system, illustrates thedistribution network. The blue spots on the pipes are valve wells.*

## The distribution network

The total length of the entire conduit system is approximately 202 kilometres of which approximately 127 kilometres are main lines and the remanding lines are distribution branches. A transmission line between the town of Nyborg and the small neighbouring town of Ullerslev make up 9 kilometres of the total length. Altogether the distribution network covers an area of 9.072 square kilometres.

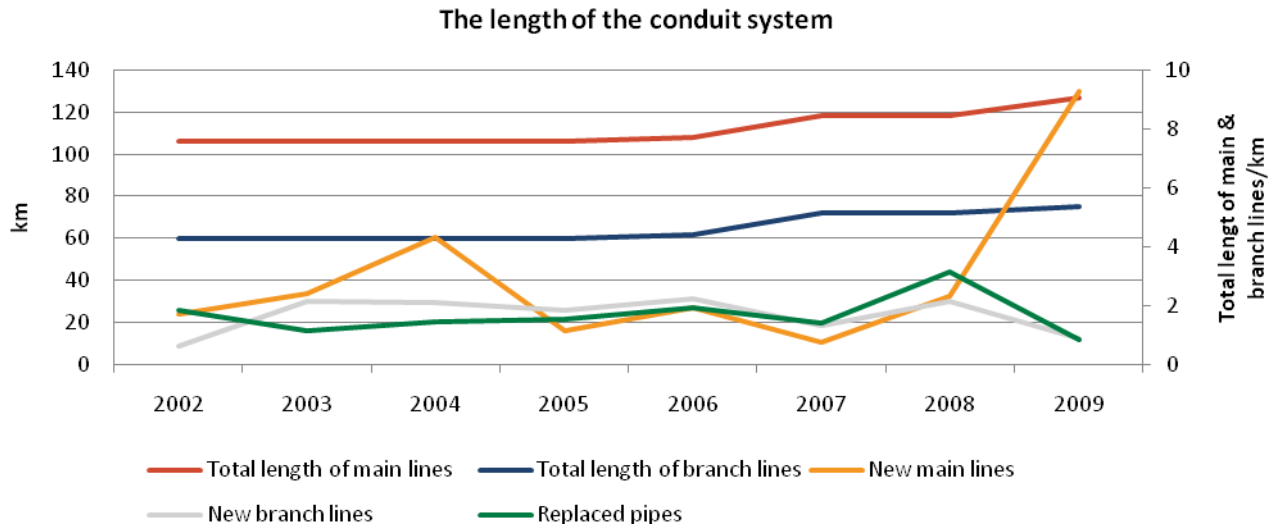



*Fig.6: In the period 1996 to 2009 the total length of the main lines has increased by 20% and the branch lines by 33%.*

To minimize the transmission loss in the conduit system the majority of the original steel pipes fitted in concrete channels and insulated with cell concrete have been replaced by pre-insulated pipes. In the period 1996-2001 the remaining channels were reduced from 5.3 kilometres to less than 1 kilometre. By the end of 2009 only an insignificant numbers were left and within near future they will be replaced.

Pre-insulated pipes have been used since 1970 and from 2006 most pipes used, have been twin-pipes. *"NFS A/S"* was among the first in Denmark to use this type of pipes, with great results.

By changing to new pipes a lower thermal loss has been obtained. Furthermore this has reduces the risk of bursting and with this a waste of water.

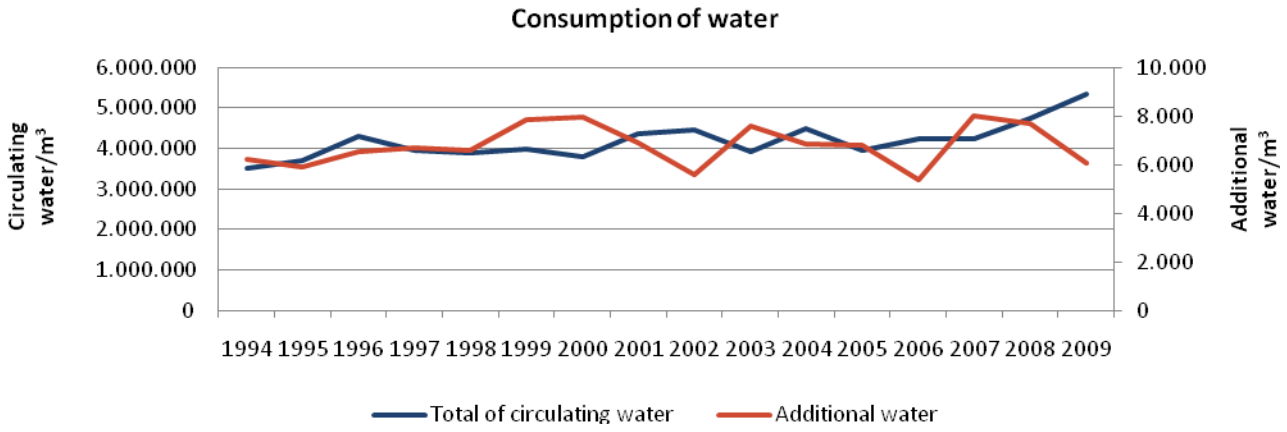



*Fig.7: The rise of the curve for circulating water in 2007 is caused by an extension of the distribution network, when NFS A/S took over the heating supply in the neighbouring town of Ullerslev.*

During the late 1980´s a great work on moving and upgrading the pipes was going on in a considerable part of the town of Nyborg. The occasion was the political decision on starting the

construction work of the third longest suspension bridge in the world. This was the connection between Funen and Zeeland. As finishing the digging in the areas affected by the bridge, the distribution network has been secured for the future developing of the town and the distribution network as well.

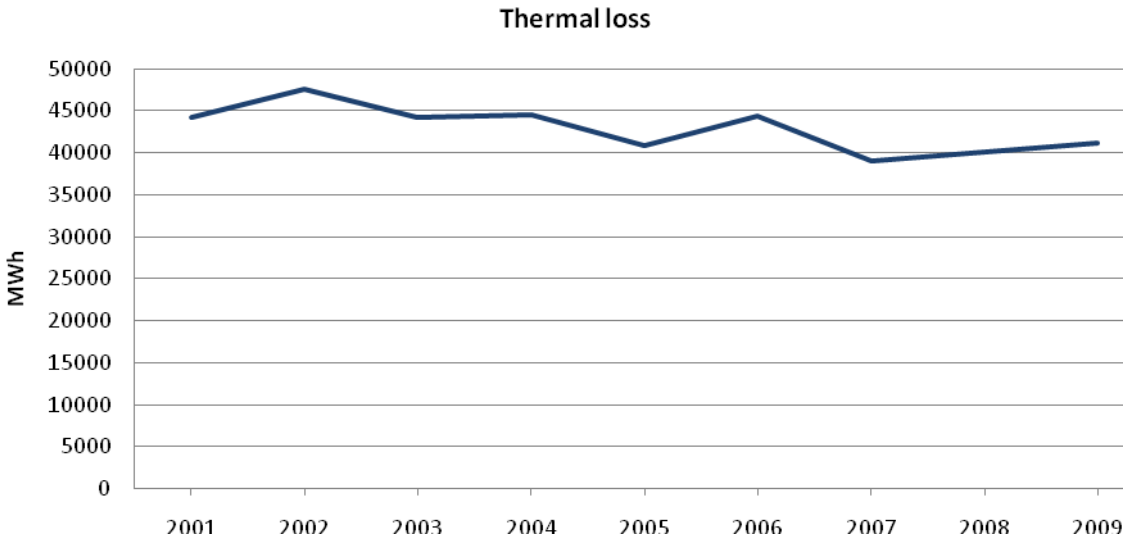



*Fig.8: The graph illustrates the thermal loss in the conduit system for of the town of Nyborg. In the period 2002-2007 a falling tendency shows as the result of the modernization. This despite of an increase of customers.*

The maintenance of the distribution network is a continuous process and as far as it is possible, schemes for the replacements of pipes and insulation of valve wells are worked out. Within the near future the process of insulation on all the valve wells will be finished. An improvement that will give a lower thermal loss and save energy

In order to keep the required static pressure and to help regulating the differential pressure a number of valve wells are placed in the system. The pressure in the distribution network can rise up to 6 bar and the differential pressure is minimum 0.35 bar. The number of wells furthermore makes the distribution system more flexible. This is an advantage when, for instance, a leak on a pipe arises, it is then easy to identify the damaged area and reduce a waste of water.

The temperature of the circulating water led out from the heating plants into the distribution network is 70°-80° Celsius, but can varies, depending on the climatic conditions. During the fall of 2008 and the spring of 2009 an experiment with adjusting the supply-pipe temperature after the temperature at the consumers residences, has been carried out.

The intention with the experiment was to minimize the variation of temperature of the water and to save energy. By reducing the temperature with 10° of the circulation water, more energy has been saved than then renovating pipes in 2009.

**A positive impact on community and environment**

By producing district heating on surplus heat great synergies has been achieved for the environment, the local community and the district heating technology.

The first experiences of using surplus heat from the chemical plant *"Kommunekemi a/s"* attracted a lot of attention within the district heating business.

*"NFS A/S"* has been most obliging in sharing the knowledge achieved in this project, and in this matter the company has participating in leading the way for similar co-operations between industries and district heating suppliers.

The use of surplus heat for producing district heating has saved the environment for major quantities of emissions that would have been led out if burning fossil fuels instead. This has reduced the air pollution in the local community and on a global scale saved oil resources and $CO_2$-emissions.

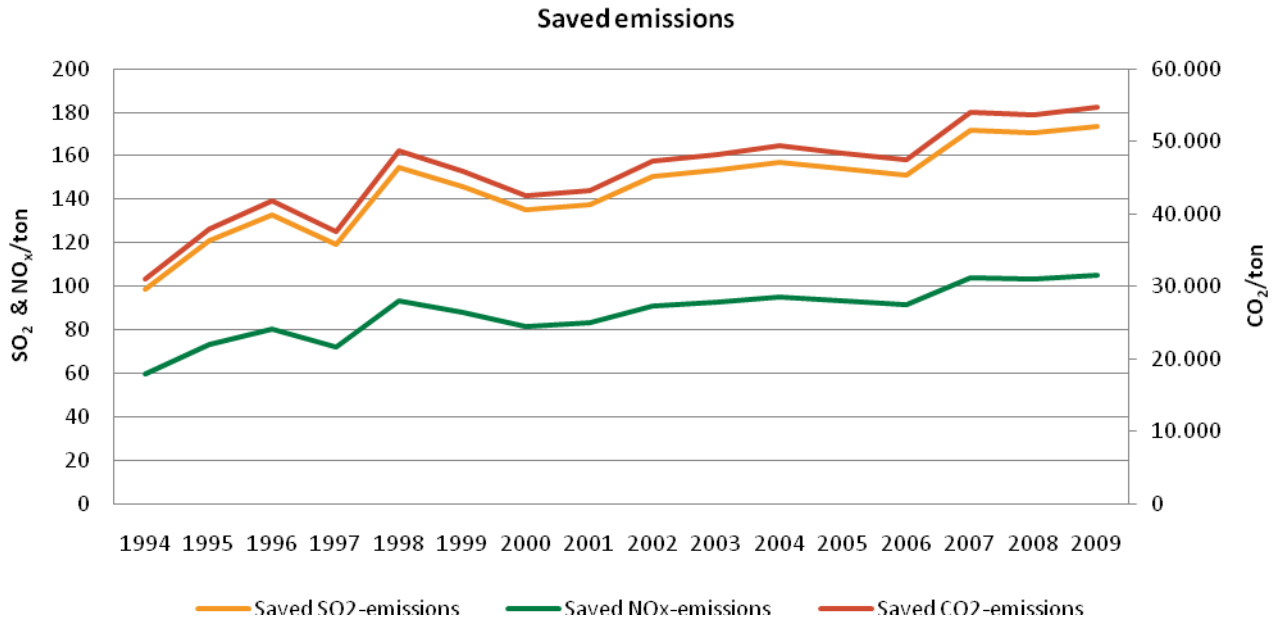



*Fig.9: The quantities of district heating produced on surplus heat have been converted to illustrate the emissions that would have been led out, if it has been produced on oil burning boilers instead.*

With a district heating production that is not depening on the price of oil, the consumers are secured low and steady prices. The favourable prices on district heating has been good for the private customers as well as the business in the town of Nyborg. Several industries with a heavy consumption of energy benefits from this, and in return these industries contribute with local jobs.

It is not only by the direct price of district heating the customers benefit. When heating with district heating expenses for service of own heating systems are avoided.

The maintenance of the district heating system is in general financed by depreciation on the investments.

According to the Danish law of district heating supply depreciations can only be made between 5 and 30 years. The typical period for depreciations made by *"NFS A/S"* is 5 years for investments in technical installations and 30 years for investments in the distribution network.

Along with the ordinary budget for the district heating a separate budget is drawn up for the coming investments. The total for this budget is on average € 3.5 millions per year depending on the work planned for the year to come.

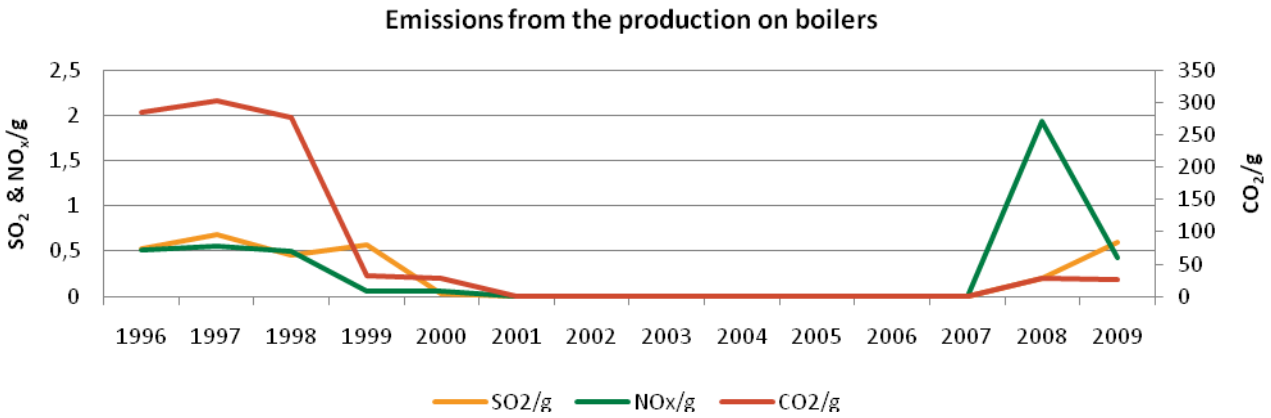



*Fig.10: As the use of surplus heat combined with bio fuels was increased the emissions fell to a minimum.*

What was started 47 years ago by a foresightfull municipality, has developed to become a vital part of the technical system in the municipality of Nyborg.

Today 99% of the total building stock in the town of Nyborg, within the area of the district heating supply, is heated by district heating. The distribution network has during the years been widely renovated, so that the production units are able to harness an increasing share of surplus heat.

Dedicated and visionary employees have put a great effort in developing the district heating system and have successfully been pioneers within the use of new technologies such as twin-pipes and implementing a SCADA-system.

Altogether this makes the district heating system of *"NFS A/S"* outstanding.

## Facts

| | |
|---|---|
| Size of area supplied with district heating: | 9.072 square kilometers |
| Lengthe of distribution network: | 202 kilometres |
| Number of heating plants: | 7 heating plants of these 2 are taking of surplus heat and the rest serves as reserve capacity |
| District heating produced: | 222,573 MWh in 2009 |
| Share of surplus heat: | 87% |
| Heating season: | October to March/April |
| Number of employees: | 60 are occupied in *"NFS A/S"* of these 13 are employed with district heating. |
| Number of district heating customers: | Approximately 7,700 spread on 6.910 meters installed. |
| Total number of customers: | 19.000 |
| Year of establishment: | 1964 |
| Population of Nyborg: | 17,000 |
| Population of Ullerslev: | 3,000 |