DANISH ENERGY AUTHORITY

Heat Supply in Denmark

Who What Where and - Why

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FOREWORD

Very few people are likely to know that there are more than two and a half million domestic heating installations in Denmark. Many of these, almost a half million, are district heating (DH) installations. Today, over 80% of DH is co-produced with electricity. This technology is called co-generated heat and electricity and is one of the most energy efficient and environmentally friendly ways of producing electricity and heat.

If you would like to learn more about heat supply - about the use of fuels for heat generation, about regulations and environmental effects - then this booklet is a good place to start.

The booklet has been written in order to provide readers interested in heat supply with an overview and an understandable description of what heat supply is, how the heat supply sector is organised, how the sector is regulated and with which mechanisms it operates.

Readers with particular interest in a specific subject are advised to refer to other material, such as laws and directives or statistics published by the Danish Energy Authority. The Authority's website, www.ens.dk, provides a summary of its publications. On the last pages of this booklet, the reader will find definitions of some of the principal concepts and a conversion table for converting the various power and energy units.

The booklet has been prepared by the Danish Energy Authority's supply department, with contributions from the Danish District Heating Association and the Danish Combined Heat and Power Plant Association. Most of the statistics given here are from the Danish Energy Authority's 2002 energy statistics.

Some of the chapters can be read independently of each other, so readers may find some of the information repeated.

Chapters 1 to 3 provide a general introduction to Danish heat supply and are intended for anyone interested in heat supply in general. Chapters 4 and 5 give a more detailed orientation on main regulations and subsidy systems and as such are intended more for local authorities and CHP managers, as well as for those with prior knowledge of the sector.

Chapter 1 presents key figures and technical data concerning heat supply in Denmark. It then outlines the general objectives for Denmark's heat supply and provides a short analysis of the degree to which these objectives have been achieved.

Chapter 3 is an historical look at objectives and means and at the underlying context.

Chapter 4 contains a short outline of the procedure for the approval of heat supply projects and of the general frameworks for heat-generating plants.

In chapter 5, some of the principal regulations governing the heat supply sector are examined, from subsidies to obligatory connection.

Enclosure 2 is a timeline of the most important developments in the history of heat supply in Denmark.

This publication on heat supply in Denmark will be updated at least once a year and will be published on the Danish Energy Authority's website.

1. HEAT FACTS

**NATURAL GAS
FOR PUBLIC SUPPLY**

Natural gas is public supply. It must be piped to land from the North Sea substratum and from there conveyed in large pipelines either to heat-producing plants or in smaller pipelines directly to consumers. When consumers receive natural gas for their own natural gas furnaces, this is known as individual natural gas heating. But it is still public supply.

**DISTRICT-HEATING SUPPLY:
KEY FIGURES**

- If all of the DH pipes were laid end to end, they would stretch for 50,000 kilometres
- In the last ten years, 400,000 new consumers were connected to the grid
- 60% of DH is delivered by the 55-60 largest DH plants (many of which are owned by local authorities)
- In 2002, the following fuels were used to produce DH:
  - Natural gas: 30%
  - Coal 24%
  - Waste: 23%
  - Biomass: 15%
  - Oil: 7%

It is the most natural thing in the world to turn up the radiator so that heat comes flowing out. But where does the heat actually come from?

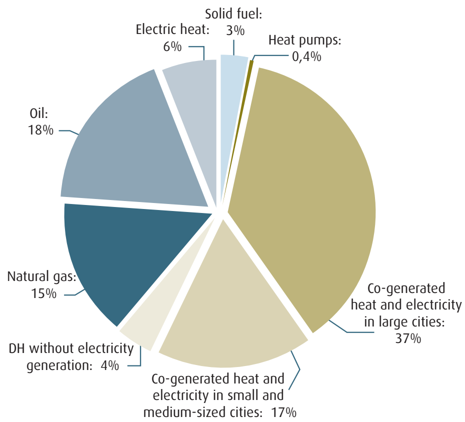
1.1 WHEN THE CONSUMER RECEIVES HEAT

In Denmark, we use various technologies to heat our homes and domestic water. Some of us use oil furnaces and others use biofuel furnaces (for wood chips, wood pellets or straw). All consumers with their own heating furnaces purchase their own oil or biofuel.

Most heat consumers - 6 out of 10 - receive their heat from public heat supply. This is an area in which plants have been built and pipes laid in the ground to deliver hot water (or steam) - known as district heating (DH) - or natural gas to consumers.

Public supply is primarily found in areas in which homes or businesses are in close proximity, that is, in cities and towns.

HEATING DENMARK'S 2.5 MILLION HOUSEHOLDS (2000)



Heat is distributed inside homes by a water-based central-heating system, that is, by means of radiators and pipes which convey the hot water throughout the building.

Irrespective of whether an oil, biofuel or natural gas furnace or DH is used, the heating system is water-based. Alternatives to water-based systems include electric heat, forced-air installations and gas, petroleum, oil and wood-burning furnaces.

Naturally, businesses and industry use heat to heat offices, halls and water. Manufacturers also use heat in their production processes. This heat consumption is called process heat.

1.2 HEAT IN VARIOUS WAYS

DH is produced in heating plants or CHP.

CHP produce both heat and electricity. Fuel consumption is thus reduced by about 30% as compared to the separate production of heat and electricity.

When electricity is fuel-generated (that is, not with wind or solar cells), heat is automatically generated (waste or surplus heat). If this heat is not used in the DH grid, it is conveyed to the sea or cooled in other ways.

The spread of co-generated heat and electricity has meant that most plants, which previously generated either heat or electricity, now produce both electricity and heat.

The abbreviations "MW" (megawatt) and "MWh" (megawatt hours) are used frequently in this booklet. The difference between them is that "MW" refers to the capacity (output) while "MWh" refers to the amount of energy generated. This corresponds to the relationship between "km" and "km/hr".

For example, if a plant operates for 4,000 hours and its capacity/output is 1 MW, it will generate a total of 4,000 MWh of energy.

Denmark's total net heat requirement is approximately 220,000 TJ (terajoules). This means that, on average, each individual Dane, at work, at home and during free-time activities, uses heat for space heating and hot water amounting to approximately 42 GJ (gigajoules) per year or 11.5 MWh. If 11.5 MWh is converted to a quantity of oil, this consumption corresponds to approximately 1,150 litres of oil.

At a slightly higher level, consumption of heat and hot water in an approximately 130-sqm single-family house amounts to around 65 GJ or 18.1 MWh per year. As a rule of thumb, it is estimated that a plant with a capacity of 1 MW can supply approximately 250 130-sqm single-family houses.

A city such as Silkeborg, which produces space heat and hot water for approximately 15,000 DH consumers, has a heat capacity of 71 MW.

1.3 FROM COAL TO NATURAL GAS AND STRAW

The fuels used to produce DH (at heating plants or CHP) can be subdivided into fossil or non-fossil fuels. Oil, coal and natural gas are examples of fossil fuels; biomass and waste, on the other hand, are examples of non-fossil fuels.

Fossil fuels, biomass and waste all emit CO_2 (greenhouse gas) when they undergo combustion. This release of greenhouse gases has a major effect on global warming.

There is a large difference between how much CO_2 fossil fuels emit. One gigajoule of coal emits 95 kg of CO_2, while the same amount of natural gas emits only 57 kg, although the actual emission depends on the installation's efficiency.

On the other hand, biomass is considered to be CO_2 neutral and CO_2 emissions from the combustion of biomass (such as straw and wood chips) is set at 0 kg. The amount of CO_2 released on combustion is bound again when forests and cereals grow. This means that if just as many trees and crops are planted as are used to generate energy, straw and wood chips can be designated as CO_2 neutral. Wood products and straw are the biomass resources most used for heating.

Denmark has large deposits of natural gas and a considerable amount of biomass.

1.4 LARGE AND SMALL PLANTS

DH consumers can receive heat from either heating plants or CHP. Typically, CHP are either centralised or decentralised. Centralised CHP are usually much larger than decentralised CHP.

There is yet another difference between centralised and decentralised CHP. The former were originally electricity plants (generating only electricity), while the latter were originally heating plants (generating only heat). While some of the decentralised CHP are new, the main purpose of all such installations is to generate heat.

Centralised CHP are located in large cities; decentralised CHP are located in smaller centres, as is shown by the enclosed map of Denmark's heat supply (see Enclosure 1).

16 centralised and approximately 415 decentralised plants supply public heating in Denmark, that is, the heat they produce is conveyed to customers by means of DH pipes.

WHAT IS BIOMASS?

The word "biomass" is a generic term for all plant and animal material created with the use of solar energy by means of photosynthesis.

Straw and manure from agriculture, wood chips and wood from forestry operations and industrial/household waste are all forms of biomass used to generate energy.

The energy stored in biomass can be used directly for heating (in fireplaces, wood-burning stoves and pellet furnaces, for example). Biomass is also used to generate electricity and DH and can be converted to biogas and other fuels, which in turn can be used for transport or to generate electricity.

For the most part, the biomass we use in Denmark consists of residual products from other forms of production. Biomass is CO_2 neutral, apart from the energy used to collect and transport the fuel.

Biomass has been used to generate energy for centuries and is still one of the most- used energy sources in the world. It is estimated that 11-14% of the world's energy consumption is covered by biomass.

BIOMASS, BIOGAS AND WASTE-DISPOSAL PLANTS: KEY FIGURES

Public-heat supply (cities):

- approximately 120 biomass-based DH plants (of which approximately are half straw-based and the other half wood-based)
- approximately 10 straw or wood-chip-fired decentralised CHP (as main fuel)
- approximately 30 waste-incineration plants (of which 18 co-produce heat and electricity and 12 are DH)
- 6 centralised CHP which use biomass, among other fuels,
- approximately 30 CHP using biogas as the main fuel

Private heat supply (enterprises, institutions):

- 200 heat and co-generating heat and electricity plants, owned by and primarily delivering heat to greenhouses, the manufacturing industry, institutions etc.

Individual heat installations (houses, farms):

- 500,000 wood-burning stoves
- 70,000 wood-burning boilers
- 30,000 wood-pellet furnaces
- 9,000 straw furnaces

Most plants produce co-generated heat and electricity whereas only a small number of the decentralised plants (approximately one-third) still produce only heat.

One in three of the decentralised DH plants and one in seven of the decentralised CHP plants use environmentally friendly fuels (straw, wood chips, wood pellets, biogas or waste). The remainder - by far the majority - use natural gas as a fuel. These CHP, owned by local authorities or co-operatives, supply heat - by means of DH pipes - to most of the households, institutions and enterprises in their areas.

Denmark has the most extensive co-generated heat and electricity system in Europe. Over one-half of Danish electricity is co-generated with heat (as shown in the accompanying figure).

The map of heat supply in Denmark (Enclosure 1) shows that there is an individual natural gas supply (which is also public supply) to most of the country and that the natural gas pipeline grid covers almost all of Denmark.

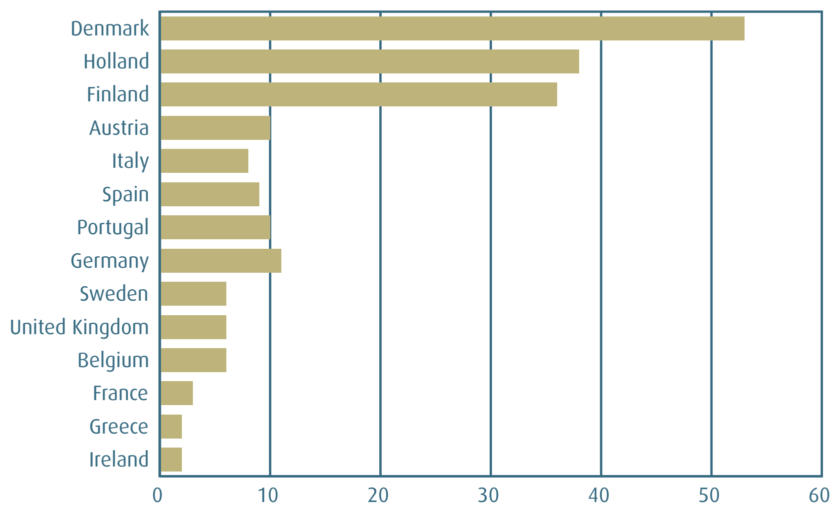
This is not the case, however, in South Zealand and Djursland where there are many biomass plants generating heat. Islands such as Læsø and Samsø also have public supply by means of biomass DH.

The map also shows that a considerable amount of coal is still used in centralised co-generated heat and electricity production.

In addition to this public heat supply, there are many plants delivering heat only to the enterprise, institution or residential block which owns them. This is the case with approximately 480 CHP and DH plants, the heat from which is used for greenhouses and the manufacturing industry or as space heat in offices, schools etc. Approximately half of these private, local plants use biomass as a fuel.

A few industries have very large plants (such as Akzo Nobel Salt and Aalborg

PERCENTAGE OF ELECTRICITY CO-GENERATED WITH HEAT (2000)



Portland), but the vast majority of self-owned heating plants are relatively small and cover only local needs.

Denmark thus has an extensive and varied heat sector. Approximately 665 plants generate both electricity and heat and approximately 230 plants produce only heat. The vast majority of the power and heat generated is used for public supply.

1.5 THE COST OF HEAT

Heat does not cost the same throughout the country. But the principles used to set the price for heat are the same everywhere, established by the law on heat supply.

According to the regulations, a supplier may not charge any more or any less for heat than it costs to produce it. These costs include the following:

- fuels
- installations
- grids and pipelines
- buildings and inventory
- installation and grid maintenance
- operation/administration salaries
- insurance
- CO_2 taxes, energy taxes and sulphur taxes on fuels.

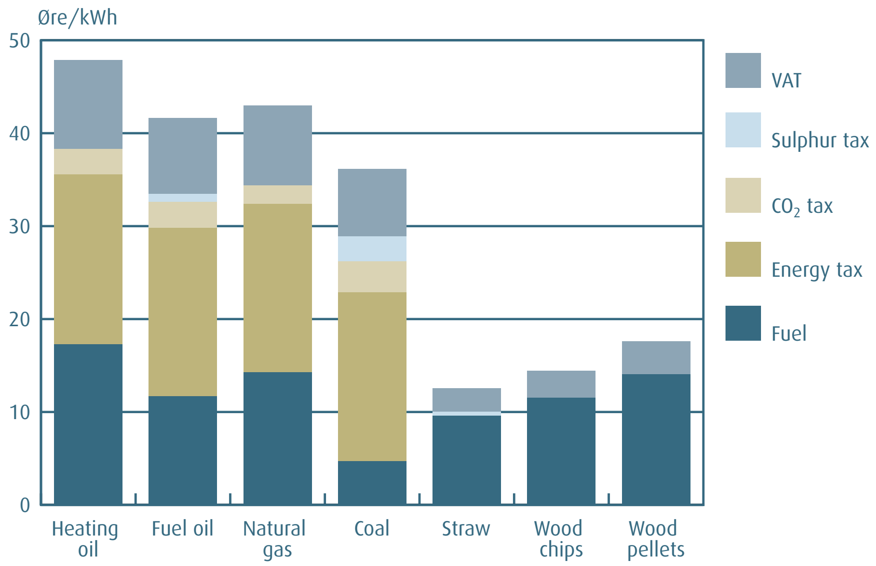
Generating plants are therefore not allowed to demand that consumers pay any more or any less for heat than it has cost to produce and distribute it. This principle is known as being "self-contained".

Consumers with their own natural gas, oil or biofuel furnaces have many of the same costs as a generating plant, such as the cost of maintenance, installation costs, fuel costs, fuel taxes etc.

The price of heat from relatively large plants, smaller plants and privately-owned heating installations is affected by the following:

- fuel prices
- fuel utilisation in the installation
- operating and maintenance costs
- costs connected to setting up an installation
- net loss (heat loss in the DH grid)

FUEL COSTS FOR DH PRODUCTION - 1 JANUARY 2002



NUMBER OF CHP AND DH PLANTS IN DENMARK

Public heat supply (cities):

- 16 centralised CHP
- 285 decentralised CHP
- 130 decentralised DH plants

Private heat supply (enterprises and institutions):

- 380 CHP
- 100 DH plants

In all:

- 665 CHP
- 230 DH plants

SOLAR ENERGY

Solar energy is collected in two ways:

- with solar cells, to generate electricity
- with solar collectors, to produce space heating and hot water for domestic use

There are approximately 35,000 installations collecting solar energy for houses. There are relatively few large solar-collection installations, although the world's largest solar-heat installation (17,000 sqm) is located in Marstal. The installation stores seasonal solar heat in a stratum of earth.

Solar cells generate electricity. 300 Danish single-family dwellings are equipped with solar cells. In 2001, a new country-wide solar cell project was initiated to provide 1,000 houses with solar cell installations.

HEAT PUMPS

A heat pump installation is essentially a cooling system (with a compressor, heating surface, pressure-reducing valve and cooling surface). The distinguishing feature is the heating surface. A heat pump takes heat from the cooling surface and delivers it to the heating surface. That is, it "pumps" heat from an area with a relatively low temperature to an area with a relatively higher temperature.

This process requires energy, usually electric energy.

A heat pump installation used to heat homes typically produces 3 times as much energy as the amount of electricity it consumes, meaning that it has an efficiency of approximately 3. The higher the temperature around the cooling surface (the evaporator surface), the higher the efficiency achieved. With the use of high-temperature heat sources such as industrial process heat, other forms of heat recirculation or geothermic heat, the efficiency increases.

Today, approximately 35,000 small heat pump installations provide heat in single-family dwellings and approximately 5,000 larger installations are used for large central-heating plants, in agriculture and industry etc. The energy produced with heat pumps accounts for approximately 3% of DH consumption.

- number of consumers
- amount of heat sold
- taxes and VAT
- subsidies
- electricity transfer price (for plants that also generate electricity).

Generally, the cost of fuel, including taxes, is one of the plants' major expenses.

There are a number of other general factors affecting the price of heat. Large plants will have larger economies of scale than smaller plants and will therefore often be able to set a lower price for the heat they produce.

DH is often cheaper than individual heating. Today, only 2% of DH customers pay more than it would cost to produce the heat they consume with oil furnaces. Compared to the cost of heat from an individual natural gas furnace, 8% of DH customers pay more for their heat.

For example, large plants are able to purchase fuel more cheaply than smaller plants or individual consumers. In addition, the net loss will, as a general rule, be less in large cities, where the houses are closer together and where overall heat consumption is greater.

The net loss is in fact a heat loss, due to the fact that the temperature of the hot water (or steam) falls a few degrees before it reaches the consumer, just as the water temperature drops a few degrees on the way back to the plant. The extent of the net loss depends on the pipes: on their diameter, length and insulation.

Consumers with their own heating boilers have no net loss because there is no pipeline grid. On the other hand, older boilers are often less efficient than the larger, DH plants' installations. The efficiency (fuel utilisation) depends on how much energy can be extracted from a unit of fuel.

Basically, the efficiency increases in proportion to the degree of refinement of the fuel, the size of the installation and the technology used.

The efficiency of plants' co-generated heat and electricity has risen sharply, from 50% in 1980 to approximately 70% in 2000, because increased co-generation of heat and electricity saves large amounts of fuel. In addition, continued technological improvements mean that more electricity and heat can be generated from a given amount of fuel.

1.5.1 TAXES AND SUBSIDIES

As mentioned, many plants produce both electricity and heat. But the fuel used to generate heat and electricity is taxable, according to various regulations. Fuels used to produce heat are taxable, although this does not apply to biofuels. This means that plants using such fuels are indirectly subsidised to use biomass.

Fuels used to generate electricity are not taxable. Instead, consumers are taxed for their electricity consumption. Some CHP are eligible for subsidies for electricity generation (this is gone into further detail in Chapter 5).

During the 1990s, some plants were also eligible for investment grants but these subsidies are being revised, given that the technologies involved are now commercially mature.

1.6 CHP AND OTHER HEAT TECHNOLOGIES

Heat can be generated in various ways, using various technologies. There follows a very short description of the technology used in a CHP.

In addition to the methods already mentioned for generating heat, the text boxes in this chapter describe individual installations/technologies used to heat homes and domestic water.

35-45% of the energy used in a traditional coal-fired (condensing) power plant is converted to electricity. The remaining energy is not utilised. It vanishes into the air, carried up the chimney stack with the warm chimney gas from the boiler or dispersed with cooling water into the sea.

Electricity is produced in a CHP in the same way as in a traditional power plant but, instead of using cooling water to convey the steam's condensation heat to the sea, the steam is cooled with the return water from a DH grid. As a consequence, the return water is heated.

The advantage of a CHP as compared to a traditional power plant is first of all that waste heat from electricity generation can be used in the DH grid. This means that the energy (fuel) used is 85-90% exploited. Another advantage is that there is no need for access to seawater for cooling, which means that the plant can be located near large cities (decentralised), where there is a particularly well-developed DH grid and high demand for DH.

In order to render electricity generation at CHP more independent of the DH demand, most installations have been equipped with an accumulation tank in which condensation heat can be stored when the DH demand is low.

Denmark has given combined heat and electricity production high priority, including with respect to power plants located near large cities such as Copenhagen, Aarhus, Aalborg, and Odense. At these power plants, part of the energy loss from electricity generation is used to produce DH. The development of CHP has been of strategic importance for a cleaner environment in Denmark. Most energy production now takes place at these plants.

The use of other energy sources also contributes - albeit to a lesser extent - to more environmentally friendly heat production. These sources include geothermics, solar heat and heat pumps.

GEOTHERMICS

At a geothermic installation, hot water is drawn from and returned to the substratum by means of two deep holes bored into the earth.

Normal heat pumps are connected to this system. Heat pumps use electricity. It is possible to achieve high energy-efficiency when heat pumps are used in geothermic installations.

Geothermics is used in Thisted for DH and covers heat consumption for 2,000 houses. The installation began operation in 1988. As of the end of 2004, a new geothermic installation in the Copenhagen area will supply 5,000 households with geothermic heat - that is, 1% of Copenhagen's total heat consumption.

In Copenhagen, the heat will be exploited by pumping hot water at 73°C up from the sandstone layer at a depth of 2.5 km.

As a rule of thumb, it is estimated that the temperature rises 25-30°C for every km of depth into the substratum. In volcanic areas, the temperature rises much faster. Today, there are over 100 geothermic installations in Europe.

Photo: Torben Skøtt

Assens CHP

2. THE STATUS OF HEAT SUPPLY

WASTE FOR ENERGY SUPPLY

In 2002, total energy production from waste incineration increased by just under 1 PJ to approximately 34 PJ.

One-quarter of the energy generated is electricity; three-quarters is heat. This amounts to 3.5% of the country's electricity production and just under one-quarter of DH production.

According to the **Biomass Agreement of 14 June 1993**, entered into between the Social Democrats, the Radical Left, the Christian People's Party, the Centre Democrats, the Liberal Party, the Danish Conservative Party and the Socialist People's Party:

"The parties agree that environmental considerations indicate that the use of waste in connection with DH production shall henceforth take precedence over other fuels".

The manner in which heat is produced and supplied to Danish heat consumers has not been arrived at by chance. It is the result of decisions made by politicians and planners during the last few decades.

The objectives for Denmark's energy policy are formulated in energy policy agreements, action plans and energy plans.

The goals for heat supply may be summarised under the following general headings:

- Supply security
- Cost efficiency
- Environment
- Consumers first

2.1 DENMARK IS AUTO-PRODUCING

Denmark became energy self-sufficient in 1997. This means that we no longer depend on fuel imports to cover our energy consumption. We export more than we import.

Denmark's oil and natural gas exports make a positive contribution to our balance of payments and to state revenues. The Danish oil and gas prices follow international market prices.

Another advantage is that energy supply in Denmark is more secure. We are now less economically and politically vulnerable to international developments.

It was the rise in the cost of oil from the OPEC countries and the short supply of oil in the '70s that stimulated Denmark into looking for oil and natural gas in the Danish substratum.

One tangible result of this effort to extract Danish oil and natural gas has been that, in 2002, Denmark's production of oil was double its consumption.

Denmark also has enough biomass resources of its own to cover biomass consumption in the near future. A considerable amount of wood pellets and other biofuels is, however, imported.

In the last few decades, waste has gained ground as a new fuel in heat and CHP. Waste incineration thus contributes to solving environmental problems in a modern society.

2.2 ENERGY EFFICIENT AND ENVIRONMENTALLY FRIENDLY HEAT PRODUCTION

Over 80% of the heat produced in Denmark is generated at CHP. For many years, this has had both environmental and economic advantages.

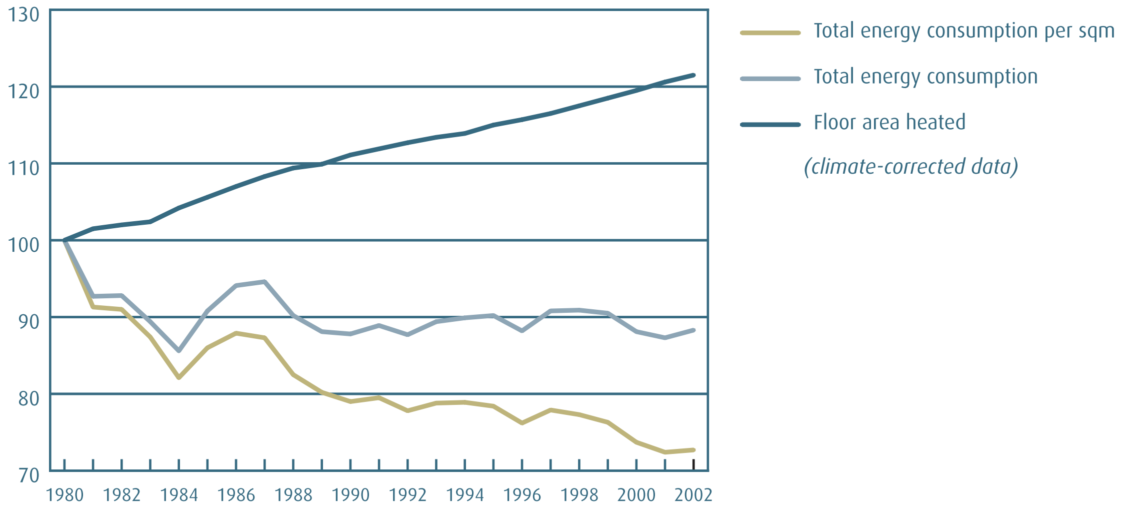
In the 1980s and 1990s, the expansion of DH based on co-generated heat and electricity led to a significant reduction in CO_2 emissions. Fewer consumers heat their houses with oil or natural gas and the co-generation of heat and electricity has replaced the electricity which previously was produced at less environmentally friendly condensation plants (electricity production only).

Moreover, larger heat supply installations are able to produce heat more efficiently than small installations owned by consumers.

The heat produced for our houses is also used more efficiently. This has meant that energy consumption has fallen since 1980 even though the floor area being heated has increased (see accompanying figure).

Heat demand has decreased primarily because we insulate our buildings better and because we have become more energy conscious. Investments in efficient combustion installations, heating systems and automatic regulating

ENERGY CONSUMPTION FOR DOMESTIC SPACE-HEATING (INDEX: 1980 = 100)



equipment has reduced energy loss in individual household installations.

There is much tangible evidence of the degree to which Denmark has converted to more CO_2-neutral fuels for energy production. For example, one-third of the heat used for heating and domestic hot water is today generated from waste and renewable energy.

Thanks to these results, Denmark has become one of the world's leaders in DH supply, in the use of co-generated heat and electricity, in energy saving and in various biomass technologies.

Danish energy planners, advisers etc. share this experience at seminars and conferences and act as consultants when other countries inquire about Danish supply solutions.

2.3 MORE ENVIRONMENT FOR THE MONEY

In the heat supply sector, the conversion from individual supply to public supply, from producing heat only to co-generated heat and electricity, as well as the use of environmentally friendly fuels, have had very significant economic consequences for society.

In other words, weight is given to the relationship between the cost to society in order to change the way heat is supplied and the results obtained.

In practice, this means that when planners, local authorities and others have to choose between various energy solutions, they must assess the various possibilities on the basis of the environmental advantages to society versus the costs involved.

What the most economic solution for society is at a given time changes according to the development of new technologies and new markets and to increased international co-operation in the solving of environmental problems. What was the best solution in the 1990s is not necessarily the best solution 10-20 years later.

In recent years, the economic advantages to society of co-generated heat and electricity have diminished as a function of the extensive development of windmills and decentralised, co-generated heat and electricity. During times of the year characterised by high winds and cold, electricity generation from windmills and CHP can exceed consumption. The market price of power can become so low that the economic advantage of co-generating heat and electricity actually becomes a loss. This is why the obligation of electricity companies to generate both forms of energy has been abolished and the system made more flexible, allowing these companies to produce either heat or electricity, according to demand. To a large degree, plants should now be able to adjust electricity production to demand, thus avoiding the production of excess electricity.

Ongoing technological developments also determine what is the most economic solution in societal terms.

Today, solar cells and wave power are expensive ways of reducing CO_2 emissions. It is not to be excluded, however, that technical and economic improvements may, in the future, lead to these technologies offering just as much environment for the money as the technologies that predominate today.

Increased international co-operation also affects the Danish choice of means to improve the environment. The Kyoto Agreement's shared international efforts to reduce CO_2 emissions has therefore meant that Denmark can also contribute to the reduction of CO_2 in other countries. For example, it is cheaper to reduce CO_2 emissions in Poland than in Denmark because Polish electricity is typically generated at coal-fired power plants, which are much more polluting than the more modern Danish plants. The Kyoto Agreement thus makes it possible to reduce CO_2 emissions both in Denmark and in other countries.

The goals and the means thus change over time.

Sakskøbing CHP

Photo: Torben Skøtt

3. HEAT SUPPLY: GOALS AND MEANS OVER THE YEARS

Prior to 1979, there was no law regulating heat supply in Denmark. Most consumers had oil furnaces or other forms of heating.

As early as 1903, the first CHP was built at Frederiksberg Hospital. The first large public DH system was developed in Copenhagen in the 1930s - the DH supply was based on surplus heat from local electricity production. In the 1950s and 1960s, DH supply was extended to most of the country's large cities. When the law on heat supply took effect, there were approximately 700,000 DH installations.

This chapter provides a short description of some of the decisions and choices that have been particularly significant in the development of heat supply in Denmark.

3.1 THE GROUNDWORK IS LAID FOR HEAT PLANNING (1970S AND 1980S)

The oil crises in 1973/74 and at the end of the 1970s resulted in the formulation of a definitive energy policy in Denmark.

3.1.1 Public heat planning

Denmark passed its first heat supply law in 1979. The law contained regulations on the form and contents of heat planning in Denmark and was the beginning of new, public planning.

The planning was divided into phases. In the **first phase**, local authorities were to prepare reports on their heat requirements, the heating methods used and the amounts of energy consumed. They were also asked to assess heat needs and heating possibilities.

County councils then used this data to prepare regional heat supply summaries.

In the **second phase**, local authorities were to prepare a draft of future heat supply while the county councils prepared "regional summaries". On this basis, the county councils then prepared a definitive regional heat plan, which became the **third phase** in overall heat planning.

The plans were required to show:

- in which areas the various forms of heat supply should be prioritised
- where future heat supply installations and pipelines should be located.

This planning made it possible to combine the desire for more environmentally friendly supply with the desire to benefit from the investments made following approval of the natural gas project in 1979.

During this same period, the possibilities for co-generation of heat and electricity were examined in order to exploit surplus heat from electricity generation.

With the 1986 Co-generated Heat and Electricity Agreement, decentralised co-generated heat and electricity became a major energy policy priority.

The agreement was made between the government and utilities, which were obliged to arrive at a capacity of a total of 450 MW electricity at decentralised CHP. Furthermore, it was emphasised that research and demonstration projects (see Section 3.1.4) should be extended to various types of installations, such as those processing biomass and waste.

3.1.2 Obligatory connection and ban on electric heat in support of public supply

The first law on heat supply also gave local authorities the power to oblige new and existing buildings to connect to public supply. Most consumers were obliged to connect to individual natural gas or DH systems.

In 1982, the obligation to connect was finalised in an executive order which was essentially unchanged until the most recent amendment in 2000. It remains in effect.

The ban on installing electric heat in new buildings dates back to 1988. It arose from the desire for more efficient energy utilisation (see Section 1.6). Later on, in 1994, the ban was extended to electric heat installations in existing buildings with water-based central heating systems. The objective with the ban was to prevent the installation of domestic electric heat in areas with public supply or zoned for such supply.

The ban on electric heat remains in effect.

Both the ban and obligatory connection were in keeping with the policy laid down in 1979 by the first heat supply law. The objective was to promote public heat supply and energy utilisation as a means of achieving economically sound use of energy.

In practice, the ban and obligatory connection made it possible for local authorities to ensure that energy supply companies' earnings were not undermined by an insufficient number of connected consumers, in turn ensuring that investments made were not lost.

Chapter 5 provides more information on the regulations in effect governing obligatory connection and the ban on electric heating.

3.1.3 Taxes and savings as control instruments

As early as 1979, the energy plan known as Danish Energy Policy presented initiatives to enable consumers to save energy.

For example, initiatives were undertaken to improve building insulation and a heat appraisal programme for houses was set up. Energy savings were introduced according to the logic that energy saved needed to be neither produced nor imported.

In addition to administrative control instruments, programmes were set in place in the heat supply sector to provide information on energy saving and on economic ways of controlling energy use.

During the 1970s and 1980s, taxes were applied to fuels used in heat generation with the objective of encouraging the use of environmentally friendly energy and efficient energy utilisation. Biomass and biogas were exempted from taxes.

Although oil and gas prices fell at the end of the 1980s, the tax level was maintained to ensure that consumers would continue to be motivated to save energy.

3.1.4 Supply subsidy and the development of environmentally friendly fuels

The conversion to more environmentally friendly fuels and co-generation of electricity and heat at new plants using new technology was achieved by means of various subsidy and grant programmes.

For example, a programme for energy research was set up in 1976 (the Energy Research Programme). The goal was – and is - to prioritise and support energy research and technological development.

Shortly thereafter, in 1981, the Development Programme for Renewable Energy (DPRE) was put in place. The objective in this case was to supplement the ERP so that research into renewable energy could lead to commercially viable technologies.

Private consumers or enterprises could receive subsidies for advanced systems or standard-certified renewable energy installations. Implementation of biofuel boilers, solar heat installations and heat pumps derived particular benefit from the subsidy programme. For example, the DPRE supported the setting up of more than 10,000 biofuel boilers.

Test stations and research centres with special knowledge in a particular field could receive a subsidy for the type approval of renewable energy installations and for disseminating knowledge and information.

After more than 20 years of such support, many environmentally friendly technologies and fuel installations became so technologically and commercially mature that they no longer required subsidising. For this reason, the 2002 Finance Act discontinued the DPRE's subsidy system.

3.2 FOCUS ON THE ENVIRONMENT AND ELECTRICITY GROWTH (1990S)

In the 1990s, there was widespread conversion from heat production using oil and coal to natural gas based co-generated heat and electricity and biomass-based heat production.

The first phase of Danish heat planning was to a large extent wound down at the end of the 1980s. All areas covered by the expansion plans then being implemented were zoned for public heat supply as part of the local authorities' heat supply plans.

3.2.1 Planning directives

With an amendment to the law on heat supply in 1990, a new planning system was introduced to adapt policies to future heat supply requirements. A so-called "project system" was developed on the basis of a general framework formulated in an agreement between the government and the Social Democrats on 20 March 1990 and in the 1990 law on heat supply.

The objective of the agreement was to promote expansion of decentralised CHP through:

- conversion of existing installations to co-generated heat and electricity supply
- increased use of natural gas
- increased use of environmentally friendly fuels
- electricity growth.

The agreement was a solution to two particular issues: reducing Denmark's CO_2

Photo: Torben Skøtt

Grenaa CHP

emissions and ensuring economic energy use through the expansion of the natural gas grid.

The conversion of DH (heat production only) to co-generated heat and electricity, as formulated in the agreement of 13 March 1990, was to take place in three phases, as specified in general and specific planning directives sent to all local authorities. Furthermore, a planning directive on large-scale customers' conversion to public supply was also issued. The planning directives, which remain the legal basis for heat supply, contain specific regulations governing conversion to co-generated heat and electricity and the introduction of environmentally friendly fuels. Local authorities were also directed to ensure that this conversion was carried out.

The conversion of DH plants was divided into the following three phases:
Phase 1 (1990-1994)
Phase 2 (1994-1996
Phase 3 (1996-1998).

Phase 1.
Large coal-fired DH plants with access to a natural gas supply were to convert to natural gas-fired, decentralised co-generated heat and electricity.

Large natural gas-fired DH plants were to convert to natural gas-fired, decentralised co-generated heat and electricity.

In connection with the foregoing, waste installations were to be introduced as well.

Phase 2.
Remaining coal-fired DH plants with access to natural gas supply were to convert to natural gas-fired, decentralised co-generated heat and electricity.

Medium-sized natural gas-fired DH plants were to convert to natural gas-fired, decentralised co-generated heat and electricity.

The majority of DH plants outside the public systems were to convert to straw, wood chips or other biofuels.

Phase 3.
Smaller natural gas-fired DH plants were to convert to natural gas-fired, decentralised co-generated heat and electricity.

Remaining DH plants outside the public systems were to convert to straw, wood chips or other biofuels.

Control room at the Assens CHP

Photo: Henrik Flyver Christiansen

For the most part, these conversion phases were successfully completed, which is why Denmark has the most extensive co-generation of heat and electricity in Europe.

Heat is generated automatically when electricity is generated but not necessarily in periods when the market price for electricity is advantageous. Production of heat-connected electricity gradually increased to such an extent that, during certain periods, it had to be sold to surrounding countries for less than it cost to produce. The result was economic loss, for both the state and producers.

Therefore, as of 1 July 2003, CHP were exempted from the obligation to co-generate electricity and heat continually in order to qualify for electricity production subsidies. Now, plants are motivated to produce electricity when there is demand and when the price is therefore favourable, and to produce heat when there is demand. Further initiatives to encourage more economic co-generation of electricity and heat were introduced with a far-reaching energy agreement in March 2004.

3.2.2 Open-field plants

In the early 1990s, DH from new plants was distributed in several large villages around the country. Most of these plants also produced electricity. Co-generation of electricity and heat saved fuel and was therefore more environmentally friendly. The public supply could also be extended to local industry in cases in which natural gas pipelines were laid, thus being advantageous to local industrial activity.

At the end of the 1990s, a number of open-field plants encountered financial difficulties, partly due to higher natural gas prices. In many cases, the government and natural gas companies came to their aid. In 2000, open-field plants received DKK 370 million for debt rescheduling from the government and natural gas companies. In 2003, another aid package was made available, amounting to DKK 85 million. During the same period, taxation of co-generated heat and electricity was amended in favour of open-field plants and other decentralised CHP.

3.2.3 Subsidies favour decentralised co-generated heat and electricity

In 1992, a subsidy for electricity production was introduced in order to promote

WHAT IS AN OPEN-FIELD PLANT?

An open-field plant (or local CHP, as they are referred to by natural gas companies) is a small, public supply heat installation in which the supply installation - usually in the form of a CHP or DH plant - is set up at the same time as the DH grid. An open-field plant characteristically produces environmentally friendly heat with low CO_2 emission.

Today, there are approximately 80 such plants in Denmark. Most of them are natural gas-fired; some, although fewer, are biomass-fuelled.

On average, an open-field plant has 250 connected consumers. Across the country, approximately 18,000 consumers are connected to open-field plants, which account for 1-2% of the country's total DH production. By far most of the plants are located in Mid- and North Jutland.

Photo: Torben Skøtt

Maabjerg CHP

the development of decentralised co-generated heat and electricity production with natural gas and renewable energy. This new subsidy replaced a previous subsidy for electricity generation from renewable energy (0.23 DKK/kWh or 23 øre/kWh) which had been established in 1994 under the Ministry of Taxation.

As had been the case with the previous subsidy, the new electricity production subsidy was made available for electricity produced with renewable energy but now also included natural gas-based decentralised and industrial co-generated heat and electricity production. The subsidy amounted to 10 øre/kWh. A further subsidy of 17 øre/kWh was given for electricity produced with wind power, waterpower, biogas, straw or wood chips.

In 1997, the electricity production subsidy was reduced to 7 øre/kWh, although not for smaller decentralised CHP and open-field plants.

In compensation for the reduced subsidy, a so-called "aid pool" was established because reduction of the electricity production subsidy created financial difficulties for a number of natural gas-based, decentralised CHP, which had invested in installations in the expectation of receiving a subsidy of 10 øre/kWh.

In 2003, new regulations were established governing electricity production subsidies, setting lower tax rates for decentralised and industrial co-generated heat and electricity production. New plants and plants over 25 MW are not eligible for the subsidy. At the same time, the electricity production subsidy for existing decentralised plants was set at 8 øre/kWh for a specific amount of electricity (see Section 5.4). The subsidy rates were not changed for industrial plants. All in all, it is expected that the financial circumstances of decentralised and industrial CHP will remain essentially unchanged.

Today, the subsidy for renewable energy has been turned into a surcharge on the electricity producers' electricity transfer price. The regulations applying to the electricity production subsidy are further described in Chapter 5.

3.2.4 Renewable energy as part of heat supply

The introduction of renewable energy for heat supply became a priority in the

Straw bales for a CHP

Photo: Torben Skøtt

1990s when objectives were set for the increased use of biomass in both centralised and decentralised installations.

The use of biomass, particularly in decentralised DH plants and to a certain extent in decentralised CHP, was supported by policy-makers and financial subsidies, as described in the previous chapter. In particular, the use of biomass in centralised plants was facilitated by the Biomass Agreement of 14 June 1993, according to which electricity plants were to use 1.2 million tons of straw and 0.2 million tons of wood chips annually for electricity production by the end of 2000.

On 1 July 1997, a surcharge agreement was reached and the Biomass Agreement was further amended on 22 March 2000. The goal was to ensure a more flexible choice of biomass, including the possibility of using surplus wood (chips) from the December 1999 hurricane to produce electricity. The agreements can be read on the Danish Energy Authority's website.

As far as biogas is concerned, a number of projects were undertaken in the 1980s. Many of them, however, had disappointing results and led to a general lack of confidence in the sector. But, in 1987, the Ministries of Agriculture, the Environment and Energy set up an action plan for centralised biogas plants in the interests of establishing economically advantageous, competitive biogas plants.

In 1995, these efforts came to an important conclusion, since technological and financial management advances had been so successful that biogas had become a viable part of Danish energy supply.

Today, biogas contributes just under 1/2% of the energy consumed in Denmark.

Photo: Torben Skøtt

Rudkøbing CHP

4. WHEN PLANTS ARE TRANSFORMED OR PRODUCTION CHANGES

A long process of negotiations, studies and decisions takes place before a plant or grid is built in Denmark, before new fuels are introduced, technologies are upgraded or production expanded. This process is part of Danish heat supply planning.

The local authorities approve heat planning in Denmark. That is, the local authorities make the final decisions as to how heat planning and expansion will take place in their respective areas.

Nevertheless, many other parties are involved in the planning process and during a project's various phases (when a project is initiated, prepared and implemented). The Danish parliament has passed a law on heat supply, defining this process and setting a series of regulations to govern it.

The most important law is the actual law on heat supply itself, which governs CHP, public heat supply installations (including block heating plants) with a heat output of more than 250 kW and CHP with an electricity output of up to 25 MW.

4.1 THE NEED FOR A PROJECT PROPOSAL

Any interested party has the right to initiate a heat-planning project: DH plants, local authorities, natural gas companies, electricity companies, businesses or citizens groups.

If a project has to do with the conversion of DH plants or with large-scale consumers' connection to public supply, the relevant local authority is responsible for preparing a project proposal. The local authority must ensure that the deadlines set by the Minister are respected.

Projects can deal with construction or expansion of the production- or supply grid, changes to the energy used in existing installations, grid improvement to increase capacity etc. There are regulations establishing the information which must be included in the project proposal and the underlying calculations which must be made. Other regulations require that supply companies, various authorities and the property owners concerned be informed.

The Minister has also set regulations concerning the fuels and technologies to be used in plants. This is the administrative basis for heat supply projects. Project proposals must be prepared in accordance with these frameworks and regulations.

A project proposal must include calculations of the economic factors (relative to society, consumers and the companies concerned), as well as the environmental and energy-related factors. Information on the conditions governing financial calculations and fuel prices to be taken into consideration when determining the economic structure of projects is made available to assist in the drafting of project proposals.

When a project proposal has been prepared, it is sent to the municipality department responsible for projects, which can then recommend it for further development. The local authority sends the project to the partners concerned (such as supply companies or citizens) for consultation.

On the basis of the response to this public hearing - and not before - the Danish Energy Authority used to be consulted. In order to make the project proposal approval process clearer, a new regulation on approval of public heat supply installations has entered into force (Executive Order No.1210 of 9 December 2004). The

Energy Authority will no longer be sent project proposals for approval of public heat supply installations. Neither will it be informed of final project approval by local authorities. This new procedure makes it clear that local authorities are responsible for project approval.

The regulations were also simplified in 2004 as far as enterprises that deliver DH or natural gas are concerned. They are no longer required to submit a biannual report to the relevant local authority on connection to installations. In the future, such reports are to be prepared only when the local authority deems it necessary. The law amendment took effect on 29 March 2004 (Law no. 205).

4.2. HEAT PLANNING FRAMEWORKS

A project proposal is prepared within the framework of a set of regulations on heat planning.

The regulations currently in effect establish two general guidelines for DH supply: one deals with the conversion to co-generated heat and electricity and with regulations on fuel consumption; the other the conversion of large-scale customers (central heating plants) to public supply. And then there is a series of specific planning directives.

Although the frameworks and guidelines referred to above were first sent to local authorities at the beginning of the 1990s, they remain the legal basis for heat planning.

Many of the conversions referred to in the planning directives have already been carried out. Other new changes to production installations, the setting up of new installations etc., still must be done within the frameworks set by these regulations.

4.2.1 General planning directives for DH plants

The general planning directives for DH plants set the regulations governing:

- choice of fuel
- choice of means of production
- dimensioning to cover 90% of the heat infrastructure with natural gas-based co-generated heat and electricity
- electricity efficiency
- connection

The requirement for continual co-generation of electricity and heat in order to be eligible for the electricity production subsidy was abolished in 2003 so as to ensure more flexible adjustment of electricity production to market demand.

Viborg CHP

4.2.2 Specific planning directives

For a number of local authorities, the general planning directives mentioned above have been supplemented with specific directives requiring that DH plants be converted to decentralised co-generated heat and electricity or biomass.

The specific planning directives contain detailed guidelines on:

- deadlines for the drafting of project proposals
- conversion to co-generation of electricity and heat
- conditions for co-operation among the various parties involved in heat planning (in the form of the setting up of co-ordinating groups etc.).

In this case as well, much of the conversion has taken place. But some of the specific planning directives require a draft project proposal for conversion to biomass-based co-generated heat and electricity.

In 2000, the Energy Authority decided that the economic conditions for co-generated heat and electricity produced with biofuels were not yet sufficiently advantageous to justify enforcing this requirement.

4.2.3 Conversion of Block Heating Units

A Block Heating Unit is a plant set up in connection with the construction of a large building or building complex. The goal is to supply a closed group or a previously determined number of users. A central heating plant, for example, may supply heat to a hospital complex or to several residential complexes, to a shopping centre or swimming pool.

The planning directive on Block Heating Units requires that a Block Heating Unit located in or near an area connected to public heat supply must be supplied from that source.

It further requires that a Block Heating Unit located in a DH area must be supplied from that source, unless economic conditions and the desire for the best possible co-generation indicate otherwise and if a change would not result in the supply company's economic conditions being significantly altered.

The local authorities approve projects for the setting up and conversion of Block Heating Units. The Energy Board of Appeal may be asked to review local authority decisions.

On the basis of an assessment of a specific project, local authorities have the power to dispense with the directive on conversion to public supply in 3 cases:

- Block Heating Units supplying buildings the characteristics of which would make such conversion disproportionately costly due to the need to use larger installations or to restructure the buildings;
- Block Heating Units supplying buildings scheduled for demolition in the near future;
- Block Heating Units supplying buildings not intended to be heated continually during the heating season.

The Energy Board of Appeal may be asked to review local authority decisions.

Furthermore, the Energy Authority, in particular cases, may in exceptional cases dispense with the planning directive (such as for development or demonstration projects).

5. REGULATIONS AND SUBSIDIES TODAY

How is the obligation to connect currently applied - and can it be appealed? And is the subsidy for producing co-generated heat and electricity with natural gas 8 øre/kWh or 10 øre/kWh?

The answers to these questions can be found here.

The specific regulations can be found in the relative laws, acts or guidelines.

The individual sections in this chapter stand on their own and may be read independently of each other.

The following regulations are referred to in this chapter:

1. The obligation to connect and to remain connected
2. Electric heat
3. Subsidies for electricity production and the aid pool
4. Calculation of taxation on electricity and co-generated heat and electricity.

5.1 THE OBLIGATION TO CONNECT AND TO REMAIN CONNECTED

5.1.1 To whom does the obligation apply?

Local authorities have the power to require that all or part of a local authority area connect either to a natural gas supply or DH (Executive Order no. 581 of 22 June 2000 on connection etc., to public heat supply installations). The degree to which this power is exercised varies considerably from area to area.

5.1.2 Where does the obligation apply?

The obligation to connect may be applied to both new and existing buildings. For existing buildings, however, the obligation first takes effect 9 years after the owner of the property has been so informed.

A local authority may, in special cases, connect an existing property to the public heat supply installation before the 9-year deadline expires. This applies if there is the possibility of supply from the heat supply installation and if the property must in any case replace essential heat installations. A local authority may also require a property that is already connected to DH or natural gas to remain connected. This is known as the obligation to remain connected. The procedure and the legal effects are the same as for the normal obligation to connect but this obligation takes effect at the same time as the property owner is so informed.

241 of Denmark's 275 local authorities (in one or more areas) apply the obliga-

OVERVIEW OF THE CURRENT MAIN LAWS AND REGULATIONS GOVERNING THE HEAT SUPPLY SECTOR

HEAT:

- Act on heat supply (no. 772 of 24 July 2000) and subsequent amendments
- Executive Order on heat planning and approval of installation projects for public heat supply installations (no. 582 of 22 June 2000)
- Executive Order on connection etc., to public heat supply installations (no. 581 of 22 June 2000
- Executive Order on energy saving in heat supply enterprises (no. 816 of 17 September 2001).

ELECTRICITY:

- Act on electricity supply (no. 151 of 10 March 2003)

SUBSIDIES, TAXES, TRANSFER PRICES:

- Proclamation of the law on electricity production subsidy (no. 490 of 13 June 2003)
- Law amending the law on energy taxes on mineral oil products etc., law on the taxation of natural gas and town gas, law on the taxation of hard coal, lignite, coke etc., law on CO2 tax for certain energy products, law on sulphur tax and law on electricity production subsidy (no. 393 of 6 June 2003)
- Executive Order on book depreciation, allocations to new investments and interest on invested capital according to the law on heat supply (no. 175 of 18 March 1991)
- Executive Order on electricity production subsidies (no. 512 of 16 June 2003)
- Executive Order on electricity transfer prices for decentralised electricity producers (no. 786 of 21 August 2000)

Photo: Henrik Flyver Christiansen

Gasification plant at Denmarks Technical University.

WHAT IS A LOW-ENERGY HOUSE?

A low-energy house is a house requiring energy for heating, ventilation and hot water supply that is less than half of the maximum energy requirement per square metre according to building regulation provisions.

These provisions refer to the Energy Authority's instruction, "Public Heat Supply and Renewable Energy: Connection Exemption, May 1983) and the instruction accompanying Ministry of Energy Executive Order no. 196 of 22 March 1991 on connection to public heat supply installations (August 1998).

The building regulations set the maximum "energy framework" for housing units. An "energy framework" is the heat required for space heating, ventilation and hot water supply.

tion to connect either for both new and existing buildings or for new buildings only.

5.1.3 How is the obligation enforced?
A local authority may apply the obligation to connect on the basis of a project proposal or a local plan.

If a local authority applies the obligation to connect on the basis of a project proposal, it must:

- indicate the specific properties affected
- specify a timeframe for connection
- demonstrate that connection is economically advantageous to the consumer
- substantiate the legality of the obligation to connect
- indicate the properties to which the obligation to connect may not be applied.

The area's property owners must be consulted before the local authority decides on the obligation to connect. Property owners may, for example, demonstrate that they are eligible for one of the exceptions (for more information in this regard, see Section 6.1.4).

The obligation to connect may also be applied to new buildings as part of a local plan. The obligation to connect enforced as part of a local plan is regulated according to the planning law. This procedure does not require as specific an assessment of the obligation and does not assume that the local authority has decided to which form of supply - DH or natural gas - the building must be connected.

5.1.4 Exceptions to the obligation
Certain existing properties may be exempted from the obligation to connect or to remain connected. This applies to properties in which:

- conversion requiring necessary, larger installations or building restructuring is disproportionately expensive; this could apply, for example, to houses equipped with electric radiators;
- more than 50% of a building's heat requirement is covered by specific renewable energy installations for surplus installations (in order to be exempted in this case, however, the building must have been equipped with, for example, a wood pellet furnace of sufficient capacity when notification was made of the obligation to connect);
- buildings are to be demolished in the near future and buildings are not intended to be heated year-round.

5.1.5 Dispensation
The local authorities determine whether or not a property is eligible for exemption from the obligation to connect.

In certain cases, and on the basis of an impartial assessment, local authorities may dispense with the obligation to connect or may extend the 9-year deadline.

Irrespective of the justification for this dispensation, it may cease to be valid if the property concerned changes ownership.

In practice, Danish local authorities grant the dispensation in various ways. Some local authorities seek to establish alternative forms of residences, some take the related social conditions into consideration more than others do, and in some cases the public supply is more economically vulnerable than in other areas.

For low-energy houses, local authorities have the power to dispense with the obligation to connect.

Some of the houses being built today are so well insulated and energy efficient that it is not worth connecting them to district heat - either for the house owners or for possible, new public heat supply installations. Householders in these cases use so little heat that there may well be no savings, even though district heat is inexpensive. In these cases, there is very little market for public heat supply since such houses are energy efficient and therefore consume relatively little heat.

The Energy Authority therefore considers allowing other forms of heating than district heating, such as electric heat and renewable energy sources, for new, low-energy houses. The Authority assesses which areas and which buildings might be concerned and which surcharges could be applied to the houses' maximum energy consumption.

5.1.6 Senior citizens

Senior citizens require dispensation from obligatory connection to the public supply. The dispensation is only valid for senior citizens and no longer applies if the owner of the property concerned is no longer a senior citizen (in the case of transfer of ownership, for example). This is because investment in a new heat installation needs to be written off over a relatively long period.

A local authority may choose to grant dispensation in cases in which a citizen is in difficult circumstances.

5.1.7 When the obligation applies

The property owner's rights and duties are the same whether the law on heat supply or the planning law were used to enforce the obligation to connect.

The obligation to connect means that a property owner is always obliged:

- to allow the supply company to install the necessary technical installations (pipes etc.) and to pay a lump sum to cover the related expenses (connection charges)
- to pay standard charges that are part of the heating bill.

On the other hand, the property owner is not obliged to buy either district heat or natural gas. For example, an owner with an oil furnace may choose to continue to use it. An owner may also choose to supplement the installed system with wood pellets, for example. In other words, the obligation to connect is not synonymous with obligatory purchase.

The obligation to connect is intended to ensure that there is sufficient connection to public supply and that the supply company's investments in the grid and the installation are covered. Consumers also pay for the security of having a sup-

APPEALING AGAINST THE OBLIGATION TO CONNECT

The local authorities enforce the obligation to connect and to remain connected.

Citizens and other parties may appeal against obligations to connect enforced according to the law on heat supply, exemptions or dispensations. The appeals are sent to the Energy Board of Appeal, Frederiksborggade 15, 1360, Copenhagen K.

Requests for appeal of an obligation to connect as part of a local plan must be sent to the Nature Protection Board of Appeal, Frederiksborggade 15, 1360, Copenhagen K.

The appeal must be made in writing and sent within 4 weeks of the citizen having been notified of the local authority's decision to enforce the obligation to connect.

Photo: Torben Skøtt

Enstedværket

THE THREE-TIER TARIFF

The three-tier tariff is based on when the electricity is produced. During peak load (in the mornings and evenings, for example), the price of electricity is high; during high load (daylight hours), the price is medium-high; and during low load (night-time), the price is relatively low.

Electricity from decentralised CHP is not put on the electricity market but sent directly to consumers who, according to the law, are obliged to purchase the electricity produced and to pay for the related costs. This is known as the obligation to purchase.

The companies responsible for ensuring electricity supply in Denmark set the tariff periods and prices in accordance with the law. A price is calculated for each period, on the basis of a reference plant's installation and operational costs, as well as saved grid costs and transmission loss. The tariff therefore also depends on the voltage level at the connection point. For example, during the first half of 2002, the following time-period tariffs were used (in øre/kWh):

LOW LOAD	HIGH LOAD	PEAK LOAD	AVERAGE
21	45	57	34-35

Generating plants' total electricity prices consist of the three-tier tariff plus subsidy in the form of either an electricity production subsidy or a surcharge. Natural gas and waste- plants receive up to a total of 45 øre/kWh in a given period, while plants based on biomass and biogas receive a total of approximately 60 øre/kWh.

ply system available and capable of delivering the amount of energy they require.

When a consumer takes possession of a building and there is no public supply in place, the local authority and the supply company (each responsible for 50% of the related costs and at no extra charge to the consumer) must ensure that the building is provided with provisional heat supply. Alternatively, the local authority may dispense with the obligation to connect. Such dispensation means that it is no longer obligatory to connect the property to public supply.

5.2. THE BAN ON ELECTRIC HEATING

Electric heating is banned in all new houses and in existing houses with water-based central heating systems and located in areas with public supply (either individual natural gas or DH).

Local authorities were notified of the ban - known as the "Ban on Electric heating" on 6 May 1994.

5.2.1 What is not allowed

According to the ban, new or existing properties with central-heating installations may not remove radiators, hot-water tanks etc., and replace them with electric heating. It is not permitted to install electric heating as the main heat source.

5.2.2 What is allowed

The ban does not apply:

- to houses in which electric heating had already been installed when the ban took effect;
- if the building's existing installation cannot be - or only with difficulty - connected to the public heat system;
- if an extension is made to a house equipped with electric heating (although not in cases of a new building)
- to heat elements in a water-based central heating system or electricity-powered heat pumps;
- electric radiators and electric water heaters which supplement other heat sources (for the heating of storage rooms, attics, or little-used rooms, for example);
- electric heating in summer houses, weekend cottages, garden allotment houses etc.

5.3 TRANSFER PRICE FOR ELECTRICITY

Electricity production from decentralised CHP provides one-quarter of Denmark's total electricity consumption.

Decentralised CHP receive up to three different types of payment for their electricity: electricity transfer price + electricity production subsidy + surcharge. The transfer price for electricity is described in this section, while surcharges and subsidies are described in Section 5.4.

The electricity produced by decentralised plants is sold at a set price, the so-called "three-tier tariff" (Executive Order on electricity transfer prices for decentralised electricity producers, no. 786 of 21 August 2000). On 1 January 2005, a new transfer price system took effect for most decentralised electricity producers (the law amending the law on electricity supply and the law on heat supply, no. 495 of 9 June 2004). The three-tier tariff was in effect until that time.

Until the end of 2004, plants' electricity production is sold on the basis of the three-tier tariff, which is a special set price. The electricity produced is not put on the electricity market but sent directly to consumers, who are obliged to purchase it at a set price. In 2001, plants received DKK 1.3 billion more for electricity produced than if they had sold it at normal market prices during the same year.

Moreover, plants do not participate in the market for system output, that is, they do not contribute completely to supply security by being available when electricity is in short supply. The subsidy is therefore converted into a surcharge for electricity according to the three-tier tariff. Instead, as of 1 January 2005, plants will benefit from a new subsidy in the form of capacity credit in return for keeping their installations operational and available to the electricity market.

The basic principle is that after transfer to market conditions, a capacity credit is applied corresponding to the difference between the three-tier tariff and the market price. The subsidy is reduced when electricity prices rise. When the electricity price is higher than 11 øre/kWh, the capacity credit is reduced and is eliminated completely when the price is 34 øre/kWh or higher. The plant is thus ensured the same income as previously. Individual plants will therefore be well-prepared to maintain the same heat price before and after transfer to the electricity market.

According to the draft bill, plants will typically sell their electricity at market price + electricity production subsidy at 8 øre/kWh for a given amount of power + capacity subsidy (which is the difference between the plant's revenues from the three-tier tariff and sale at the electricity market price). If the plant skilfully adapts production to the market price, it will have higher total revenues than by applying the three-tier tariff.

The capacity subsidy may be enjoyed for 20 years from the date the plant is connected to the electricity grid, and in any case for at least fifteen years as of 1 January 2004.

A transition system has been established for plants under 10 MW:

- for a period of two years, until 1 January 2007, plants between 5 and 10 MW may decide when they want to switch over from the three-tier tariff system to the new subsidy model;
- plants under 5 MW will be able to continue applying the three-tier tariffs as currently calculated; these plants are free to choose to switch over to the new subsidy model at anytime.

5.4 HEAT PRODUCTION: TAXES AND SUBSIDIES

As has already been mentioned, during the 1990s many heating plants were converted to decentralised CHP. Most of the plants producing DH today also produce electricity. The regulations on subsidy for electricity production, calculation procedures for state subsidies and

Photo: Torben Skøtt

Haslev CHP

surcharges for renewable energy, as well as taxes on DH from CHP, are described in this chapter.

5.4.1 Tax on heat from co-generated heat and electricity production

As of 1 January 2002, taxation of co-generated heat and electricity for gas consumption used to generate heat was changed for decentralised CHP, including those producing industrial co-generated heat and electricity.

Operators may choose to calculate taxable gas consumption for producing co-generated heat and electricity in one of two ways.

Either on the basis of the heat production divided by 1.25. That is: fuel (heat) = heat production/1.25.

Or on the basis of the total gas consumption minus the gas consumption for electricity generation. Electrical efficiency remains set at 65%, which means that the taxable gas consumption is calculated as follows: fuel (heat) = fuel (total) - (electricity production/0.65).

5.4.2 Tax-free fuels and peak and reserve loads

As of 1 January 2005, decentralised CHP will be able to produce heat without electricity within more flexible frameworks. When the electricity market price is low, plants will be able to produce heat with so-called "peak" and "reserve" load boilers, thereby avoiding uneconomical production of electricity and yet still producing district heat.

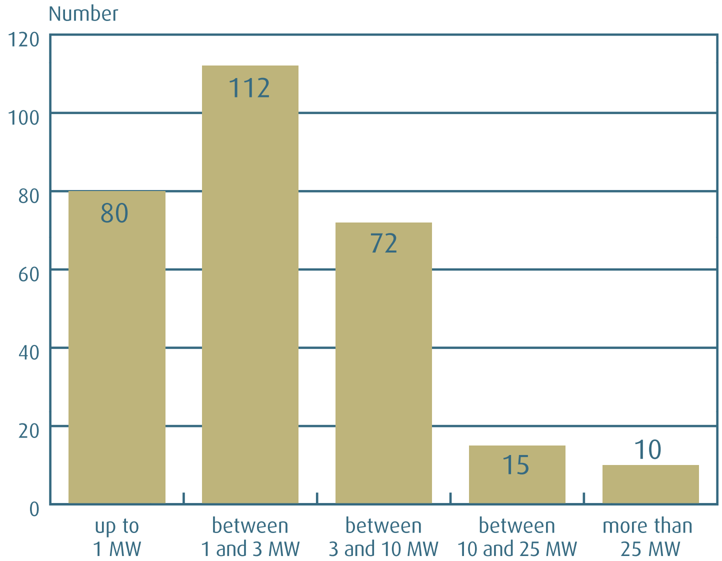
Plants are equipped with peak and reserve load installations (with the exception of those burning cereals, rapeseed oil and other foodstuff-based fuels). For example, a plant could choose to use tax-free fuels in the form of wood pellets instead of taxable natural gas. When plants, as of the beginning of 2005, are able to produce large quantities of heat with peak and reserve load installations, there may well be a significant revenue loss for the government. The law on heat supply has therefore been amended so that state financial considerations are included in local authority heat planning (the law amending the law on electricity supply and the law on heat supply, no. 495 of 9 June 2004).

Changes has been made to the project regulation so that, as of the beginning of 2005, only natural gas or oil may be used in existing natural gas plants' peak and reserve load boilers. Local authorities may

Gas boiler at Skive DH

Photo: Henrik Flyver Christiansen

NUMBER OF DECENTRALISED CHP WITH PUBLIC SUPPLY, ACCORDING TO SIZE



only approve use of tax-free fuels in two instances. Either when peak and reserve load boilers are enlarged due to increased heat demand; or when boilers are established in connection with existing co-generated heat and electricity production using biogas, landfill gas etc., that is, when the main fuel is already tax-free.

5.4.3 Electricity-production subsidy

The objective of the subsidy system for electricity production is to promote co-generated heat and electricity production. Today, an electricity production subsidy is made available to CHP which produce electricity from waste, natural gas or natural gas in combination with biogas.

Regulations on the electricity production subsidy have been changed several times (most recently in the Executive Order based on the law on electricity production subsidy, no. 490 of 13 June 2003, and subsequent amendments). As of 1 July 2002, the electricity production subsidy for most decentralised CHP was reduced. The lower subsidy is compensated for by the fact that correspondingly less must be paid in heat tax.

According to the regulations, new decentralised CHP with public heat supply and which began operating after 1 July 2002 do not receive the electricity production subsidy (Executive Order no. 512 of 16 June 2003 on electricity-production subsidy). The subsidy is also abolished for the relatively few existing natural gas-based, decentralised CHP with an electricity capacity of more than 25 MW, although such plants do still receive tax relief.

More than 285 decentralised plants began operating before 1 July 2002 and produce electricity and heat for public supply. As shown in the figure below, all but 10 of these plants have less than 25 MW of output and - as well as a number of central heating plants eligible for subsidy - still receive electricity production subsidy.

The electricity production subsidy is outlined below. For further details, see Executive orders nos. 490 and 512, referred to above.

The **existing decentralised, natural gas-based CHP or those using combined natural gas and biogas** receive a subsidy amounting to 8 øre/kWh for electricity production if the plant's total electricity capacity is 25 MW or less. The subsidy provides support for 80 million kWh of annual electricity production. This ceiling does not apply to open-field plants.

For industrial co-generated heat and electricity production based on natural gas or waste, an electricity-production subsidy of 7 øre/kWh is available for 6 years from the date the individual installations begin operation. This subsidy is available only to plants that began operation before 1 January 2004. The subsidy does, however, apply for 8 years for electricity production at industrial CHP with a total electricity capacity of 4 MW or less.

If the installation or a significant part thereof is replaced, a subsidy of 2 øre is available for a new 6 or 8-year period (applicable only to plants which began operation before 1 January 2004.

All electricity produced from waste - with the exception of industrial co-generated heat and electricity - receives a subsidy of 7 øre/kWh, with a larger subsidy of 10 øre/kWh available to waste-based CHP with a capacity of 3 MW or less and that began operation before 1 January 1997.

5.4.4 Surcharge

Electricity produced by decentralised and industrial CHP based on natural gas and waste are supported with a state electricity production subsidy. The centralised CHP based on biomass and biogas are subsidised in another way. They receive a surcharge, which is paid by consumers.

As of the beginning of 2005, the following are the most frequently used surcharges.

CHP using wood chips or straw as fuels receive a surcharge if they were connected to the grid no later than 21 April 2004. Together, the surcharge and the market price amount to 60 øre/kWh. The surcharge increases by the amount of øre/kWh that the market price for electricity falls - and vice versa.

The total settlement amounts to 60 øre/kWh over 20 years, and in any case for at least 15 years as of 1 January 2004.

CHP using biogas as fuel also receive a settlement. If the plant was connected to the grid by 21 April 2004, it receives a total settlement of 60 øre/kWh over 20 years, and in any case for at least 15 years as of 1 January 2004.

Biogas installations receive 60 øre/kWh during the first 10 years and 40 øre/kWh in the following 10 years, if the plant was connected to the grid between 22 April 2004 and the end of 2008.

Special regulations apply if a **CHP uses both biogas and natural gas.** In this case, the plant receives the same payment for power as an ordinary decentralised CHP (see Section 5.4), plus a special surcharge.

If the plant began to use biogas before 21 April 2004, it receives a surcharge of 26 øre/kWh for biogas-based electricity over a period of 20 years, and in any case for at least 15 years as of 1 January 2004.

If the plant began to use biogas between 22 April 2004 and the end of 2008, it benefits from a special surcharge for biogas-based electricity of 26 øre during the first 10 years and a reduced surcharge of 6 øre/kWh during the subsequent 10 years.

DEFINITIONS

Area limitation
In a given public supply area, there may only be one form of supply: either DH or individual natural gas. This limitation of areas with DH and areas with individual natural gas is called area limitation and was first established during the 1980s in regional plans, intermediate plans and local-authority plans.

Block Heating unit
A Block Heating Unit is a plant set up in connection with the construction of a large building or building complex. The goal is to supply a closed group or a previously determined number of users. A Block Heating Unit is a large-scale consumer or a major customer.

Capacity
Term used to describe how much electricity or heat a plant has been built to produce or how much energy a grid has been built to transmit.

Condensing power plant
Power plant producing only electricity. There are now only very few such plants in operation.

CO_2
Also written as "carbon dioxide". One of several gases collectively known as greenhouse gases.

CO_2 shadow price
The price society must pay in order to avoid emitting one ton of CO_2. The shadow price is used to assess various heat supply projects. In order to reduce CO_2 emissions, a heating plant may, for example, convert to a more energy-efficient form of production (co-generated heat and electricity) or to a less polluting fuel. Production changes of this kind can lead to lower CO_2 emission in Denmark. The price for converting production is calculated and compared with the number of tons of CO_2 emission eliminated. In the heat supply context, the CO_2 shadow price is therefore used to assess whether the additional cost of reducing CO_2 emission is justified by investment in the project.

Efficiency
There are various terms used to designate efficiency. The total efficiency is that part of the energy conveyed which an energy installation converts to electricity or heat. Fuel efficiency describes the percentage of a given amount of fuel that actually generates heat and electricity. Electricity efficiency describes the percentage of a given amount of fuel that actually generates electricity.

Electricity company
Term designating plants that produce or supply electricity.

High load
The price for electricity produced by decentralised CHP depends on when it is produced. There are three different tariff periods: low load, high load and peak load. The peak and high-load periods are between 5 AM and 10 PM. The low-load hours are between 10 PM and 5 AM.

Load
See: high load.

Local plan
Local authorities must draft local plans for large building and installation work or development, on the basis of which they implement local authority plans. The local plan sets the regulations governing which buildings, roads, walkways, greenery, open space etc. are to be located, set up and used within a given area.

The plan is made available for public hearing for at least 8 weeks so that citizens and other parties have the opportunity to comment, object, or suggest changes. At the same time, the local plan must always be submitted to the county council (which assesses whether or not the proposal conforms to the regional plan), to the Minister of the Environment and any other state or local authorities within whose jurisdiction the proposal falls. On the basis of the public hearing, the municipal council decides whether or not the local plan is to be definitively approved. The local authority has the power then to grant dispensations from the local plan, on the condition that so doing does not significantly alter the particular conditions which the plan is intended to establish or maintain.

Micro co-generated heat and electricity
A micro-CHP is a small CHP supplying only one consumer.

Output
The output for an installation (boiler or motor, for example) is its yield, most often measured in MW or kW. It is the amount of energy an installation can produce in one hour (or other time unit).

Peak load
See: high load.

Planning directives
The Ministry of Energy issued the following directives as a follow-up to the 1990 law on heat supply:

- general directives concerning fuel choices and co-generation at DH plants, taking effect as of 13 September 1990;
- directives concerning the conversion of existing central heating plants and the establishment of new central heating plants over 0.25 MW, taking effect as of 13 September 1990;
- specific directives for most of the country's local authorities.

The directives are heat planning guidelines for local authorities. They contain specific and general requirements for power plants and central heating plants concerning, for example, the choice of technologies.

Process energy
Energy used in industrial production, to grow fruit, flowers etc.

Public supply
A form of supply in areas where houses or businesses/industry are in close proximity.

Public supply grid
Term describing gas pipelines and/or DH pipes, as well as the plants themselves.

Supply company
A term designating companies which supply consumers with heat or electricity.

Supply security
According to this concept, particular arrangements must be in place to cover all energy

demand (installations, plants, motors etc.), particular fuels at accessible prices and appropriate supply mechanisms (pipeline networks). With reference to electricity, this means that each individual consumer has the right to pay for and receive electricity. The right to supply includes the right to be connected to the public electricity supply grid and the right to a delivery offer from an enterprise responsible for supply.

Surplus heat
Surplus heat is an energy surplus resulting from a particular industrial process. For example, surplus heat is generated when glass hardens after founding (or during evaporation, fermentation etc.). Surplus heat is also known as waste heat.

System responsibility
In Denmark, two companies are responsible for the system: Elkraft System (east of the Great Belt)and Eltra (west of the Great Belt). These companies are independent companies responsible for the electricity system's overall operational reliability and for complying with the public obligations prescribed by the law on electricity (supply security, consumer protection and respect for the environment).

Three-tier tariff
Term designating the price system whereby decentralised CHP sell their electricity at a price which depends on when the electricity is sold. There is one price for each of three time zones in the day.

Units of measurement
1 kW (kilowatt) = 1,000 W
1 MW (megawatt) = 1,000 kW
1 GW (gigawatt) = 1,000,000 kW

1 kW hour (kilowatt hour) = 1,000 watt hours
1 MWh (megawatt hour) = 1,000 kWh
1 GWh (gigawatt hour) =1,000,000 kWh
1 TWh (terrawatt hour) =1,000,000,000 kWh

CONVERSION TABLE

Output

1 kW	=	1 kJ/s

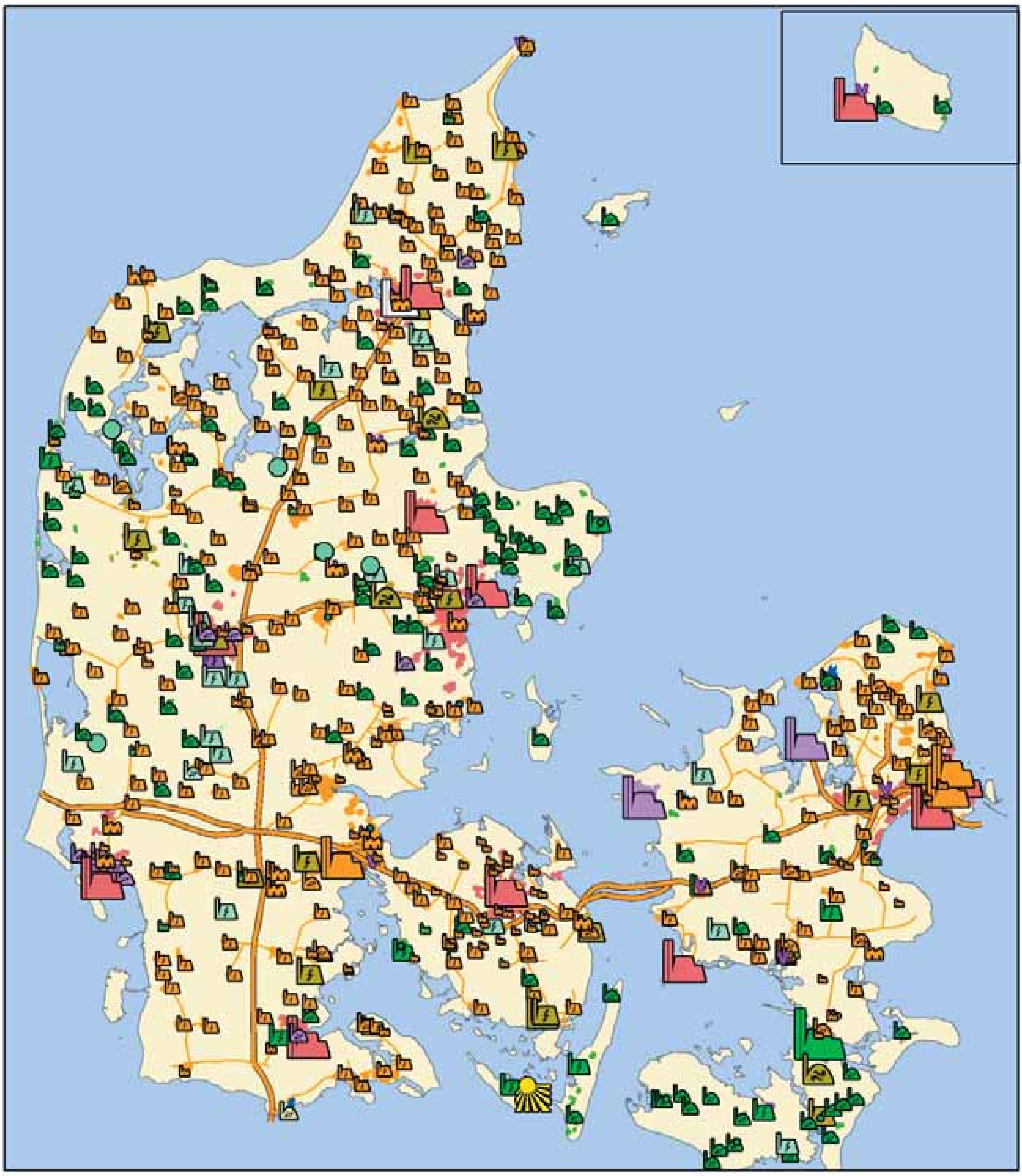
Energy

1 kWh	=	3,6 10^6 J
1 MWh	=	3,6 GJ
1 GJ	=	0,278 MWh

k (kilo)	=	10^3
M (Mega)	=	10^6
G (Giga)	=	10^9
T (Tera)	=	10^{12}
P (Peta)	=	10^{15}

J (Joule)

ENCLOSURE 1: MAP OF DENMARK'S HEAT SUPPLY



Explanation of symbols

Plant type

- Centralised plant
- De-centralised CHP
- DH plant without electricity production
- Industrial co-generated heat and electricity

Primary fuel

- Coal
- Natural gas
- Oil
- Biomass
- Biogas
- Waste

Natural gas transmission

- Primary natural gas pipeline
- Secondary natural gas pipeline

ENCLOSURE 2: TIMELINE FROM 1973 TO 2002: HEAT SUPPLY IN FOCUS

October 1973
Saudi Arabia cuts back oil production, resulting in sharp price increases. The government sets up the Energy Commission and the Oil-Saving Commission.

November 1973
Car-free Sunday. Housing associations call for hot water shutoff on weekdays and reduction of room temperature.

February 1974
Normal car Sunday.

May 1975
The energy policy report points out the need for energy savings, co-generated heat and electricity, and presents a proposal on Danish atomic power.

July 1975
The Academy for Technical Sciences: Denmark must focus on wind energy.

January 1976
Denmark's first overall energy plan: "Danish Energy Plan '76". The plan is intended to lay the basis for a long-term energy policy.

April 1976
The Danish Energy Authority is established.

Electricity tax introduced (2 øre/kWh)

September 1977
The law on state subsidy for the utilisation of surplus heat from CHP.

October 1977
Oil tax introduced (7 øre/l).

March 1979
Energy Report 1979 is presented to Parliament. A central point is the plan to establish a natural gas system and CHP.

June-July 1979
First law on heat supply.
The 2nd energy crisis begins.
Sharp oil price increases.
All energy taxes increased.

October-November 1979
The Ministry of Energy is established.

Opinion poll shows majority in favour of Danish atomic power, on the condition that the waste problem is solved.

November 1980
Experts suggest that Danish fields in the North Sea can supply Denmark with oil and gas for 20 years.

Law on state subsidy of energy savings in residential properties.

January 1981
Law on state subsidy for utilisation of renewable energy sources.

April 1981
Heat planning is begun throughout the country. Mapping of heat supply is to be completed before 1 April 1982.

December 1981
"Energy Plan '81" is issued.

February-March 1982
Executive order on approval of projects for public heat supply and executive order on obligatory connection to public heat supply.

June 1982
Parliament focuses efforts on North Sea oil. Ceiling set on the natural gas price corresponding to the oil price. Coal tax introduced. Coal for energy generation is exempted.

September 1983
The Ministry of Energy undertakes a study of possibilities for improving the natural gas project's finances.

April 1984
Agreement between the government and the Social Democrats on support for the natural gas project. Natural gas to be promoted in heat supply. In the meantime, no new coal-fired plants are to be built.

October-November 1984
North Sea natural gas production begins.

The Ministry of Energy directs power plants to adapt installations to natural gas.

March 1985
Parliamentary decision on public energy planning without atomic power. Coal eliminated from heat planning.

December 1985
Energy taxes increased following the oil price drop.

January-February 1988
For the first time in 25 years, Danish oil and gas production shows a surplus.
Denmark's first public biogas and straw-burning plants begins operation.

October 1988
Electric heat is permanently banned in new buildings and in areas with DH or natural gas.

November 1989
Report on the natural gas project's finances shows a major deficit. Report suggests obligatory connection and natural gas in coal-fired CHP.

March 1990
Agreement between the government and the Social Democrats on increased use of co-generated heat and electricity, natural gas and other environmentally friendly fuels, as well as on electricity growth in the 1990s.

April 1990
"Energy 2000 - Action Plan for Sustainable Development". Objective: 15% decrease in energy consumption and at least 20% decrease in CO2 emission up to 2005.

June 1990
2nd law on heat supply.

September 1990
Planning directives for fuel choice and co-production sent to all local authorities.

December 1991
CO_2 tax package approved by Parliament. Takes effect in May 1992.

January 1992
Law on subsidy for:
- energy savings in industry
- decentralised co-generated heat and electricity and utilisation of biofuels

January 1992 (cont'd)
Law on subsidy for:
- electricity production
- completion of DH grid
- conversion of older houses to co-generated heat and electricity

June 1993
Majority agreement in Parliament on biomass. EU enacts SAVE and ALTERNER.
December 1995
Fixed electricity transfer price for decentralised CHP is written into the law on electricity supply

April 1996
"Energy 21" – Government Energy Action Plan 1996
June 1996 Law on promoting energy and water-saving in buildings.
December 1996 Law establishing the Foundation for Saving Electricity

July 1997
Supplementary agreement to the 1993 biomass agreement
May 1998
Denmark is self-sufficient with energy.
March 1999 Electricity reform - electricity market liberalisation.

June-July 1999
Law (2) on electricity production subsidy.
"Energy 21" status report.
March 2000
"Climate 2012 - Status and Perspectives for Danish Climate Policy".

June-July 2000
3rd law on heat supply. A political majority decides to help the country's 250 decentralised CHP and open-field plants.

September 2001
The Danish District Heating Association publishes the results of its heating price study, which shows that most DH is competitive with individual oil heating.

February 2002
A large majority in Parliament enters into an energy policy agreement, setting aside DKK 85 million for debt reduction in open-field plants and making decentralised CHP tax-exempt.

DANISH ENERGY AUTHORITY

There are two-a-half-million heating installations in Danish homes. Of these, more than half are district heating installations. Today, most district heating is produced along with electricity and is known as co-generated heat and electricity. If you would like to know more about heat supply, about the use of fuel in heat production, about regulations or environmental consequences, then this booklet is a good place to start.

The booklet gives an overview and an easily understandable description of heat supply. The first chapters are intended for anyone interested in heat supply. The last two chapters provide a more detailed orientation to regulations and subsidy systems and as such are intended more for local authorities and other administrative bodies with prior knowledge of the sector.

This publication will be updated at least once a year and will be published on the Danish Energy Authority's website: www.ens.dk

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