Danish Energy Agency

Regulation and planning of district heating in Denmark

Contents

Preface

Denmark is one of the most energy efficient countries in the world. The widespread use of district heating (DH) and combined heating and power (CHP) is one of the most important reasons why it has been possible to increase energy efficiency and reduce carbon emissions over several decades.

The district heating (DH) system is a cornerstone in Denmark's green and efficient energy system. Not only does DH ensure that Denmark has a sound and reliable heating supply but also greatly supports Denmark in maintaining a sustainable energy sector and fulfilling the longterm energy policy targets. Therefore, we have prepared this publication to serve as an inspiration to other countries seeking to achieve some of the same benefits from DH as we have.

The publication presents an overview of DH in Denmark and how the DH system, through its inherent flexibility, has been able to support different Danish energy policy ambitions over time, including targets on energy efficiency and renewable energy. DH has been a very important element in Danish energy policy for many years and it still is today.

The first chapter presents the main characteristics of today's district heating where DH networks provide heat for nearly two thirds of private households in Denmark both for space heating and domestic hot water. A main focus in Denmark is to reuse heat that would otherwise be wasted, for example by utilizing waste heat from power production. Moreover, almost half of DH in Denmark is produced from renewable energy and waste-to-energy.

Chapter 2 presents the historical development of Danish DH. The first CHP plant was built more than 100 years ago in 1903 to supply electricity and heating for a hospital. But it was in the aftermath of the two international oil crises in the 1970s that the development of DH in Denmark really gathered speed. By now, Denmark has obtained decades worth of valuable experience within DH and CHP.

In 1979, Denmark passed its first heating supply law and, although there have been several revisions, it is still in effect today. Chapter 3 describes the heating supply law and how the important status of DH today is the result of many years of active energy policy, systematic heating planning and regulation.

Looking ahead, DH systems remain a key element of the energy system in Denmark. By 2020, about half of the Danish electricity consumption will be supplied from wind power. This has increased the focus on flexible DH/CHP systems using, for example, heat storage, electric boilers, heat pumps, and bypass of power turbines, to support integration of wind power into the energy system. Chapter 4 presents these latest developments and future trends within DH in Denmark.

The final part of this publication provides a brief overview of some of the core competences of the Danish DH industry, and gives information about the Danish Energy Agency's bilateral cooperation with several countries within renewable energy and efficiency, including DH.

We are looking forward to sharing the many years of Danish regulatory experience in ensuring a sustainable energy sector development.

I hope you will be inspired.

Morten Bæk
Director General of the
Danish Energy Agency
December 2015

Main characteristics of today's Danish district heating

Today, 63 % of all private Danish houses are connected to district heating – not only for space heating, but also for domestic hot water. Denmark has six large central DH areas with a total heating supply of 67 petajoules (PJ) in 2014, 56 % of the national DH supply. There are also around 400 small- and medium-sized DH areas with an annual heating supply of approximately 53 PJ.

In 2014, the total DH supply in Denmark amounted to 122 PJ and 68.9 % of all DH was produced in cogeneration with electricity (CHP). This saves a significant amount of fuel compared to separate generation of heating and power.

PRODUCTION OF HEATING AND HEATING AREAS

Heating supply options

Different technologies are used for heating supply in Denmark. Some consumers use an individual oil boiler, gas boiler, biomass boiler or heating pump, but most consumers (over 60 %) receive their heating from the DH system.

DH is primarily established in areas where the building density, and thus the heating density, is relatively high (i.e. in urban and suburban areas). However, also smaller towns and large villages of around 500 households can be supplied with DH.

In order to distribute the heating within the buildings, most heating consumers have water based heating systems, i.e. radiators or floor heating systems. New buildings have heating systems with relatively large heating transfer surfaces, which allow for lower temperatures in the DH network.

The domestic hot water is typically produced using DH via an instantaneous heat exchanger. There may also be a hot water tank to assist with smoothing out the peak demand.

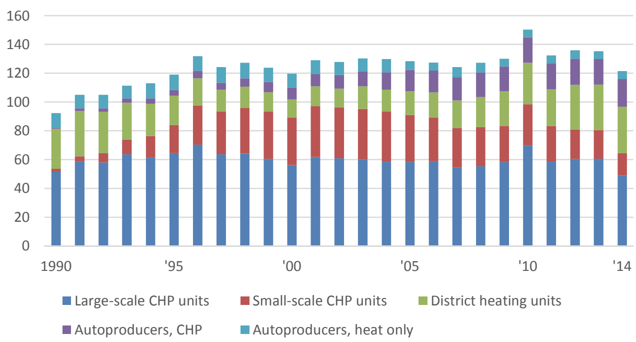
Production of district heating

The production of DH is mainly from combined heat and power plants (CHP) or heat only boilers (HOB).

Heat and power generated using CHP has a significantly higher efficiency than heat and power generated separately. Typically, a heat only boiler has an efficiency of around 90-95% and a condensing power plant generating electricity only has an efficiency of 40-50%. A CHP plant may have a total efficiency (combined heating and power) of 85-93% resulting in an overall fuel saving of approximately 30% compared to separate production of heating and electricity.

Figure 1 shows the development over the last two decades in DH production in Denmark by type of production plant.

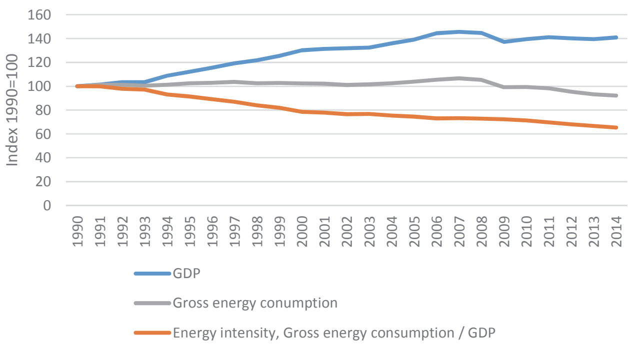
Figure 1: DH production by type of production plant



As this figure shows, DH production especially from small-scale CHP units and surplus heat from industries (so-called auto-producers) has developed significantly over the years. During recent years, however, the production from small-scale CHP units has decreased slightly and the production at DH units (heat only boilers) has increased correspondingly. This is mainly due to lower market prices of electricity.

In 2014, more than 68 % of the DH in Denmark was produced by CHP units. The widespread use of DH combined with the large share of cogeneration with electricity is one of the key reasons why it has been possible to increase energy efficiency, decouple the development in energy consumption and economic growth (GDP), and reduce carbon emissions over severel decades. The decoupling of energy consumption and GDP is illustrated in the figure below.

Figure 2: Energy consumption, GDP and energy intensity



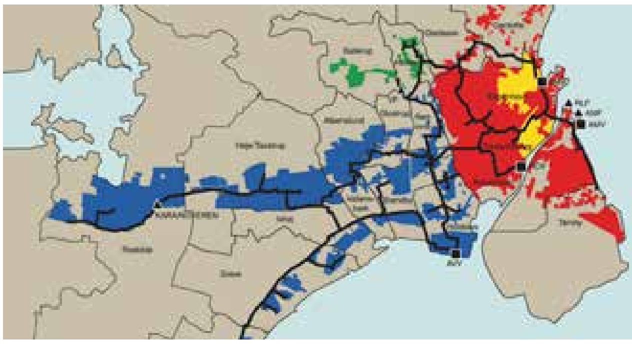
A number of large CHP units

In general, the large-scale CHP units are located in large urban areas whereas the small-scale CHP units and DH boilers are located in smaller cities and villages. This distribution is shown on the map of heating supply in Denmark included in Appendix A.

The large-scale networks typically consist of a number of distribution networks interconnected by a transmission grid. Heating is produced at a variety of different plants including large generation plants (based on coal, biomass or natural gas), municipal waste plants, surplus heat from industry, and peak load boilers.

An example of a large central DH area is the Greater Copenhagen DH system, shown in the figure below. It is by far the largest system in Denmark supplying 35 PJ of DH annually. The distance from the eastern to the western part of the system is approximately 50 km.

Figure 3: The Greater Copenhagen DH system – the largest Danish DH system



A variety of medium and small-scale CHP units and DH boilers

The smaller DH areas vary in size but typically consist of a single distribution network in each area. Heating is produced by one base load unit and one or more peak and reserve units. The base load unit is typically a natural gas CHP unit or a biomass boiler (e.g. straw or wood chips). The peak and reserve boilers are typically heat only boilers based on oil or natural gas (which have low investment costs). Today several areas also have supplementary solar heating or electric boilers.

The value of heating storage

One very important element of all Danish DH networks is short-term heat storage. This means that the CHP plants can optimise their cogeneration according to the electricity demand without compromising the heating supply. Both large and smaller DH systems utilise short term heat storages.

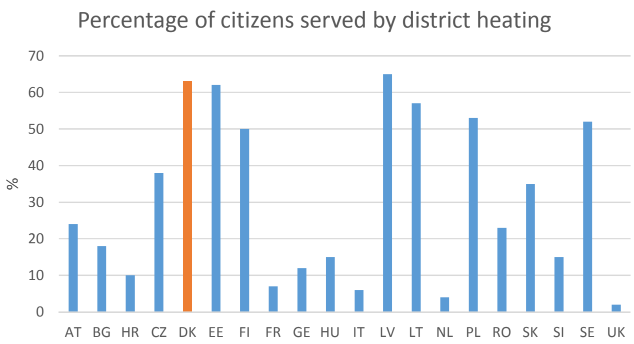
Heating storage allows CHP plants to decrease their production when there is plenty of electricity in the system, e.g. when it is very windy. Similarly, they can increase their production when there is a higher electricity demand. When the heat production is higher than the excess heat demand, the heating is simply stored. Conversely, when the heat production is lower than the demand, heat energy from the storage can be used.

Typically, short-term heat storage has a storage capacity corresponding to approx. 12 hours of full load heat production at the heating plant.

The short-term heat storage introduces a flexibility to the energy system, which is crucial to optimise the total system, both economically and environmentally.

Danish DH and CHP expansion in an EU context
The figure below shows the percentage of citizens supplied by DH in a number of EU countries.

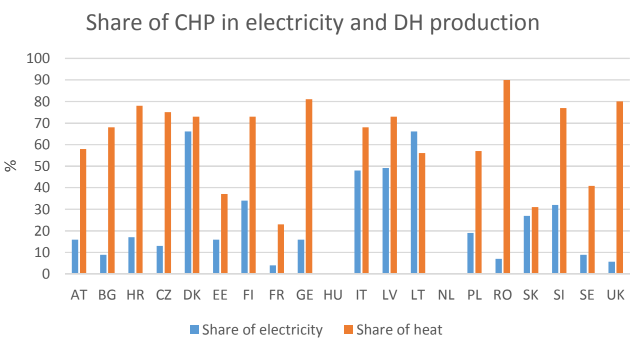
Figure 4: Percentage of citizens supplied by DH, 2013



Among EU countries, Denmark has one of the highest shares of DH (63%) along with Latvia (65%). Finland, Lithuania, Poland and Sweden also have more than a 50% share of DH.

The figure below shows the share of CHP in electricity and DH production for a number of EU countries.

Figure 5: Share of CHP in electricity and DH production, 2013



As can be seen above, more than 70 % of all DH in Denmark in 2013 was produced in cogeneration with electricity. Consequently, Denmark is the country with the highest share (more than 60 %) of national electricity generation from CHP. Lithuania is the only other EU country with an electricity share from CHP production of more than 50%.

FUELS FOR DISTRICT HEATING

From fossil fuels to biomass, waste and solar
The fuels used for heating production at heat only boilers and CHP plants comprise both fossil fuels (e.g. coal, oil and natural gas) and non-fossil fuels (e.g. biomass, waste and solar).

Biomass
Biomass has been part of Denmark's energy profile for many years. The energy crises in the 1970s compelled Denmark to rethink its use of energy, which at that time was dominated by the use of imported oil. Currently, Denmark is striving to create an energy system that is independent of fossil fuels by 2050, and biomass combustion is expected to be an important factor of this transition.

Both fossil and non-fossil fuels emit CO_2 when burned, which has an impact on global climate change. There are, however, big differences in how much CO_2 the different fuels emit. One gigajoule (GJ) of combusted coal emits 95 kg CO_2 whereas one GJ natural gas emits 57 kg CO_2. Biomass is often considered as being CO_2-neutral due to the assumption that the amount of CO_2 emitted during the combustion equals the amount of CO_2 bound in the biomass during the growth. This is, of course, true for all fossil fuels, but the relatively short regeneration time for biomass in comparison with coal or natural gas lead to its inclusion as a renewable source.

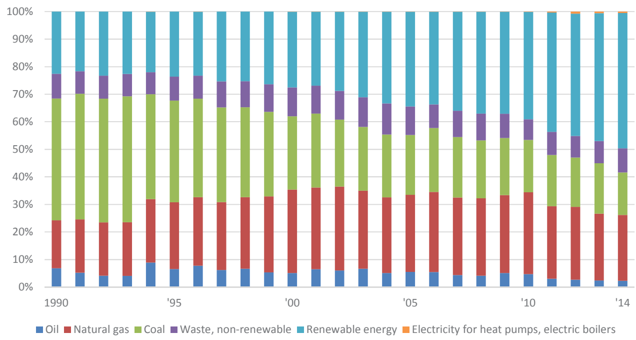
In recent years, the amount of heating produced by renewable sources and used in DH has increased. This is partly because some CHP plants in the large

DH areas have switched from using fossil fuels to biomass fuels (see also Chapter 2, "The history of Danish district heating").

The principal biomass resources utilised in Denmark (aside from waste) are wood pellets, wood chips, and straw. Biomass is primarily combusted and used for heat and power generation, and since 1993, Denmark has been increasing the deployment of large-scale biomass CHP plants. Older large-scale coalfired CHP plants are also being converted to biomass as part of the strategy to reduce CO_2-emissions.

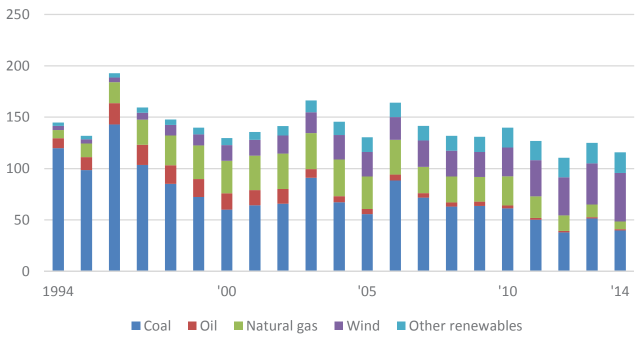
The figure below shows how the amount of biomass DH has increased significantly during the last decades. In 2014, the share of biomass was more than 40% of total fuel use for DH.

Figure 6: Fuel composition for district heating, percentage of distribution 1990-2014



Before 1995, biomass for DH was used mainly in smaller heat only boilers. But since that time, a number of both small- and large-scale biomass CHP units have been established. In addition, a number of large CHP plants have been converted from fossil fuel to biomass, or are planning a conversion. For this reason, the power generation from biomass has increased as shown in the figure below. In 2014, the power generation from biomass amounted to 13.8 TJ corresponding to 11.9% of total Danish power generation.

Figure 7: Power generation by fuel type (PJ)



The development of the use of biomass for district heating has been supported by grants, policies, and tax exemptions. For example, a political agreement on biomass in 1993 specified that centralised power and CHP plants should use 19.5 PJ/year of biomass by 2000, with certain shares from wood chips and straw. Amendments to the agreement were made in 1997 so that the shares of different sources of biomass could be adjusted according to annual variations, with the purpose to achieve better market conditions.

Today biomass used for heating is supported in the way that it (unlike fossil fuels) is exempt from fuel taxes.Furthermore, if biomass is used for power generation or CHP, the plant receives an add-on to the market price of electricity of 20 EUR/MWh.

Waste-to-energy

In addition to biomass, waste makes up an important energy resource for the production of DH.

In Denmark, waste is generally considered as an "energy resource" rather than a problem to be disposed of. Almost all waste, if not recycled, is used for energy production, and only a minor fraction of the waste is deposited in landfill.

Consequently, waste-to-energy is one of the corner stones in the Danish waste management system and benefits both energy consumers and the environment.

Typically, waste is used in CHP plants, thus producing both heat and power with a high overall efficiency.

Solar heating

Solar heating in Denmark started in the early 1980s with individual domestic installations of 8-10 m^2. In 2005, it was estimated that approximately 40,000 individual domestic systems had been installed. Over time, various financial support schemes have been available for solar heating installations.

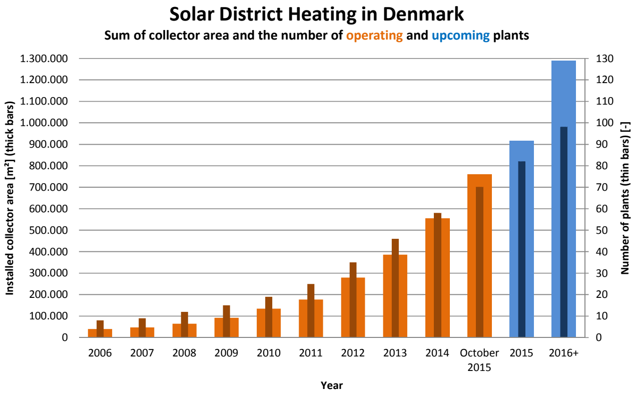
Before 2005, there were few solar heating plants in DH systems. However, the technological development in solar heating combined with a change in regulatory setup for small-scale CHP plants started a development of solar heating specifically for DH production.

Today Denmark is among the worldleading countries within the field of integrating large-scale solar heating into DH systems. During the last couple of years, the number of solar heating plants larger than 1,000 m^2 in Denmark has increased significantly. This is due to solar heating technology becoming cheaper and therefore a more viable alternative to natural gas during the summer. In addition, solar thermal heating is also exempt from fuel tax (see Chapter 3, "Regulation of the district heating sector").

In 2015, there were an estimated total surface area at large-scale solar facilities (>1,000 m^2) of more than 750,000 m^2, with the largest facilities being 70,000 m^2. Since the main solar production occurs in the summer, with heating demand being highest in the winter, many large solar DH systems often utilise seasonal thermal storage with capacities up to 120,000 m^3.

The figure below shows the development in solar heating in Denmark (plants larger than 1,000 m^2 only).

Figure 8: Development in solar heating in Denmark
Source. Danish District Heating Association



STRUCTURE OF THE DH SECTOR

Natural monopoly

The supply of DH is to a certain extent a natural monopoly. This is due to the economies of scale both for heat production plants and network costs

It would not be costeffective to have a parallel supply network distributing heating to individual consumers. The costs involved are so prohibitive that there is often only one provider in a given area. The production of district heating for a supply network is also monopoly-like in nature.

Who owns the plants?

With regard to ownership of energy generating plants in Denmark, there are various ownership structures. The largest plants tend to be owned and operated by large energy companies, whilst smaller plants are typically owned by municipalities or consumer owned cooperatives.

The Danish DH companies are organised in two different associations: the Danish District Heating Association and the Association of Danish CHP plants.

Supply controlled by the consumers

Common for all DH areas in Denmark is that the heating supply is controlled by the consumers heating demand. Consumer metering measures the actual heating demand, which means that the consumers have an incentive to save heat. Payment for heating is most often divided into a fixed part (per installation and/or capacity) and a variable part (per gigajoule of consumption).

COSTS AND PRICING

The heating price

The price of heating is not the same in all Danish DH areas, but the principles of determining the heating price are set by law (see also Chapter 3, "Regulation of the district heating sector").

The legislation states that the heating price paid by the consumer should cover all necessary costs related to supply heating. However, the heating supply company is not permitted to make a profit. Heating cost therefore includes:

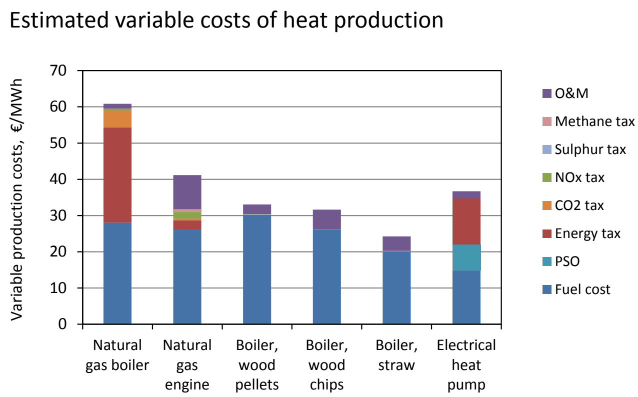
- Fuel costs
- Heating production facility
- DH network
- Buildings
- Operation and maintenance (O&M)

The heating plants cannot charge more for the heating than the costs of producing and transporting heating to the consumers. It is, however, important to emphasise that these costs also include depreciation of assets and financing costs, so that the heating companies can be financially sustainable both in the short and long term. Cost of heating to the consumer is therefore affected by the following parameters:

- Production facility investment
- DH network investment
- Production facility O&M
- DH network O&M
- Fuel prices
- Efficiency of the production facility
- Heat loss in the DH network
- Taxes and VAT
- Financial support/grants
- Electricity price (relevant for DH production facilities that either use or produce electricity)

In general, the fuel costs including taxes and VAT make up the largest proportion of the costs. The fuel costs are illustrated in the figure below, which shows an example of variable heat production costs of different technologies"

Figure 9: Fuel costs for heating production including taxes and VAT



The heating price is usually lower in large-scale networks than in the smaller networks. This is mainly due to economies of scale and higher heating density, which means that the larger networks have lower capital costs and heating losses per unit of heating supplied to consumers. Large production plants may also be able to buy fuels at a lower price than smaller plants.

Generally speaking, DH in most cases is cheaper for the consumers than if they had their own individual heat supply. This is also one of the deciding factors for implementing new DH systems in Denmark

Investment costs versus operating costs

Establishment of DH systems requires large investments in infrastructure compared to individual heating supply options. However, the operation costs and the environmental impacts are in many cases significantly lower. This is particularly the case if heating is produced by an energyefficient CHP unit or if heating is produced by utilising waste heating from an industrial plant, for example a steel or cement plant.

The life-cycle viewpoint

Danish experiences show that when evaluating the feasibility of DH, it is important to consider the costs over the full lifetime of a heating supply system (typically referred to as "levelized costs of energy" or LCOE). In many cases, DH is the most feasible solution over a full lifecycle analysis. Infrastructure investments will be recovered after some years by lower annual costs. Of course, viability depends on a number of factors including heating demand and the heating density in the specific area.

The use of high quality components, although initially increasing capital cost, usually results in lower annual costs. Therefore, in many cases, a lower lifetime cost due to lower maintenance costs and longer lifetime can be achieved with the use of highquality components. This also leads to lower annual heating costs for the heating consumers.

It is important to consider that the technical lifetime of a high quality DH network is typically 40-50 years.

The history of Danish district heating

The first combined heat and power plant in Denmark was built in 1903. It was a waste incineration plant, which made it possible to handle waste and to provide electricity and heating to a nearby hospital. Since then, significant developments have taken place. Denmark passed its first heating supply law in 1979, which has been followed by other successful policies.

From the early beginning
During the 1920s and 1930s, a collective DH system was developed based on waste heat from local electricity production. From here on, DH from CHP expanded in the larger Danish cities and by the 1970s, around 30% of all homes were heatinged by DH systems.

At the time of the energy crisis in 1973/74, energy consumption per capita had risen considerably. The energy crisis made it evident that saving energy (including heating) was critical both to decrease the dependency on imported fuels and to reduce consumers heating costs. Therefore, a decision was made to expand the fuelefficient CHP systems not only to the larger cities, but also to small- and medium-sized cities in Denmark.

First heating supply law in 1979
Up until 1979, there was no specific law regulating the heating supply in Denmark. Most heating consumers had small oilfired boilers or other forms of individual heating.

Denmark was greatly affected by the international oil crises. By the end of the 1970s this led to the formulation of an energy policy in Denmark aimed at improving the security of supply and reducing the dependency on oil.

In order to fulfil the policy goals and at the same time utilise the natural gas resources, which had recently been discovered in the Danish part of the North Sea, Denmark passed its first heating supply law in 1979. The law contained regulations regarding the form and content of heating planning in Denmark and became the beginning of a new era in public heating planning, which still exists today.

The planning was divided into steps. As a **FIRST STEP**, the local municipalities were required to map the existing heating demand, the existing heating supply method, and the amounts of energy (fuels) used. The municipalities also made an estimate of future heating demand and heating supply possibilities.

The information provided by the local municipalities from local planning was used by the regional authorities (i.e. the counties) to make regional heating supply overviews.

As a **SECOND STEP**, the municipalities prepared options for the future heating supply, whereas the counties prepared regional summaries.

Based on this, the counties prepared regional heating plans, which was the **THIRD STEP** in the overall heating planning.

The heating plans identified:

- The priority of heating supply options in any given area.
- The locations for future heating supply units and networks.

Zoning
Within the framework of the regional plan, and after negotiation with local energy utilities, the local authorities prepared municipal heating plans. The heating plans included “zoning” that defined which areas that were to be supplied by DH or natural gas, respectively. The purpose was to establishing efficient, low-emission energy systems in urban areas. Zoning also prevented overinvestments in infrastructure by identifying

entire areas that were most viable for infrastructure development.

Projects for establishment, extension or other changes of the local DH system or the local natural gas system were subject to local authority approval and had to correspond to the regional and municipal heating plans.

Choice of heating supply based on costs

The choice of heating supply was (and still is) to be based on socioeconomic costs. To help local authorities complete the relevant economic analyses, the first Danish technology catalogue was developed. The catalogue contained information, not only on heating supply plants, but also on other items of importance, such as how to calculate the distribution of heating demand over a year, how to assess the investments in gas networks and DH networks etc. Forecasts for fuel prices were also provided. This formed a standard and comparable way of assessing the heating supply possibilities for local authorities across Denmark.

District heating and natural gas

Increased use of DH and natural gas played an important role in heating plans, and the heating planning process led to extensive development of both natural gas and DH networks. From 1972 to 1990, the share of natural gas for heating grew from 0% to more than 10%, and the share of DH grew from 20% to approx. 40%. Since 1990, the use of natural gas and DH has continued to increase.

Co-generation agreement from 1986

The possibilities of co-generation of heating and electricity on a large scale was also examined with the intention of utilising surplus heat from power generation.

The introduction of the "co-generation agreement" in 1986 made small-scale co-generated heating and electricity a major energy policy priority.

The agreement was made between the government and national electricity utilities, who were obliged to establish at least 450 MW power capacity of small-scale CHP units. Emphasis was also placed on the implementation of a program including test- and demonstration of different types of boiler units, e.g. biomass and waste.

Possible obligatory connection and ban on electric heating in support of public supply

The first law on heating supply also provided the municipalities with an option to require new and existing buildings to connect to the public DH or gas supply. In 1982, this option was transposed into an executive order, which has more or less remained unchanged since. The purpose is to secure the investments in the DH infrastructure by avoiding households opting out. The municipalities' power to require buildings to connect to the public supply is still in effect, although it is very rarely used today.

To improve efficient utilisation of energy, a national ban on electric heating in new buildings was introduced in 1988. Later on, in 1994, the ban was extended to prevent the installation of electric heating in existing buildings with water based central heating systems that were located in areas with public DH or gas supply. The ban on electric heating is still in effect, although new low energy buildings are exempt.

Both the obligatory connection and the ban on electric heating were in line with the energy policy formulated in 1979. Together the obligatory connection and the ban made it possible to ensure a secure income for energy companies, which also ensured the competitiveness of the public energy supply.

Taxes as a control system

During the 1970s and 1980s, taxes were applied to fuels used in heating generation with the intention to encourage the use of environmentally friendly energy and efficient energy utilisation. Therefore, biomass and biogas were exempted from taxes.

Figure 10: Installing new DH pipes in Copenhagen

When oil and gas prices dropped at the end of the 1980s, the tax level was increased for these fuels. This ensured that consumers continued to be motivated to use environmentally friendly energy sources and to save energy.

Focus on environment and power expansion in the 1990s

With an amendment to the law on heating supply in 1990, a new planning system was introduced. A "project system" was developed on the basis of a general framework set out in a political agreement. The objective was to promote expansion of decentralised CHP through:

- Conversion of existing installations to co-generated heating and electricity supply
- Increased use of natural gas
- Increased use of environmentally friendly fuels
- Increase in energy produced by CHP plants

The agreement was intended to solve two particular issues: reducing Denmark's CO_2-emissions and ensuring the economic viability of the expansion of the natural gas network though increased sales of natural gas.

The conversion from heating only boilers to CHP as formulated in the agreement took place in three phases:

- In the first phase (1990-1994), the large coal fired DH units with access to natural gas supply were converted to gas fired CHP. Also, larger natural gas fired DH units were converted to CHP and relevant waste incineration plants were considered for conversion to CHP.

- In the second phase (1994-1996), remaining coal fired DH units with access to natural gas supply were converted to gas fired CHP. Also medium sized natural gas fired DH units were converted to CHP and DH units without access to natural gas were required to consider conversion to straw, wood chips, or other biofuels.

- Finally, in the third phase, the smaller natural gas fired DH units were required to convert to CHP, and the remaining DH units without access to natural gas were required to consider conversion to straw, wood chips or other biofuels.

As a result of these initiatives and due to a combination of attractive policy incentives, Denmark today has one of the largest share of co-generation of heating and power in Europe.

Green-field plants
In the early 1990s, new DH plants were established in a number of larger villages around the country which had not earlier had DH, so called green-field plants. Most of these new DH plants also produced electricity. The co-generation of heating and electricity saved fuel and so was more environmentally sustainable than separate production.

At the end of the 1990s, a number of green-field plants encountered financial difficulties, partly due to higher natural gas prices. In several cases the government and the natural gas companies provided support. During the same period, taxation of co-generated heating was amended in favour of green-field plants and other small-scale CHP.

Subsidies promote decentralised CHP
In 1992, a subsidy for electricity production was introduced. This was aimed at promoting the development of small-scale co-generated heating and electricity based on natural gas and renewable energy. This new subsidy replaced a previous subsidy for electricity generation from renewable energy.

In 1997, the subsidy was reduced, although not for the smallest CHP plants and green-field plants. Reduction of the subsidy created financial difficulties for a number of natural gas based CHP plants. It was therefore necessary for the government to provide compensation for those affected via a so-called "aid pool".

In 2003, new regulations came into force under which small-scale and industrial CHP generation could benefit from a tax reduction while the subsidies remained at their reduced level.

Today, the subsidy for renewable energy is levied as a surcharge on the producers' electricity transfer price.

Renewables as part of heating supply
Renewable energy for heating supply became a priority in the 1990s when targets were set for the increased use of biomass at both centralised and small-scale plants.

The use of biomass was supported by policy and by financial subsidies. In particular, the use of biomass in centralised plants was facilitated by the Biomass Agreement on 14 June 1993. This agreement required power plants to use 1.2 million tons of straw and 0.2 million tons of wood chips annually by the end of 2000. Later, the agreement was altered to allow a more flexible choice of biomass.

In 1987, a biogas action plan was set up with the purpose of creating competitive biogas plants. In 1995 it was concluded that biogas technology had developed to a point where it could play a part in the Danish energy supply. In 2014, biogas contributed to 1.4 % of the Danish DH production.

Regulation of the district heating sector

Public heating supply is regulated under the heating supply law. According to the heating supply law, the city councils, in cooperation with utility companies and other stakeholders, has the responsibility to carry out heating planning for the municipal area. The overall objectives of the heating planning are: to promote the heating form with the most net benefits to society; to promote the most environmentally friendly heating form (including promotion of cogeneration of heat and electricity); and to reduce the energy supply's dependency of oil and other fossil fuels.

THE DH SECTOR'S ORGANISATION AND KEY ACTORS

The municipalities are the central players in the collective heating supply. They carry out heating planning and are responsible for ensuring that the extension of DH and changes in the DH system are in line with the heating supply law.

The Danish Energy Regulatory Authority and the Board of Appeal within the energy area oversees the DH sector and deals with complaints regarding prices and conditions. Appeals against decisions of public authorities and interpretation of laws and regulations can be directed to the Energy Appeal Board.

MUNICIPAL HEATING PLANNING AND THE HEATING SUPPLY LAW

Today's municipal heating planning
In Denmark, the municipalities are responsible for preparing and updating municipal heating plans and approving heating projects. This means that it is the City Council that makes the final decision on heating planning and expansion of heating supply in the municipality.

Authorities that oversee the DH sector and deal with complaints
THE DANISH ENERGY REGULATORY AUTHORITY oversees the DH sector and handles complaints of a general nature. All DH and CHP units have the obligation to submit information to the Danish Energy Regulatory Authority on prices and conditions, so that the authority can deal with complaints and objections. The Danish Energy Regulatory Authority mainly deals with general issues such as tariffs and terms for heating delivery.

Private consumers' complaints about DH companies concerning purchase and delivery of heating are handled by THE BOARD OF APPEAL WITHIN THE ENERGY AREA.

THE ENERGY APPEAL BOARD handles complaints concerning the authority's decisions in individual cases and any possible misinterpretation of the law. Appeals can be made to the Ministry of Energy, Utilities and Climate, the Danish Energy RegulationAuthority and the individual municipalities.

The most important law in Danish heating supply is the Heating Supply Act. This act regulates public heating supply installations (including so-called "block heating stations") with a heating output of more than 250 kW and CHP units with a heating output of up to 25 MW.

Block heating stations
A block heating station is a heating production - facility established in connection with a larger building complex and supplying heating to a predetermined number of heating consumers, e.g. an apartment complex or a hospital. A block heating station located in or nearby a public energy supply sys-tem, e.g. a DH network, should in most cases be connected to this system.

Large CHP plants are regulated by the electricity law. However, the heating supply from these plants is regulated by the law on heating supply.

The need for a project proposal
When a DH unit or a DH network is established or a major change is made to an existing system (for example a change of fuel, technical concept or expansion of production) a socalled project proposal must be prepared and sent to the municipality for approval. In case of demonstration projects and similar, it is possible to apply for dispensation/exemption from the project proposal.

The project proposal must be carried out in accordance with certain policies and rules, which include a number of requirements, e.g. the choice of fuels and cogeneration of heating and electricity.

The project proposal must include socio-economic, user-economic, company-financial, and environmental analyses of different project alternatives. In other words, different options for heating supply are compared using a set methodology. The City Council then has to approve the project alternative that has the largest socio-economic benefits.

As a basis for preparing the project proposal, the Danish Energy Agency provides a number of socio-economic assumptions. These assumptions include among others fuel prices, electricity prices, externality costs of emissions and interest rates. The Danish Energy Agency also provides technology data, which can be used as a reference.

Non-profit principle
The public heating supply is subject to non-profit rules and regulation. The non-profit principle is defined from the following two municipal law principles:

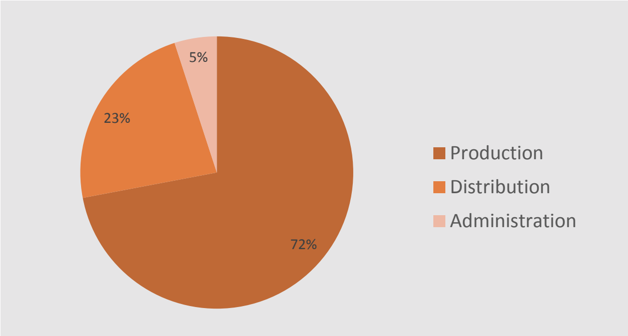
- Supply services must not result in indirect taxation of the consumers. In other words, the municipality is not allowed to increase its income through utility services.
- Supply services must not result in an indirect subsidisation of the consumers. In other words, the municipality is not allowed to give subsidy to any users of the utility service.

It is the DH company itself which is subject to the non-profit principle. All services and supplies to the DH company in terms of fuel supply, legal assistance and consulting services are considered commercial activities.

The heating supply law defines which expenses can be included in the heating price, and only these expenses can be included. Furthermore, it is a prerequisite that the expense is a "necessary expense".

The figure below shows how Danish DH companies costs are divided by production, distribution and administration. As it can be seen, 95% of the costs relate to production and distribution of heating.

Figure 11: Division of Danish DH companies costs, 2011
Source. Danish District Heating Association



Return on investment
Depreciation, reserves for future investments as well as interest on invested capital may in special cases be included as a necessary expense. The interest rate used for calculating the interest on invested capital must be based on a specific assessment in each case.

Socio economic cost-benefit analysis used for heating project evaluation

One of the main approval criteria for heating projects in Denmark is the socio economic cost-benefit analysis. Only projects showing the most net benefit to society are prioritized.

A socio economic analysis ensures that all societal and externality costs of the heating projects are included in project evaluations. The analysis is always a comparison between two or more alternatives where taxes are excluded and externalities, such as cost of emissions, are included. The project alternatives are always evaluated over their entire expected technical lifetime. If the technical lifetimes of different technologies are not the same, scrap values or reinvestments are included in the analysis.

The socio-economic analysis has to be based on a methodology and on data supplied by the Danish Energy Agency. The data consist of forecasts for future energy prices, costs of emitting certain pollutants and other considerations that are necessary for a full accounting of the socio-economic analysis of a project. This ensures that different heating projects are evaluated and chosen on the basis of comparable analysis and methodology.

The Danish Energy Agency is responsible for providing a national technology catalogue and data on:

- Future fuel prices
- Future electricity prices
- Cost of externalities
- Cost and technical specifications of different heating production units

These data helps municipalities and heating companies develop accurate costs estimates which strengthens the planning and approval process. However, if the heating company that applies for a project approval has more accurate local data, these data have to be used instead of the data from the Danish Energy Agency. For instance, this is always the case with regards to heating prices, when applying for projects in existing district heating areas.

Protection of the consumers

The non-profit principle ensures the consumers are protected against abuse of the natural DH monopoly, because the DH price is based on costbased pricing. Consumer protection from inefficient management and operation is however not ensured by the non-profit principle. To help ensure efficiency, DH companies are voluntarily benchmarked against each other on an annual basis.

Obligation to connect and to remain connected

The obligation to connect means that the City Council can impose buildings to connect to the public heating supply. This effectively means that the consumers are obligated to pay a connection fee and/or a fixed annual fee to the heating supply company, whether or not they use heating. In some cases, there might also be an obligation to actually purchase heating. But if there is no obligation to purchase heating, it is possible for the consumer to establish an alternative individual heating supply source, providing that they also continue to pay the annual fixed fee to the public heating supply company.

The obligation to connect, or mandatory connection, can be imposed on both new and existing buildings. For existing buildings, however, the commitment only comes into force after a grace period of nine years after the City Council's decision on mandatory connections. In certain cases, however, an existing building might be required to connect to the public heating supply before the nineyear grace period. For example, this may be imposed if the building has to replace its heating installations anyway.

The City Council can also impose buildings which are already connected to public heating supply to remain connected. This is called "obligation to remain connected". The procedure and the legal effects are the same as for the general obligation to connect and the obligation to remain connected comes into effect immediately after the City Council's decision.

Dispensation

Consumers might, in some cases, be exempted from the obligation to connect or the obligation to remain connected. For instance the municipalities are required to give dispensation for new low energy buildings. Exemption might also be given in case of demolition of an existing building and construction of a new low energy building.

Fuel choice

When establishing or extending DH supply in an area, rules regulate which fuels can be used. In the case of CHP, more or less all fuel types can be chosen. But for heat only production (without cogeneration with electricity), the fuel types allowed depend on whether the DH facility is in an area with or without natural gas supply.

If the DH facility is in an area with natural gas supply, only natural gas can be used for heat only production. If the DH facility is in an area without natural gas supply, the fuels can be either biomass, waste, biogas, landfill gas and other gasified biomass.

However, in 2013 and 2015 a number of DH companies with exceptionally high heating prices located in areas with public gas supply were permitted by law to establish a 1 MW heating only boilers based on biomass fuel. Since biomass is exempt from tax, these DH companies were able to lower their heating price for consumers.

Sharing of cost and income on heating and electricity

A challenge of monopoly regulation is to avoid cross-subsidisation between the monopoly activities and the commercial activities. This is particularly relevant for DH, which through CHP is closely connected with the liberalised/commercial electricity sector.

In a CHP context, cross-subsidisation from the regulated heating supply to the liberalised electricity supply occur if the heating price is higher than it would be without CHP generation and the electricity is sold at a price lower than the marginal costs of producing the electricity. Within this definition there are, however, still a number of possibilities for sharing the costs and income between the electricity and heating side.

Today the sharing of costs at large CHP plants, which are allowed to make profit in the electricity market, is based on negotiations between the electricity and heating side. For small-scale CHP units, which are not allowed to make profit in the electricity market, the costs of heating production is simply determined as the "net heating production costs" that also considers the income from sale of electricity. In other words, at small-scale CHP units, the possible profit from sale of electricity reduces the heating price for the consumers.

SUBSIDIES AND TAXES

Subsidies

In the 1990s, some heating plants received investment grants. However, most of these grants have now ceased as the technologies have become more commercially mature.

Today, all centralised CHP plants and most decentralised CHP plants sell electricity at the market price in the Nordic power market. Therefore, they must optimise their production according to the market price of electricity on the spot market, where prices are set for each hour. Therefore, CHP plant operators aim to produce electricity and heating in cogeneration when electricity prices are high. Likewise, they try to minimise their production when electricity prices are low. This method of operation is facilitated by active use of heat storage in the system.

In addition to the income from electricity sales on the spot market, most of the decentralised CHP plants receive an electricity production subsidy. Originally, this subsidy was granted as a feed in tariff with three different tariff levels depending on the time of delivery, but has been converted to a fixed annual amount, which is available until the end of 2018.

After 2018, only power and CHP plants using renewable energy sources will receive an addon to the market price of electricity. For example, electricity produced from biomass receives an add-on to the market price of EUR 20 per MWh.

Taxes on fuels used for heating production

Taxes are imposed on the use of fossil fuels for heating production, but biomass is exempt from tax. Therefore Danish DH producers have an incentive to use biomass fuels.

The taxes shown in Figure 9 (page 9) together with the fuel costs apply to fuels used for heating production. Taxation for fuels used for electricity production is different since the tax is levied on the consumers' use of electricity rather than the fuel type itself.

Since tax is not charged directly (with the exception of VAT) on fuels used for electricity production, it is necessary to divide the fuel consumption at CHP plants into heating and electricity production. This can be done in different ways, but for tax purposes, a fiscal heating production efficiency of 120% is used in many cases. So, if a CHP plant produces 1 MWh heating in cogeneration with 0.65 MWh electricity, a fuel amount of (1 / 120%) MWh = 0.83 MWh is allocated on heating production and the rest is allocated on electricity production.

Allocation of fuel at CHP for heating and electricity

There is no exact way of dividing the fuel at a CHP plant between heating- and electricity generation. If the benefit / fuel savings of combined generation (CHP) are given solely to the heating side, the electricity production efficiency will correspond to the efficiency at a reference "electricity only plant" (e.g. 40%). In that case, the marginal heating production efficiency can be estimated to 250 300% depending on the CHP plant. If the benefit / fuel savings of CHP is given solely to the electricity side both the electricity and heating production efficiency will be in the range of 85-90%. In other words, the electricity production efficiency can vary between 40% and 90% and the heating production efficiency can vary between 90% and 250-300% depending on how the benefit / fuel savings of CHP are allocated.

Future development trends for district heating in Denmark

The Danish energy policy goals have changed over time and DH systems have demonstrated their flexibility to develop and continuously support the different policy goals. Looking ahead, DH will continue to be an important factor in fulfilling policy goals. Both in the short term in relation to fulfilment of the EU 2020-targets as well as in the long-term ambitions up to 2050.

Energy policy goals
District heating in Denmark is expected to play an important role in reaching the following goals:

- The 2020 EU energy-targets include a 20% reduction in CO_2 emissions compared to 1990 levels, an increase in the share of renewables to 20% of the energy (Denmark's share is 30%), and a 20% increase in energy efficiency.
- In 2020, wind turbines in Denmark are expected to cover 50 % of the domestic electricity supply.
- In the longer term, i.e. 2050, the energy system in Denmark is to be independent of fossil fuels.

The fulfilment of the policy goals listed above increases among others the challenges of balancing wind power in the power system. Wind power, by its nature, is intermittent and wind power production cannot be matched with demand. Sometimes the wind power only covers a minor part of the electricity demand and at other times power production from wind turbines covers a very large part or even exceeds the electricity demand. Flexible DH systems can help to balance these fluctuations in the power system and thereby support the integration of wind power.

According to the longer-term 2050 ambitions, a very large share of the electricity and heating generation will have to come from renewable energy. In that respect, DH has a big advantage because it is flexible with regard to both fuels and heating generation technologies.

Flexible DH systems
Some technical measures can improve the flexibility of the DH/CHP system and can help integrate wind power, for example:
- Heat storages
- Electric boilers and heat pumps
- Bypass of power turbines

By use of HEATING STORAGE, which is already common in Denmark, DH plants can decrease their CHP production when there is sufficient electricity in the system from wind turbines and still be able to supply heating from the thermal storage.

By using ELECTRIC BOILERS and HEAT PUMPS, DH plants can use excess electricity from wind turbines directly for heating production.

By BYPASS OF POWER TURBINES, a CHP plant can avoid generating electricity when there is excess in the system. Instead, it can produce only heating with the same efficiency as a heating-only boiler.

The flexibility of the DH/CHP system is therefore an important aspect with regard to integrating a large share of wind power into the energy system.

Low-temperature DH-systems
In many Danish DH networks, the flow temperature is around 80 °C or higher, and the return temperature around 40-45 °C. Many DH companies have focused on reducing the temperatures in their networks, in some cases as low as 50/25 °C flow/return. In the future, even lower temperatures may be possible. Lower temperatures have a number of advantages:

- Lower temperatures reduce the heat losses in the pipeline network.

- A lower return temperature increase the efficiency of the thermal based heating production facility, especially when using flue gas condensation.
- A lower flow temperature increases the efficiency of heating pumps in DH system and increases the possibilities of using different sources of low temperature heating for DH production.

Low-temperature DH systems are particularly relevant in new buildings with modern underfloor heating systems. In some older buildings, however, the old building installations (radiator systems etc. with small surfaces) may require a high temperature in order to heat up the building sufficiently, at least during peak load.

A number of existing DH areas have successfully reduced the temperature level in the DH network over the last few years. Particularly for large networks, it is important that the temperature level is continuously optimised (online optimisation) according to the actual demand in the DH network.

Low-temperature DH is a key element in the next generation of DH. This will allow for a more optimal and efficient use of different energy sources including surplus heat, heat pumps, solar heating, and geothermal energy. The next generation of DH may also include combined heating and cooling as well as two-way DH where houses with a possible heating supply during some hours, e.g. from local solar heating, can deliver heating to the network.

BIOMASS

As discussed in Chapter 1, "Main characteristics of today's Danish district heating", the amount of biomass used for DH in Denmark has increased significantly over recent decades, and the share of biomass fuels in Danish DH production in 2014 was more than 45%.

The share of biomass is expected to increase even further in the coming years, partly due to the continued conversion of existing CHP plants from fossil fuels to biomass.

The increased use of biomass for energy has led to sustainability concerns from scientists and environmental groups. Sustainability concerns include CO_2-impact, change of land use, and biodiversity.

In December 2014, the Danish energy industry associations adopted an industry agreement to ensure sustainability of wood pellets and wood chips used in Danish CHP plants with a capacity of more than 20 MW. This includes ensuring that the biomass used in the CHP plants derives from sustainable forestry, which is defined by a number of parameters including reforestation and biodiversity, and protection of ecosystems and global carbon cycle.

Electric boilers and heat pumps

With a high share of wind power in the system, there will be times where the power generation from wind turbines exceeds the demand. During these times, it may be beneficial both from an economic and socio-economic point of view, to utilise electricity for heating production in an electric boiler or heat pump.

An electric boiler has a relatively low investment cost and a fast reaction time, which makes it a good supplement to electrically driven heat pumps. Heat pumps generally have higher investment costs, longer start up time, but also higher efficiency. In contrast to heat pumps, electric boilers do not depend on the availability of a low temperature heat source e.g. industrial surplus heat, sea water or sewage water.

Since electricity consumption is taxed in Denmark, this presents a challenge for utilising electric boilers in DH systems. Therefore, special regulation has been introduced that reduces the tax and levies on electricity used for DH purposes and also provides a tax deduction for other heat producing units. The

Different types of heat pumps
Common for all heat pumps is that they use some energy to “transport heat” from a low temperature reservoir to a high temperature reservoir. This energy might be electricity, steam or natural gas. In order to support wind power integration in the system, electrically driven heat pumps are the most relevant. An electric driven heat pump can be turned off relatively quickly if the electricity production from wind turbines drops.

The efficiency of the heat pump is expressed in terms of the COP-value (Coefficient of Performance) which is calculated as the ratio between heating produced and energy input. The higher the temperature of the heat source and the lower the temperature in the DH network, the higher the COP. Therefore, heat pumps can be a particularly good option in combination with low temperature DH.

Heating pumps can be used for cooling production as well as heating. In case of combined heat and cooling, a very high overall efficiency can be obtained.

tax reductions for electric boilers have made it more financially attractive to use electric boilers when there is a low electricity price.

Solar heating in the DH system
Large-scale solar heating in Denmark is experiencing a very rapid expansion. In the long term energy scenarios, the Danish Energy Agency includes a heating production from solar heating of 6,000 TJ in 2025, which is approximately 9 times the amount in 2014.

Solar heating plants connected to DH networks are typically designed to cover about 20% of the total DH consumption on an annual basis. In practice, this means that the plant can cover most of the heating demand during the summer, meaning that the previous base-load plant can be shut down leaving only the peak load boilers. An overall supply of 20 % requires short-term heat storage in combination with the solar heating plant. If a larger percentage of heating is required from the solar heating plant, it can be necessary to establish seasonal heat storage.

A short-term heat storage for solar heating is typically a large insulated steel tank similar to those used at CHP plants. Seasonal heat storages are typically a pit, i.e. a large hole in the ground, which is covered with a liner, filled with water, and covered by a floating cover. The cover is one of the most expensive part of the seasonal storage, and therefore a lot of effort has been put into investigations of different designs and materials.

Latest energy analyses carried out by DEA
In 2014, the Danish Energy Agency carried out a number of studies, including a comprehensive analysis of the DH system and the future role of DH.

One central question to be covered by the DH analysis was in which situations the socio-economic and company-financial benefits from DH exceeds the costs.

The benefits of DH are particularly related to economies of scale when utilising solid fuels for CHP, opportunities for utilising excess heating, and increased flexibility that allow for more efficient incorporation of wind energy in the energy system.

The change of the energy system to a fossil fuel free energy supply presents a challenge to the DH system in the following ways:

- **Lower energy demand**. New building requirements as well as requirements on energy savings in existing buildings will decrease the feasibility of DH because the specific heating costs of DH in EUR/MWh increases as the heating density decreases.

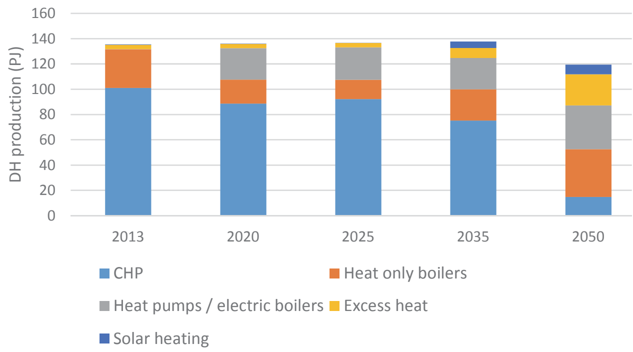
- **Decreased thermal production**. Another challenge is the increasing share of wind power which will decrease the thermal power generation (and consequently also the heating production) at CHP plants. When the number of annual full load hours at the CHP plants decreases, the specific costs of producing DH at these plants may increase.

The analysis concluded that DH is still very relevant in Denmark and that there may be potential for even more DH. The analysis showed that it can be feasible for those consumers located in a DH area which are not connected today to connect to the DH system. Moreover, the analysis showed that it will be feasible to convert some buildings to DH which are today located outside an area with DH supply.

Regarding the future production of DH, the analysis showed that in the long run, a significant amount of DH should be produced from wind power in heat pumps and electric boilers, from excess heat from industries, and from solar heating. As biomass is considered as a finite resource and because of a high penetration of wind power in the system, the thermal based DH production is expected to decrease.

The figure below shows the future DH production as estimated in the so-called “wind-scenario” in the analysis. The reason why the total DH production is lower in 2050 than today is not because of a lower DH coverage, but because of a lower heating demand in buildings due to renovations and new low-energy buildings.

Figure 12: DH production in Denmark as estimated in the DH-analysis (wind scenario)



The Danish district heating industry

Denmark has become a leading country within DH and has developed a dedicated DH industry with world leading technologies and insights in establishing cost- and energy efficient high quality DH systems.

Due to the advanced development of DH in Denmark, a large number of companies involved in the DH sector, including design, engineering, construction and manufacturing of different DH components, are based in Denmark. Many of these companies have also expanded their activities to the international arena.

The Danish competences within DH are divided into manufactures, consulting companies and utilities, and include:

Manufacturing of components for DH, e.g.:

- Biomass boilers
- Controls and heating transfer solutions.
- Pumps and pump systems.
- Preinsulated pipe systems.
- Power and automation technologies.
- Solutions for metering electricity, heating/cooling, water and natural gas.

Consultancy expertise within:

- Energy planning and energy system analyses including analyses of CHP and DH.
- Conceptual planning and design of DH systems.
- Optimal operation of DH systems including temperature optimisation.
- Low temperature systems and integration of different renewable technologies into a DH system.
- Combined heating and cooling.
- Utilities' hand-on experiences with operating all the Danish DH systems of different sizes and types and based on different heat sources.
- Furthermore, Danish research institutions and universities have gained world leading academic knowledge with R&D activities within DH systems, components, heating production and system integration.

Danish manufacturers cover all aspects of the DH supply chain from production, transmission and distribution to building installations including metering systems. The main reasons why the DH industry is so advanced with significant exports, even to countries outside Europe, is the decades of experience with DH in Denmark with a continued focus on high quality products, both in terms of performance and lifetime.

The Danish consultancies within DH, including energy planning, energy production and energy efficiency, have been active throughout the development of DH. In the early stages, they assisted the municipalities with heating planning and the DH companies in implementing production facilities and DH networks. Nowadays, the consultancies assist national and local authorities in analysing DH and the role of DH in the energy system. Also, the consultancies assist utility companies in continuously developing and optimising their DH systems as well as integrating renewable technologies.

The utility companies continue to modify and improve their DH systems according to the regulatory framework conditions, which among others also include conversion from fossil fuels to renewable energy.

The Danish branch organisation "The DH Industry" anticipates a doubling of the Danish DH industry's export in 2020 compared to 2013.

Green global assistance

Denmark has bilaterally government-to-government cooperation with several countries to share the Danish experiences of mitigating greenhouse gas emissions while maintaining economic growth. The Danish Example serves as a catalyst for other countries to advance the retrofit of their energy systems, while the Danish Energy Agency offers global assistance on scenario modelling, renewable energy, energy efficiency and district heating.

By cooperating internationally, our aim is to assist our partners towards a cleaner and more reliable future energy system. The primary focus of Danish Energy Agency's international initiative is government-to-government assistance, inspired by Denmark's long-standing experience in the energy field. The goal is to promote capacity building, concrete energy savings and emissions reductions, as well as to promote government collaboration through expert consultancy.

As a secondary and derived focus of DEA spotlighting Danish strongholds in green solutions, may be an expanded market for Danish energy products and solutions. This may open up further trading collaboration both directly and indirectly.

The assistance concentrates on growth economies
Geographically, the Danish Energy Agency's assistance concentrates on growth economies. Denmark currently cooperates with China, Mexico, Vietnam and South Africa. Also, there are newly-initiated cooperation with Turkey, Indonesia and Ukraine. Here, the Danish approach to energy system design can assist the retrofit and development of the future energy system to be cleaner, more efficient, and flexible regarding energy sources while still being reliable.

The Danish Energy Agency provides guidance and expert consultancy within the following fields:

- District heating: Combined heating and power generation, utilisation of excess heat in the DH system, and flexible DH systems as a means for efficient in-cooperation of renewable energy in the energy system.

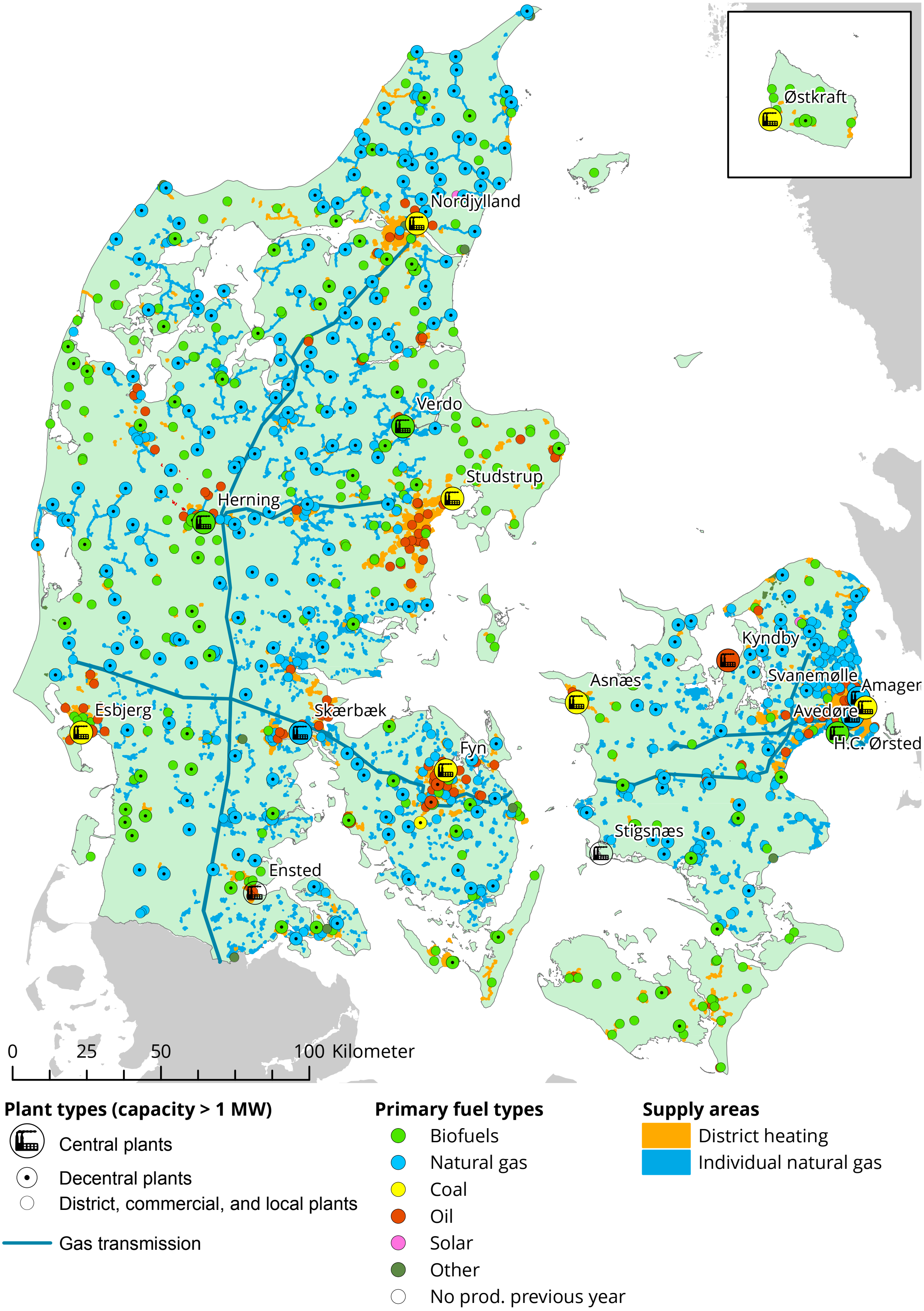
- Wind energy: Mapping of wind resources and integration of wind energy in flexible grids.

- Energy efficiency: Retrofit of existing energy systems to use energy as efficiently as possible and working with energy efficiency through building requirements.

- Energy planning: Analyses of energy systems, modelling and scenario planning

Combining sustainable future energy with viable growth
The Danish Energy Agency provides global guidance with the ambition to enable our partners to preempt future growing energy demands by making it possible to integrate a higher proportion of renewable energy in the energy supply and create an efficient system. The objectives are to mitigate emission levels whilst at the same time ensuring economic growth, consequently spreading awareness about the unique Danish policy and regulatory experience in the energy policy area.

Enclosure 1
Map of Denmark's heating supply



Enclosure 2 – Timeline from 1973 to 2015: Heating supply in focus

Focus on energy efficiency and security of supply

1973/74. The high energy prices caused by the international energy crisis increased the Danish focus on fuel independence and motivated improvements in energy efficiency.
January 1976. Denmark's first overall energy plan lays the basis for a long-term energy policy.
April 1976. The Danish Energy Authority is established (name was later changed to the Danish Energy Agency).
1979. The first law on heating supply starts a new era in public heating planning which still exists today. A main purpose of the law was to introduce domestic natural gas into the heating supply and ensure that surplus/waste heating CHP from the large thermal power plants was utilised in the Danish energy supply where economically viable.
1979. The second international energy crisis occurs.
1981-1982. National heating planning takes place throughout the country. The heating plans include "zoning" with the purpose of establishing efficient, low-emission energy systems, and to prevent overinvestment in expensive infrastructure (e.g. by avoiding development of both gas pipe lines and DH networks in the same areas).

Increased focus on domestic fuels

1984. The Danish North Sea natural gas production begins. The Ministry of Energy directs power plants to establish natural gas installations.
1985. Parliamentary decision on public energy planning without nuclear power. Coal was excluded from heating planning.
1985. Energy taxes are increased due to a drop in oil prices (in order to ensure a continued focus on energy efficiency and renewable energy)
1986. The co-generation agreement emphasises small-scale CHP plants as a major energy policy priority.
1990. Political agreement on increased use of both natural gas-fired CHPs and biomass for heating in DH. Furthermore, the agreement increased installation of wind power.

Change from national planning to project approcah

1990. Revision to law on heating supply introduces a new planning system. Planning directives and guidelines for fuel choice and CHP is provided to all local authorities/municipalities.
1992. A range of subsidies were introduced in order to support energy savings, CHP and renewable energy sources.
1993. Political agreement on the use of biomass in power production. The so-called Biomass Agreement stated that the power plants were to use 1.2 million tons of straw and 0.2 million tons of wood chips annually by the year 2000.
2000. Revision to law on heating supply. A political majority in the Danish Parliament decide to improve conditions for 250 small- and medium-sized CHP plants outside the major cities.

Focus on climate and renewable energy

2008. Political agreement improving the conditions for wind energy and other renewable energy sources.
2012. Major political agreement about Danish energy policy for the period 2012-2020 containing a wide range of ambitious initiatives and investments within energy efficiency, renewable energy and the energy system. Results in 2020 to include approximately 50% of electricity consumption supplied by wind power, and more than 35% of final energy consumption supplied from renewable energy sources. A number of initiatives will reduce individual heating based on oil and gas in buildings and promote renewable alternatives. These include a halt to installation of oil-fired and gas-fired boilers in new buildings from 2013 and a halt to installation of oil-fired boilers in existing buildings from 2016 in areas with district heating or natural gas.

Danish Energy Agency

The Danish Energy Agency is responsible for handling all national and international agreements and tasks linked to the production, supply and consumption of energy in Denmark. The Agency also deals with efforts to reduce emissions of greenhouse gases, and oversees the legal and political frameworks for reliable, affordable and clean supply of energy in Denmark.

The Agency is part of the Danish Ministry of Energy, Utilities and Climate.

Read more at www.ens.dk.

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