Energistyrelsen

Comprehensive Assessment 2020

Denmark

Introduction

This analysis has been prepared as part of the Danish obligation to identify and harness the potential for efficient heating and cooling. The analysis must be prepared every five years to fulfil the obligations. The obligations are set out in Article 14 of the Energy Efficiency Directive (EED) concerning the promotion of efficiency in heating and cooling. The previous analysis was prepared in 2015, and the Danish Energy Agency has therefore prepared this analysis, *Comprehensive Assessment 2020*, which is hereby reported to the European Commission.

This comprehensive analysis comprises four parts:

1. An assessment of the technical potential for heating and cooling;
2. A description of strategies, policies and measures;
3. A cost-benefit analysis of a baseline scenario for Denmark and a sensitivity analysis of this;
4. Recommendations and tools for realising the potentials identified.

The analysis of the heating sector is primarily based on data from the Danish Energy Agency's baseline projection for 2020 (BF20), while the data forming the basis for the cooling sector is based on projections from Rambøll's screening tool, DC Mapper, and interviews with existing district cooling suppliers.

Besides the assessment of the technical potential for heating and cooling, part 1 of the analysis also identifies the potential supply sources for waste heat with a thermal input capacity of more than 20 MW. Part 1 also contains a GIS map illustrating heating and cooling requirements in Denmark. The technical potential has been assessed by consultancy company Rambøll in consultation with the Danish Energy Agency.

Part 2 describes the objectives, strategies and policy measures agreed following the reporting of the National Energy and Climate Plan at the end of 2019.

Part 3 of the analysis analyses the most beneficial district heating technologies in socio-economic and corporate economic terms in 10 different district heating areas. Part 3 also contains a sensitivity analysis of CO_2 and heat pump investment costs. The economic potential has been assessed by consultancy company Rambøll in consultation with the Danish Energy Agency.

Part 4 of the analysis describes the potential new policy measures for which implementation is sought to harness the potential for green and efficient heating and cooling in Denmark.

1. Overview of heating and cooling

This section initially assesses the quantity of useful energy and final energy consumption per sector. Heating and cooling demands are then projected based on a frozen policy approach. It is generally noted that the data used for the projections and subsequent cost-benefit analysis are based on the Danish Energy Agency's BF20[1], which is projected until 2030. The projection follows a frozen policy approach and thus does not contain changes or measures adopted in 2020. The heating demand in 2030 has been extrapolated to 2050 based on the anticipated development of a particular sector. This extrapolation has been prepared by Rambøll and used exclusively for this analysis and may not be used in other contexts.

1.1 Assessment and projection of useful energy and final energy consumption per sector

Heating and cooling demand is divided by sector, which in turn is divided according to industry codes from the Danish Energy Agency's energy statistics[2]. The heating demand is specified as useful energy and final energy consumption, and is defined in the Energy Efficiency Directive[3].

'*Useful energy*' is defined as all the energy required by the end-users in the form of heat and cold after all the steps of energy transformation have taken place in the heating and cooling equipment.

'*Final energy consumption*' is defined as 'all energy supplied to industry, transport, households, services and agriculture. Final energy consumption excludes deliveries to the energy transformation sector and the energy industries themselves'.

The difference between the final energy requirement and useful energy is the local loss in the conversion unit, e.g., an oil or natural gas boiler.

The results, divided into both heating and cooling requirements are shown in Annex 5.5 for each year between 2018 and 2050.

Table 1 and Table 2 show the heat requirement distribution in the final energy consumption and useful energy divided according to sector. The figures are based on the Danish Energy Agency's BF20[4], which is projected until 2030. The projection follows a frozen policy approach and thus does not contain changes or measures adopted in 2020. The heating demand in 2030 has been extrapolated to 2050 based on the anticipated development of a particular sector. This extrapolation has been prepared by Rambøll and used exclusively for this analysis and may not be used in other contexts.

Table 1shows that in the period leading up to 2050 it is anticipated there will be increasing demand for useful energy while the final energy consumption is declining. This is due to the

[1] https://ens.dk/service/fremskrivninger-analyser-modeller/basisfremskrivninger
[2] Confidential statistics not published partly because of commercially sensitive information.
[3] https://eur-lex.europa.eu/legal-content/DA/TXT/HTML/?uri=CELEX:32019H1659&from=EN#ntr2-L_2019275DA.01009601-E0002
[4] https://ens.dk/service/fremskrivninger-analyser-modeller/basisfremskrivninger

anticipated increase in efficiency in the conversion technologies, which reduce energy losses. Table 2 has deducted energy savings and energy efficiency, as shown in BF20.

Heating demand, final energy consumption (GWh)					
Sector	**2018**	**2020**	**2025**	**2030**	**2050**
Households	46 126	45 465	43 893	42 819	42 764
Services sector	13 789	13 964	14 455	15 155	15 794
Industry sector	18 908	18 735	18 471	18 836	19 336
Other sectors	3 497	3 471	3 472	3 475	3 642
Total GWh	82 320	81 636	80 291	80 285	81 535

Table 1 Final energy consumption, overall heat demand divided according to sector (source: BF20).

Heating demand, useful energy (GWh)					
Sector	**2018**	**2020**	**2025**	**2030**	**2050**
Households	39 674	39 270	38 435	38 187	38 295
Services sector	12 532	12 726	13 319	14 106	15 005
Industry sector	14 608	14 477	14 397	14 873	16 457
Other sectors	2 791	2 764	2 800	2 846	3 108
Total GWh *	69 606	69 238	68 951	70 013	72 865

Table 2 Useful energy, overall heat demand divided according to sector (source: BF20). *Minus energy savings/efficiency

Figure 1 Illustrates the development in the final energy consumption and useful energy in the period leading up to 2050. The heat demand (useful energy) is generally expected to increase leading up to 2050. The heat demand in 2020 is 69 238 GWh. In 2050, the heat demand is expected to be 72 865 GWh due to an increase in the building stock. This is an increase of 5% from 2020 to 2050. Although the heating demand is expected to increase leading up to 2050, the final energy demand is expected to fall over the same period. This is because more energy-efficient buildings are anticipated to have lower heating demands concurrent with a gradual replacement of conversion technologies to more efficient technologies.

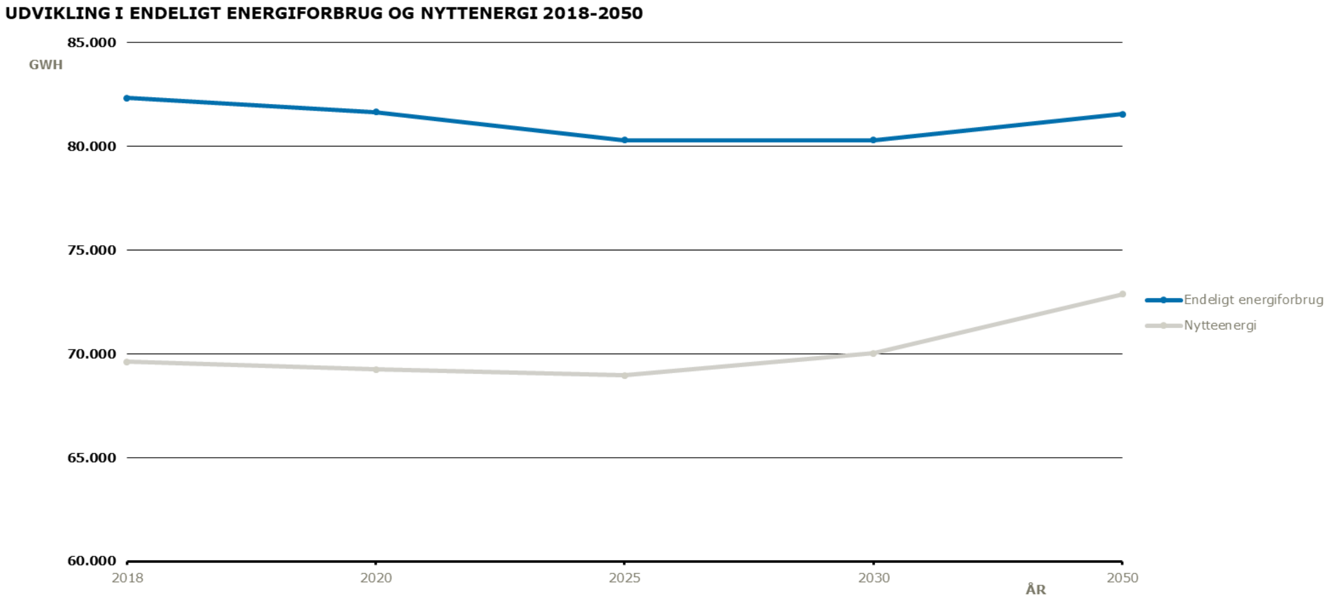

Figure 1 Development in final energy consumption and useful energy 2018-2050 (source: BF20).

UDVIKLING I ENDELIGT ENERGIFORBRUG OG NYTTENERGI 2018-2050	DEVELOPMENT IN FINAL ENERGY CONSUMPTION AND USEFUL ENERGY 2018-2050
Endeligt energiforbrug	Final energy consumption
Nyttenergi	Useful energy
ÅR	YEAR

Heat pumps for both individual and collective supply purposes are expected to play a major role in an increase in efficiency. Heat pumps are described in more detail in Annex 5.1.

1.2 Cooling demand and energy consumption for cooling generation

While heat demand is based on realised data, cooling demand is based on Rambøll's screening tool DC Mapper, and therefore on a theoretical cooling potential. The data is subject to the fact that DC Mapper does not include the economic potential. Consequently, this does not provide a realistic overview of cooling demand.

The total technical cooling demand has been identified as being around 12 8000 GWh/year. Based on the results from DC Mapper, an economic potential for around 5 500 GWh/year to be converted to central supply in building clusters larger than 2 MW is assessed. This is subject to an assumed economic potential and thus is not directly an expression of the realistic potential. It is noted that at present less than 1% of the cooling demand in Denmark is covered by district cooling. This is partly because individual cooling is in competition with district cooling. It cannot therefore be assumed that the potential will be realised, as individual cooling technology has developed markedly in line with an increasing focus on heat pumps to supply heat, as heat pumps are also used for cooling generation, and when used for cooling generation are known as refrigeration compressors.

The total demand for cooling is expected to remain constant leading up to 2050. This is due to increased energy efficiency requirements for new and renovated buildings. Cooling demand is assumed to be limited in the household sector, which is why the cooling demand in this sector is assumed to be 0 throughout the analysis period. Rambøll's analysis tool DC

Mapper has identified a theoretical cooling demand potential in the industrial and service sector in particular.

The development in energy consumption (electricity consumption) for cooling depends on the technologies used for cooling generation and the development in the efficiency of the facilities.

Rambøll has assumed that cooling is generated by cogenerating heat pumps, free cooling and refrigeration compressors cooling heat to the outside air.

Data for the years 2018 – 2050 is provided in Annex 5.5. Table 3 shows the total cooling demand divided according to sector and has been calculated by Rambøll. Rambøll uses experience-based factors to estimate demand for district cooling, e.g. a factor that assumes that the total capacity is reduced by district cooling generation in relation to individual cooling. These assumptions are assessed as significant for the overall assessment of the demand for district cooling, which is why the demand is assessed as potentially different using other assumptions.

Cooling demand, useful energy (GWh/year)				
Sector	**2020**	**2025**	**2030**	**2050**
Households	0	0	0	0
Services sector	6 403	6 207	6 011	5 228
Industry sector	5 826	5 621	5 416	4 595
Other sectors	349	340	330	291
Total GWh	**12 579**	**12 168**	**11 757**	**10 113**

Table 3 Useful energy, overall cooling demand divided according to sector (source: Rambøll).

As shown in Table 3, the majority of the cooling demand is currently covered by individual cooling. Interviews with existing district cooling suppliers estimate current demand for district cooling at around 100 GWh[5]. District cooling therefore meets less than 1% of the cooling demand, but is expected to increase in future if demand is present and if district cooling is profitable in relation to individual cooling.

Cooling output demand in Denmark (MW)				
Sector	**2020**	**2025**	**2030**	**2050**
Households	0	0	0	0
Services sector	7 160	7 160	7 160	7 160
Industry sector	3 820	3 820	3 820	3 820
Other sectors	445	445	445	445
Total MW	**11 425**	**11 425**	**11 425**	**11 425**

Table 4 Cooling output demand divided according to sector (source: Rambøll).

[5] Rambøll has estimated the supply of cooling from HOFOR (HOFOR – Greater Copenhagen Utility) and Frederiksberg Forsyning. An 85 MW facility has been estimated for HOFOR with a usage time of 800 hours, corresponding to 68 000 MWh. This is based on information from HOFOR's website. An estimate has been produced for Frederiksberg Forsyning based on its 2019 Environmental Declaration and is estimated at 4 800 MWh in 2019. Based on information from the website and project proposals, a facility capacity of around 6 MW with a usage time of around 800 hours has been estimated.

Table 4 and Table 5 show both the cooling output demand and the final energy demand to meet the cooling demand in Denmark. This shows that the final energy demand is less than the useful energy demand due to the high efficiency of individual cooling facilities.[6]

Cooling demand, final energy consumption (GWh/year)				
Sector	**2020**	**2025**	**2030**	**2050**
Households	0	0	0	0
Services sector	1 281	1 241	1 202	1 046
Industry sector	1 165	1 124	1 083	919
Other sectors	70	68	66	58
Total GWh	**2 516**	**2 434**	**2 351**	**2 023**

Table 5 Cooling demand, total cooling demand divided according to sector (source: Rambøll).

Rambøll estimates electricity consumption for cooling generation will decrease as efficient cooling generation through cogeneration of heat and cooling increases.[7] A small increase in the efficiency of individual cooling facilities is anticipated.

[6] A COP value of 5 is generally calculated for compressor cooling installations.
[7] Calculated with a COP of 5 for individual cooling and a COP of 6 for combined cooling/heating.

1.2.1 District cooling demand with DC Mapper

As stated previously, cooling demand in Denmark is based on results from Rambøll's DC Mapper tool. The tool has been developed to identify buildings with a potential cooling demand as well as to suggest which buildings could favourably be connected to a district cooling network. This is therefore a theoretical potential assessment.

Due to the smaller temperature differences associated with cooling, the cooling network typically requires larger pipe dimensions than for a district heating network with corresponding capacity. Establishing a cooling network is therefore generally considered to be associated with greater costs than a district heating network. The energy density must therefore be higher than for district heating to establish a cooling network. This also means that where a district heating network extends over a greater distance, a district cooling network is expected to be more local in scope.

DC Mapper combines data from the Danish Building and housing register Bygnings- og Boligregistret (BBR) and Central Business Register (CVR) to identify a theoretical cooling demand for specific commercial buildings. The cooling demand of buildings is identified by combining information concerning the building with knowledge of the cooling needs of associated industries. The cooling demand of industries has been obtained using '*Kortlægning af energiforbrug i virksomheder'* (Assessment of energy consumption by businesses) Danish Energy Agency 2015 and Rambøll's empirical data for cooling demand and efficiencies.

DC Mapper assesses the potential to connect several buildings in a cluster based on the cooling needs in the individual building as well as information on the costs of establishing a district cooling facility and establishing district cooling pipelines The savings for district cooling for individual buildings are visualised by showing the range if the savings are used for pipes in the ground. This creates a circle/buffer, and there is a technical potential for district cooling if the circles overlap. DC Mapper is thereby used to identify potential district cooling clusters, but DC Mapper does not calculate the economic gain from district cooling in relation to individual cooling. A subsequent project proposal will identify whether there is an economic gain for consumers. An economic calculation is necessary to transfer the results from theory to practice. The potential assessment of the demand for district cooling is thus subject to reservations.

A technical district cooling requirement per year has been identified based on DC Mapper during the analysis period for building clusters larger than 2 MW. Table 6 shows the district cooling demand in energy consumption (GWh) by sector and region, while Table 8 shows district cooling capacity (MW) by sector and region.

District cooling demand in Denmark GWh/year (over 2 MW groups)						
Sector	**Total GWh**	**Capital Region of**	**Region Zealand**	**Region of Southern**	**Central Denmark**	**North Denmark**
Households	-	-	-	-	-	-
Services sector	**2 608**	1 084	369	478	506	172
Industry sector	**2 721**	707	634	611	458	312
Other sectors	**131**	77	7	10	30	6
Total GWh	**5 460**	**1 867**	**1 010**	**1 099**	**994**	**489**

Table 6 District cooling demand for cooling clusters larger than 2 MW by sector (GWh/year) (source: Rambøll).

District cooling demand in Denmark MW (over 2 MW groups)						
Sector	**Total MW**	**Capital Region of Denmark**	**Region Zealand**	**Region of Southern Denmark**	**Central Denmark Region**	**North Denmark Region**

Households	**-**	-	-	-	-	-
Services sector	**2 512**	1 015	251	507	558	181
Industry sector	**1 217**	269	278	294	236	140
Other sectors	**164**	96	9	13	38	7
Total MW	**3 893**	**1 381**	**538**	**814**	**832**	**328**

Table 7 District cooling capacity for cooling clusters larger than 2 MW by sector (MW) (source Rambøll).

1.3 Account of current final consumption of heating and cooling

The following section provides an account of the current final consumption of heating and cooling divided according to technologies and fuels. Heating data was obtained from the Energy Producer Count (Energiproducenttællingen) 2018, while cooling data was estimated using Rambøll's theoretical tool DC Mapper.

Table 8 shows the current final consumption of heating for 2020 divided according to technologies. The data was obtained from the Danish Energy Agency's Energy Producer Count 2018.

Heating, current final consumption (GWh)	
Technologies	**2020**
Direct use, e.g., furnaces and generators	8 611
Boilers and heat exchangers, e.g., steam and hot water circuits	25 992
Heat pumps	4 880
Boilers/heat exchangers	41 675
Electrical panels	478
Total GWh	**81 636**

Table 8 Current final consumption of heating by technologies (source: Danish Energy Agency, Energy Producer Count 2018).

1.3.1 Cooling, final consumption

Rambøll has not analysed the distribution between technologies generating cooling at present. There is no central data on generation distribution between technologies, which is why Rambøll has assessed this. Rambøll has assessed that the majority of the cooling is produced using compressor coolers cooling outdoor air. During periods when there is a need for cooling and sources with lower temperatures (outdoor air, groundwater, seawater, etc.), are available, these sources are used for free cooling. Rambøll has assessed that 15-20% of the cooling demand is covered using free cooling. Furthermore, Rambøll has assessed that cooling generation using absorption cooling is limited.

1.3.2 District cooling, final consumption

There is no central data on generation distribution between technologies. Therefore, Rambøll asked existing district cooling companies about the way they produce cooling using a questionnaire survey. Cooling generation is often split between various technologies, such as compressor cooling and free cooling. The district cooling companies did not specify the exact distribution of district cooling. The district cooling companies also did not specify the sectors cooling is supplied to. The distribution Table 9 is therefore based on estimates.[8]

District cooling, current final consumption (GWh/year)		
Technologies		**2020**
Heat pump		3
Compressor		52
Absorption		1
Free cooling		44
Total GWh		**100**

Table 9 District cooling, current final consumption divided according to technologies (source: Rambøll).

1.4 Potential supply sources of waste heat/surplus heat

Rambøll has calculated a theoretical potential to utilise surplus heat from businesses in Denmark for this analysis. It is noted that surplus heat sources less than 20 MW are not included; see Annex to Article 14 concerning the content of the reporting obligation. However, some of the surplus heat is used internally by companies or is not anticipated to be technically available for external utilisation, e.g., because of a company's own plans for increased energy efficiency and savings.

The business sector's surplus heat potential in Denmark is estimated by combining two methods: A top-down and a bottom-up method. The use of the methods is described in more detail in Annex 5.2. The primary data source is Statistics Denmark's (DTS) database *ENE2HA*[9]*:* Energy accounts in GJ according to use and energy type (*Energiregnskab i GJ efter anvendelse og energitype*), Danish Building and housing register (Bygnings- og Boligregistret, BBR), the Danish Address Register, the Joint Municipal Property Register (Ejendomsstamregister, ESR), the Central business Register (CVR) and the EU Emissions Trading System (EUETS). EU Emissions Trading System (EUETS).

1.4.1 Results of the analyses

78 theoretical surplus heat sources have been identified with a thermal input of 20 MW with a total potential of 8.9 PJ or 2 471 GWh.

Figure 2 shows the distribution of surplus heat by industry groups. The results are specified in GWh/year. It is clear that oil refineries and the manufacture of cement account for the majority of the available surplus heat in Denmark. The majority of this is already currently utilised. However, this analysis has identified a greater theoretical potential for utilisation in

[8] It is assumed for HOFOR, that 40 GWh is produced using free cooling, while the remaining 28 GWh is produced using compressor cooling installations. For Frederiksberg Forsyning, it is assumed that all 4.8 GWh is produced via compressor cooling.
[9] https://www.statbank.dk/statbank5a/SelectVarVal/Define.asp?Maintable=ENE2HA&PLanguage=0

companies already supplying surplus heat to the district heating network. Whether the realisation of this is profitable has not been assessed further.

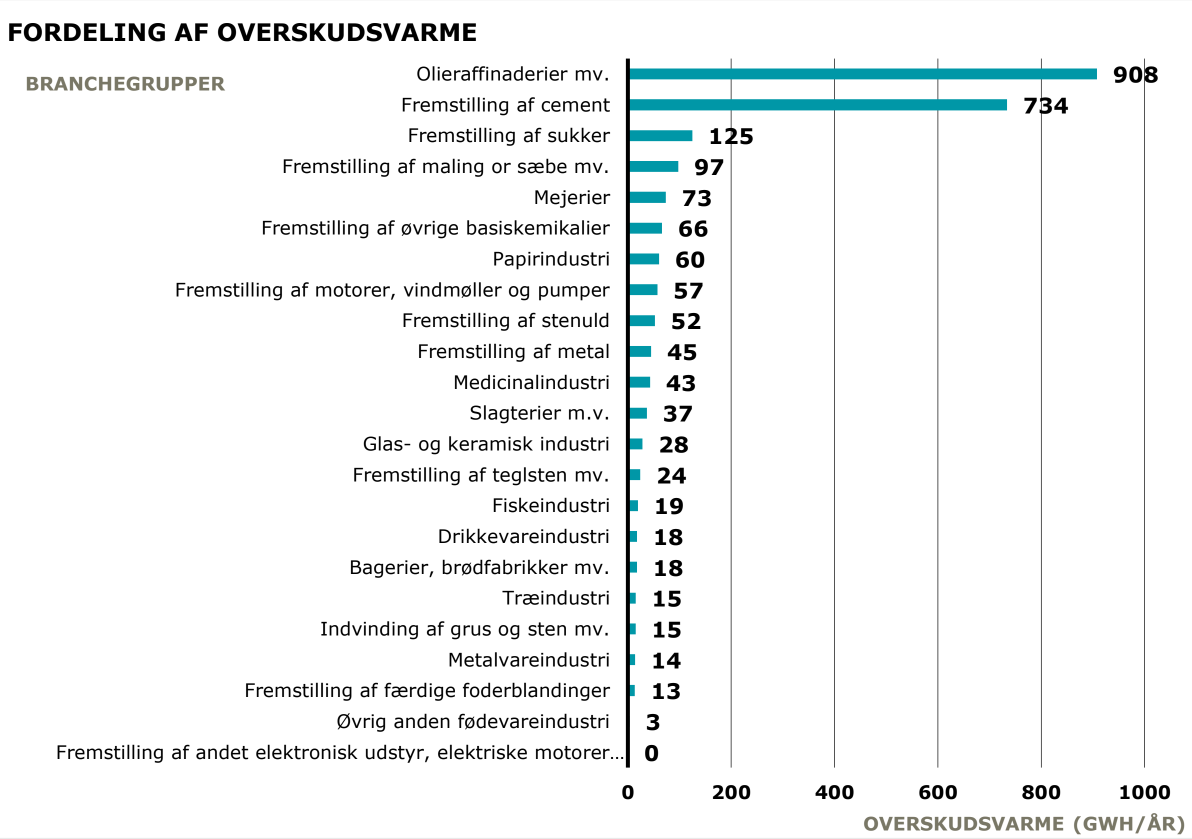

Figure 2 Quantities of surplus heat distributed according to industry groups with a thermal input exceeding 20 MW (Source: Rambøll).

FORDELING AF OVERSKUDSVARME	DISTRIBUTION OF SURPLUS HEAT
BRANCHEGRUPPER	INDUSTRY GROUPS
Olieraffinaderier mv.	Oil refineries, etc.
Fremstilling af cement	Manufacture of cement
Fremstilling af sukker	Manufacture of sugar
Fremstilling af maling or sæbe mv.	Manufacture of paint or soap, etc.
Mejerier	Dairy plants
Fremstilling af øvrige basiskernikalier	Manufacture of other basic chemicals
Papirindustri	Paper industry
Fremstilling af motorer, vindmøller og pumper	Manufacture of generators, wind turbines and pumps
Fremstilling af stenuld	Manufacture of rock wool
Fremstilling af metal	Manufacture of metal
Medicinalindustri	Pharmaceutical industry
Slagterier m.v.	Slaughterhouses, etc.
Glas- og keramisk industri	Glass and ceramics industry
Fremstilling af teglsten mv.	Manufacture of bricks, etc.
Fiskeindustri	Fishing industry
Drikkevareindustri	Beverages industry
Bagerier, brøfabrikker mv.	Bakeries and bread manufacturers, etc.
Træindustri	Wood industry
Indvinding af grus og sten mv.	Extraction of gravel and stone, etc.

Metalvarindustri	Metal products industry
Fremstilling af færdige foderblandinger	Manufacture of finished feed mixtures
Øvrig anden fødevareindustri	Other food industries
Fremstilling af andet elektronisk udstyr, elektri-ske motorer...	Manufacture of other electronic equipment and electric motors...
OVERSKUDSVARME (GWH/ÅR)	SURPLUS HEAT(GWH/YEAR)

1.5 Projection of heating and cooling demand

See under section 1.1 and 1.2.

1.6 GIS map of heating and cooling in Denmark

Figure 3 illustrates heating demand in Denmark. The heating demand is distributed among the central facilities from the Danish Energy Agency Producer Count and is specified in GWh. The heat is distributed from the central heat generating facilities to buildings.

Figure 4 illustrates the cooling output demand in Denmark. The cooling output demand is divided according to buildings identified in DC Mapper and is specified in MW. It can be seen in both figures that both the cooling and heating demand is primarily located around major towns and cities in Denmark.

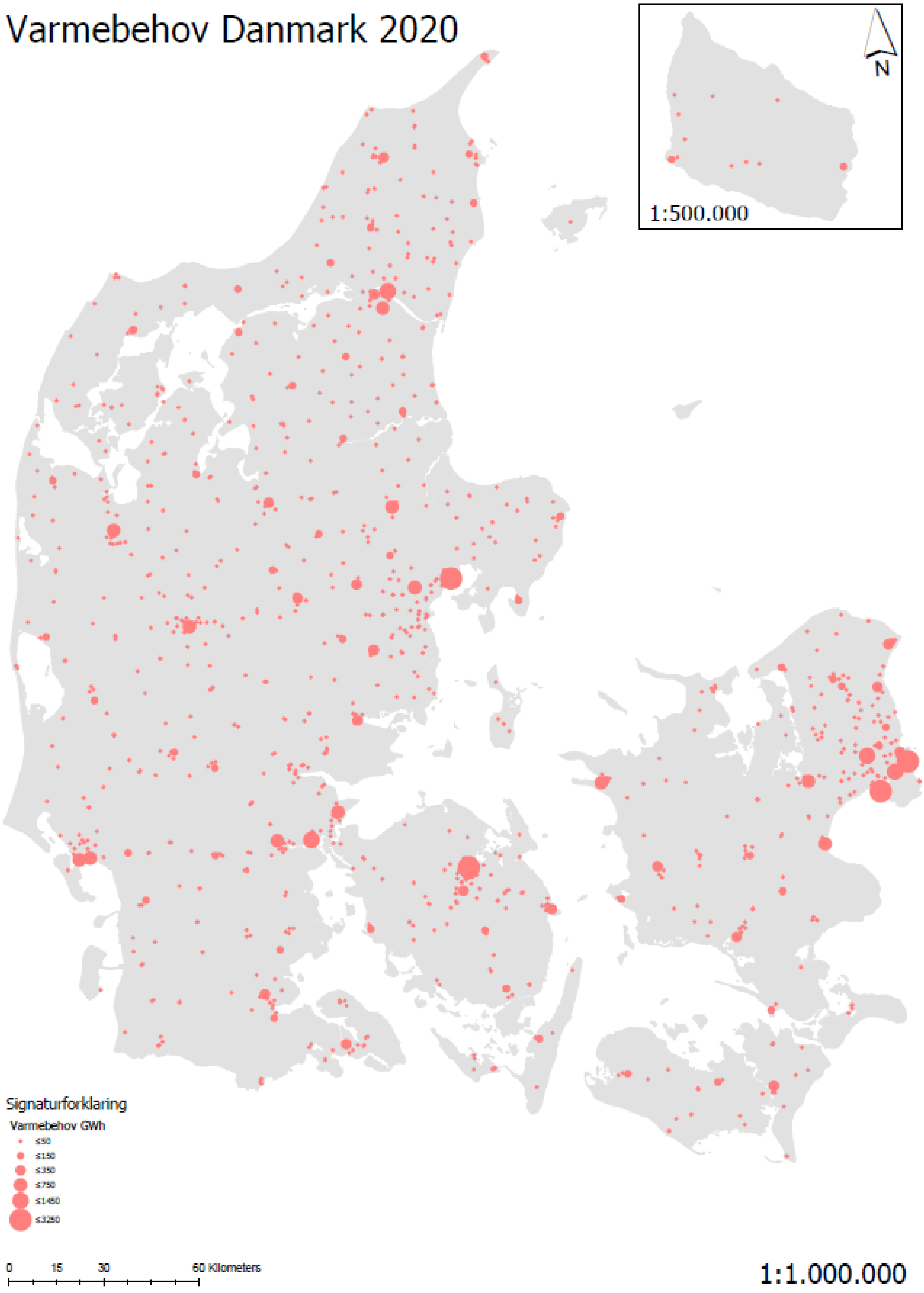

Figure 3 Heating demand in Denmark (source: Danish Energy Agency).

Varmebehov Danmark 2020	Heating demand, Denmark 2020
Signaturforklaring	Legend

Varmebehov GWh	Heating demand, GWh
60 Kilometers	60 kilometres

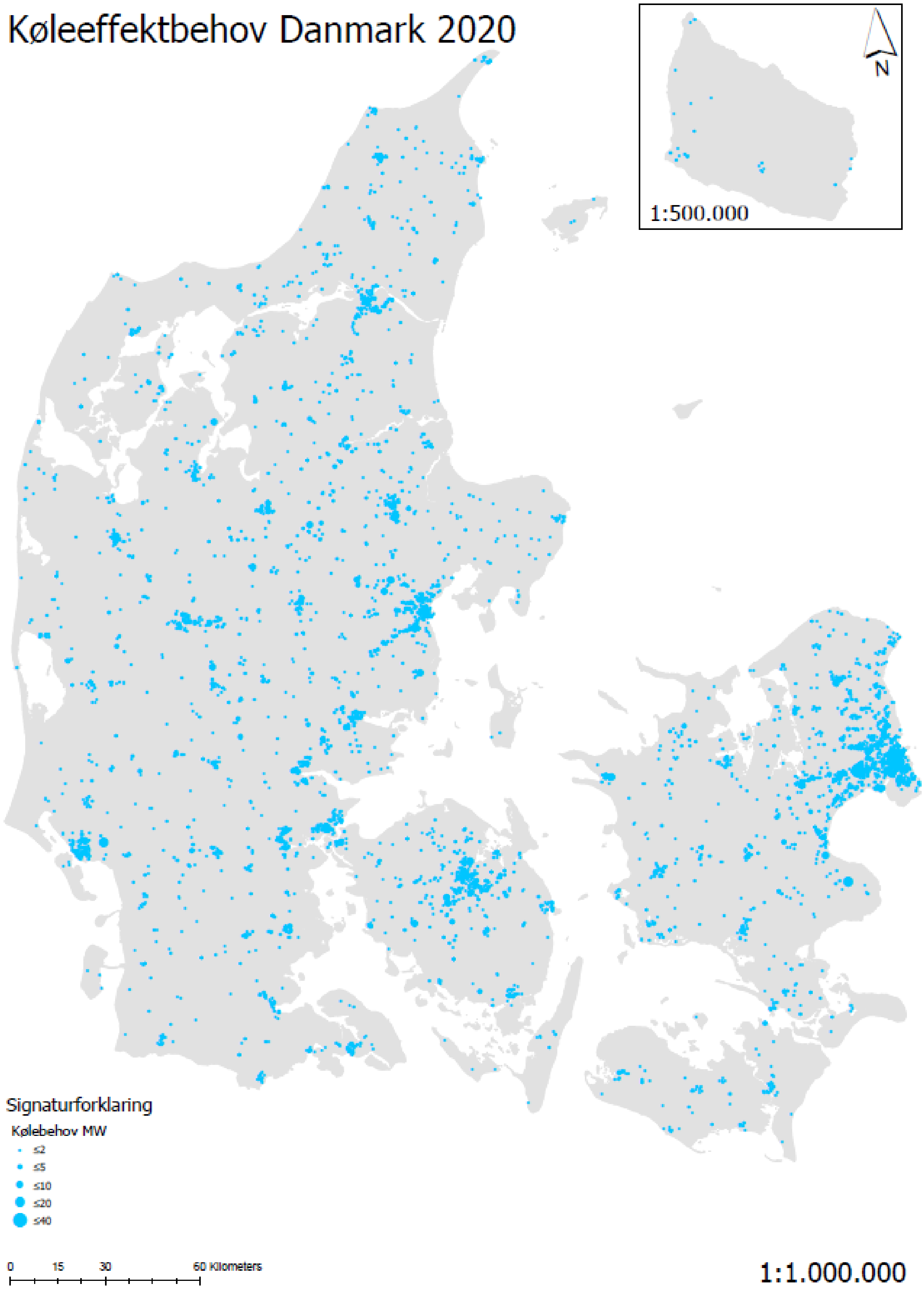

Figure 4 Cooling output demand in Denmark (source: Rambøll).

Køleeffektbehov Danmark 2020	Cooling output demand, Denmark 2020
Kølebehov MW	Cooling demand MW

Figure 5 shows the district heating and district cooling network in Denmark. The red lines indicate the district heating transmission lines, while the green and yellow areas show the current supply areas for both district heating and natural gas. Data for the supply areas was obtained from Plansystem.dk and is the best data available despite some areas remaining to be updated.

The blue and purple circles show existing and known planned district cooling networks. It has not been possible to specify the exact pipeline networks for cooling, but the circles indicate where the networks are located. The circles are not scaled by size, but the majority of the district cooling network is located in the Copenhagen Metropolitan Area.

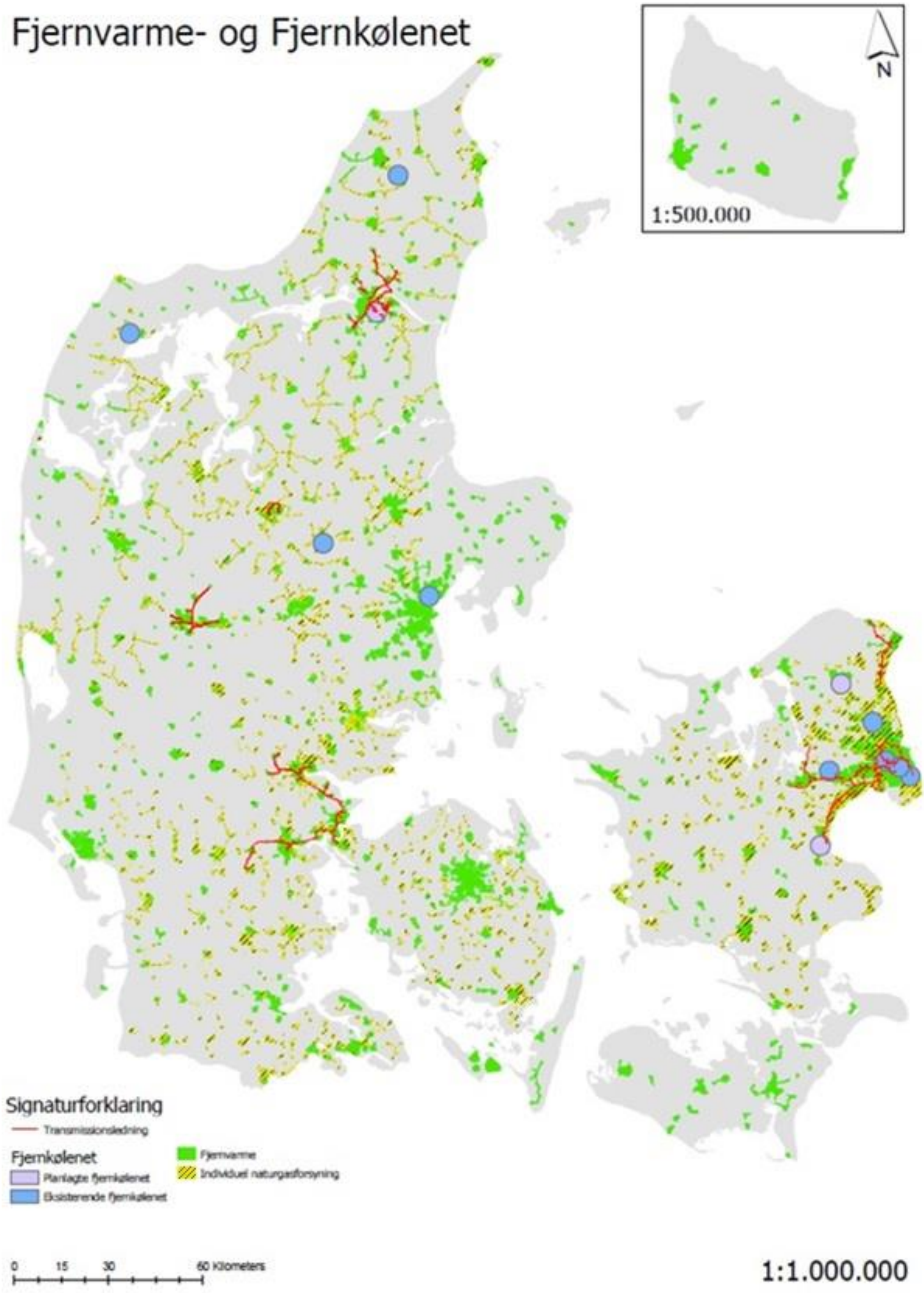

Figure 5 District Heating and district cooling network in Denmark (source: Rambøll).

Signaturforklaring	Legend
Transmissionsledning	Transmission line
Fjernkølenet	District cooling network

Planlagte fjernkølenet	Planned district cooling network
Eksisterende fjernkølenet	Existing district cooling network
Fjernvarme	District heating
Individuel naturgasforsyning	Individual natural gas supply

2. Objectives, strategies and policy measures

This chapter describes Denmark's objectives, strategies and policy measures in relation to individual or collective heating and cooling. However, this is only based on the objectives, strategies and policy measures formally adopted following the reporting of Denmark's National Energy and Climate Plan (NECP) on 20 December 2019[10]. The heating sector is described first, primarily based on the Danish Energy Agency's BF20. These figures do not include the policies adopted after the reporting of NECP. Amongst other things, this means that the initiatives from the Danish Climate Agreement for Energy and Industry from June 2020 have not been included. Decisions have been made on a number of initiatives in the agreement relating to phasing out of fossil fuels in both the collective and individual heating sectors as well as waste incineration. A new projection is expected in the spring of 2021, which will include these initiatives.

2.1 Green and efficient heating

The green transition is well under way in the district heating sector, and it is anticipated that by 2030 there will only be limited potential for further greenhouse gas reductions. It is however anticipated that there will be somewhat greater potential to reduce individual fossil heating where there are already known technologies for reducing greenhouse gas emissions.

2.1.1 Greenhouse gas emissions

Households and businesses can obtain heating either via collective district heating supply or individual heating (electric/heat pumps, oil, natural gas and wood pellet boilers and wood-burning stoves).

Greenhouse gas emissions from individual heating in 2030 are expected to amount to total emissions of 1.82 million tonnes of CO_2e (see Figure 6), which is expected to come from 220 000 natural gas boilers and 30 000 oil boilers, and is based on BF20.

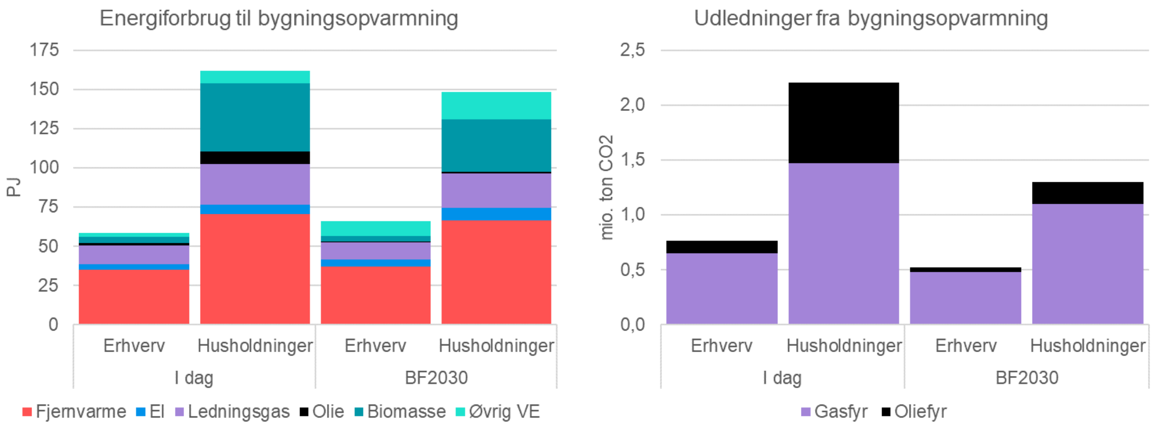

Figure 6 Energy consumption for and emissions from building heating (source: BF20).

10 Denmark's National Energy and Climate Plan (NECP) (source: https://ens.dk/en/our-responsibilities/energy-climate-politics/eu-energy-union-denmarks-national-energy-and-climate)

Energiforbrug til bygningsopvarmning	Energy consumption for building heating
Udledninger fra bygningsopvarmning	Emissions from building heating
Erhverv	Businesses
Husholninger	Households
I dag	Today
BR2030	BR2030
Fjernvarme El Ledningsgas Olie Biomasse Øvrig VE	District heating Electricity Mains gas Oil Biomass Other renewable energy
Udledninger fra bygningsopvarmning	Emissions from building heating
Gasfyr	Gas boilers
Oliefyr	Oil boilers

The district heating sector (including cogeneration facilities producing both electricity and heat) had emissions of 7.8 million tonnes of CO_2 in 2018 according to BF20. Waste incineration accounted for an additional 1.54 million tonnes of CO_2 in 2018.

According to BF20, greenhouse gas emissions from district heating are predicted to amount to around 0.5 million tonnes of CO_2 in 2030, of which 0.2 million tonnes out of the total 0.5 million tonnes of CO_2 in the sector is expected to come from peak and reserve load facilities using natural gas or oil. In addition, around 1.5 million tonnes will come from waste incineration. CO_2 emissions from larger facilities in the district heating sector are covered by the quota system, which will cover around 61% of emissions from the sector in 2030.

The renewable energy share of collective heating is expected to be almost 80% in 2030, of which 63% will come from the incineration of solid biomass; see Figure 7. In addition, around 2% of district heating is generated through solar heating and 1% is generated from biogas, and additionally around 8% is generated by electricity-based facilities such as heat pumps or electric boilers. By 2030, it is estimated that Danish electricity will exceed 100% renewable energy, which is why electricity-based heating facilities will also be considered as renewable energy after this date.

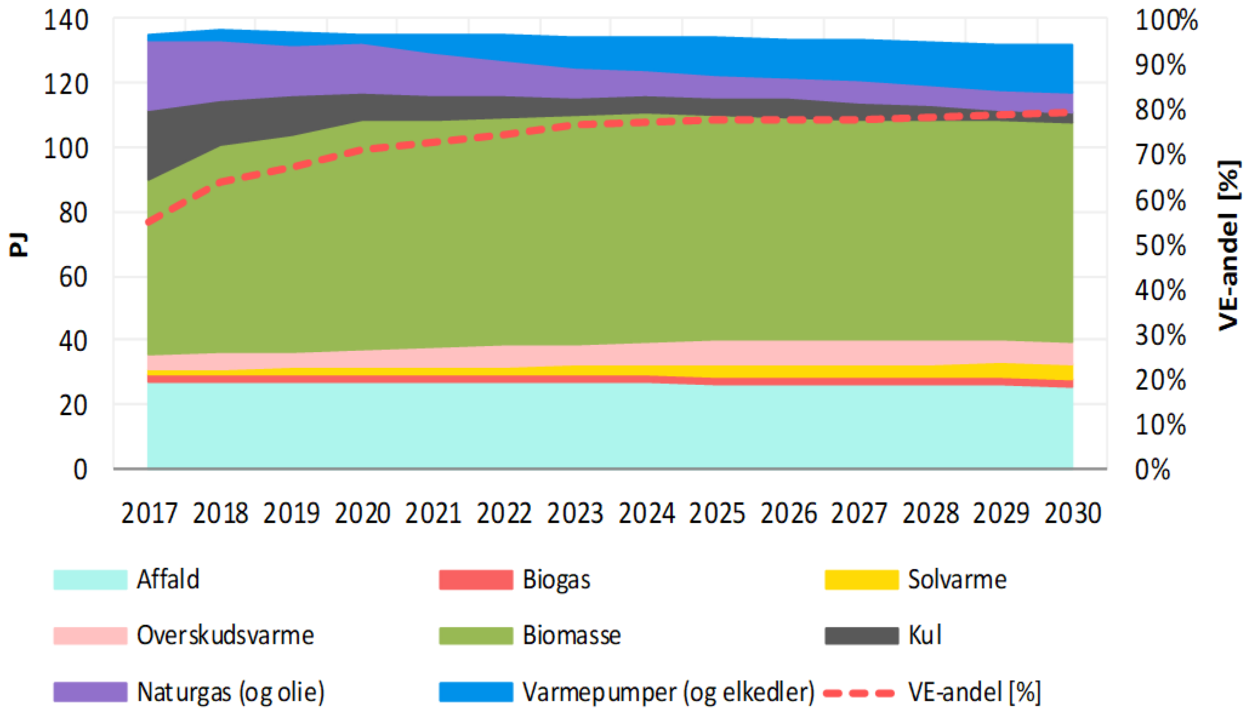

Figure 7 Percentage renewable energy for collective heating (source: Danish Energy Agency, Baseline Projection 2019).

VE-andel	Renewable energy percentage
Affald	Waste
Overskudsvarme	Surplus heat
Naturgas (og olie)	Natural gas (and oil)
Biogas	Biogas
Biomasse	Biomass
Varmepumper (og elkedler)	Heat pumps (and electric boilers)
Solvarme	Solar heating
Kul	Coal

2.1.2 Strategy for the heating sector

Together with a broad majority in the Danish Parliament, the current Danish Government has set a target for a 70% reduction in greenhouse gas emissions by 2030 (in relation to 1992 levels). The Danish district heating sector must contribute to this by switching from fossil heat to renewable energy-based heating. The *Climate Agreement on Energy and Industry, etc. 2020* (Climate Agreement) states: 'With its anchoring in the community, the Danish district heating sector has provided a secure, stable and increasingly green heat supply to Danish district heating consumers. District heating will play a significant role in the supply sector of the future, where increased sector coupling between district heating and other sectors will drive the green transition. It is important that the district heating sector is subject to framework conditions supporting households and businesses in accessing green district heating at consumer-friendly prices.'[11]

[11] Climate Agreement for Energy and Industry, etc. 2020 https://fm.dk/media/18085/klimaaftale-for-energi-og-industri-mv-2020.pdf

2.1.3 Climate Agreement 2020

On 22 June 2020, a majority of the Danish Parliament voted in favour of the *Climate Agreement for Energy and Industry, etc. 2020*. The Climate Agreement contains several initiatives to accelerate the green transition of the heating sector. Article 2.1.4 provides an overview of the greenhouse gas reductions for the Climate Agreement's initiatives, and thus how the initiatives contribute to the Danish government's target of a 70% reduction in greenhouse gas emissions in 2030 (in relation to 1992 levels). The Climate Agreement means emissions from the heating sector are expected to be reduced by DKK 0.72 million CO_2e by 2030; see Table 10.

2.1.4 Green district heating and the five energy dimensions

Article 2.1.4 and Article 2.2 describes how each of the initiatives from the Climate Agreement for Energy and Industry, etc. 2020 and additional initiatives after 20 December 2019 will contribute to the five EU dimensions: Decarbonisation(Table), general energy efficiency (Table), energy security (Table), the internal energy market (Table) and research, innovation and competitiveness (Table).

Initiatives to reduce greenhouse gases *Including the reduction and removal of greenhouse gas emissions*
Green restructuring of heating taxes The parties are therefore in agreement to raise the rate for the space heating tax (fossil fuels) from DKK 56.7/GJ to DKK 62.3/GJ and to reduce the rate of the electric heating tax from DKK 15.5 øre/kWh to DKK 0.4 øre/kWh for businesses and DKK 0.8 øre/kWh for households (corresponding to the EU's minimum rates). The changes will enter into force on 1 January 2021. *Phasing out individual oil and gas boilers* DKK 290 million (calculated in 2020 prices and including derived tax losses) was allocated in 2020 for phasing out oil and gas boilers. The pool was implemented with DKK 35 million for the Scrappage scheme, and DKK 245 million for the Building Pool In addition, it is agreed that consumer connections to the natural gas network will be abolished and that the socio-economic requirement will be modernised; see Green district heating. The parties are furthermore in agreement regarding allocations of DKK 410 million in 2021, DKK 500 million in 2022, DKK 455 million in 2023, DKK 375 million in 2024 and DKK 545 million annually in 2025 and 2026, DKK 240 million in 2027, DKK 260 million in 2028, DKK 280 million in 2029 and DKK 300 million in 2030 (calculated in 2020 prices and including derived tax losses) for subsidy pools for phasing out oil and gas boilers, including a pool for disconnection from the natural gas network and for rolling out district heating. The Danish Government and the Danish Social Liberal Party, Socialist People's Party, the Red-Green Alliance and The Alternative are in agreement to further strengthen the green transition of individual heating by increasing the phasing out of oil and gas boilers. A total of DKK 225 million in 2021, DKK 225 million in 2022, DKK 145 million in 2023, DKK 155 million in 2024 and DKK 60 million in 2025 will be allocated for phasing out oil and gas boilers, which was agreed for the Climate Agreement for Energy and Industry, etc. 2020 and the follow-up agreement of 30 October 2020. The funds allocated include derived tax losses.[12] In addition, a total of DKK 300 million in 2021 and DKK 25 million annually from 2022 will be allocated exclusively for the Building Pool. The funds include derived tax losses. *Green district heating* In order to illustrate a fossil-free district heating sector and ensure that regulation follows technological developments in the sector, and to pave the way for an energy sector that is free of coal, oil and natural gas by 2030, an analysis will be conducted to illustrate the consequences of a possible ban on oil and natural gas for district heating generation from 2030, including for security of supply, electricity and heat prices.

[12] Agreement concerning the Danish Finance Act 2021 and the Agreement concerning stimuli and the green recovery (https://fm.dk/media/18330/aftale-om-finansloven-for-2021-og-aftale-om-stimuli-og-groen-genopretning.pdf)

Green tax reform

The energy tax on fossil fuels for businesses will be increased by DKK 6 per GJ.

Reduction of CO_2 in the waste sector

The Climate Plan for a Green Waste Sector and Circular Economy is expected to reduce total CO_2 emissions in the waste sector by around 0.7 million tonnes in 2030. A large part of this reduction will contribute towards reducing CO_2 emissions in the district heating sector. The most important initiatives in the Climate Plan for a Green Waste Sector and Circular Economy from a climate perspective are sorting 80% Danish plastic away from incineration by 2030, reducing the volume of Danish waste, and reducing the total Danish environmentally approved capacity for incinerating waste, which must be reduced by 30% by 2030 compared with at present. This means that the total environmentally approved capacity for waste incineration must be reduced to national volumes of waste by 2030.[13]

Table 10 Initiatives under the energy dimension of decarbonisation (source: Climate Agreement for Energy and Industry, etc. 2020, Agreement concerning the Danish Finance Act 2021 and Agreement concerning Stimuli and the Green Recovery).

General energy efficiency

Including contribution to meet the EU's energy efficiency targets for 2030 and the indicative milestones for 2030, 2040 and 2050.

Promoting the use of surplus heat

The tax on heat based on electricity, e.g. surplus heat, will be reduced to the EU's minimum rates, whereby the tax for electricity-based surplus heat will be abolished. This promotes surplus heat from locations including data centres and supermarkets.

Table 11 Initiatives under the energy dimension of general energy efficiency (source: Climate Agreement for Energy and Industry, etc. 2020, Agreement concerning the Danish Finance Act 2021 and Agreement concerning Stimuli and the Green Recovery).

Energy security

Including diversification of supply, increasing the resilience and flexibility of the energy system and reducing import dependency.

Sustainability requirements for biomass for energy

Biomass accounts for the majority of the renewable energy used in Denmark and has increasingly replaced the use of coal in the electricity and heating sector. The possibility of setting legal requirements for the sustainability of wood biomass for energy as well as requirements for documentation and verification is currently being investigated. The requirements must support the use of wood biomass for electricity and heating being as sustainable as possible, taking into account security of supply. The specific requirements will be agreed between the parties based on a proposal from the government.

Security of electricity supply

In order to illustrate a fossil-free district heating sector and ensure that regulation follows technological developments in the sector, and to pave the way for an energy sector that is free of coal, oil and natural gas by 2030, an analysis will be conducted to illustrate the consequences of a possible ban on oil and natural gas for district heating generation from 2030, including for security of supply, electricity and heat prices.

Table 12 Initiatives under the energy dimension of energy security (source: Climate Agreement for Energy and Industry, etc. 2020).

Internal market

[13] Climate Plan for a Green Waste Sector and Circular Economy of 16 June 2020 (source: https://www.regeringen.dk/media/9591/aftaletekst.pdf)

Including improving interconnectivity, transmission infrastructure, competitive prices and stakeholder involvement-oriented consumer policy and alleviating energy poverty.

The Climate Agreement for Energy and Industry states that the district heating sector must be modernised:

Firstly, the district heating sector generation links must be modernised to give district heating generators more free choice over their own investments. Specifically, this means that the fuel connection to natural gas and the cogeneration requirement for the district heating generators will be abolished. The socio-economic requirement will also be adjusted to enable approval of district heating projects without a comparison with fossil alternatives, which amongst other things will ensure that regulation does not unnecessarily delay conversions of natural gas areas to district heating areas. There is also an agreement that the purchase obligation for district heating must be modernised to enable increased utilisation of surplus heat and own renewable energy generation.

Table 13 Initiatives under the energy dimension of internal energy markets (source: Climate Agreement for Energy and Industry, etc. 2020).

Research, innovation and competitiveness
Including contributions to private research and innovation and the use of clean energy technologies.
EUDP
High temperature heat pumps with natural refrigerants for sustainable process heat
Development of quick regulating heat pumps using dynamic models
Legionella safety and energy efficiency for installations and supply
Green research
The Danish Government has additionally allocated funds for the public research budget, including funding for green research amounting to DKK 24.2 billion in 2021[14].

Table 14 Initiatives under the energy dimension research, innovation and competitiveness (source: https://ens.dk/sites/ens.dk/files/Forskning_og_udvikling/oversigt_over_stoettede_eudp_projekter_2020-i.pdf).

2.2 Green and efficient cooling

Denmark contributes to green district cooling partly by promoting renewable electricity, which can be used for cooling generation via electricity-based heat pumps, and partly by setting requirements for coolants.

District cooling is primarily generated by compression cooling, absorption cooling and free cooling. Free cooling uses the environment (e.g., lakes, air, sea) to supply cooling, while absorption cooling uses surplus heat primarily from district heating generation to provide cooling. Free cooling is therefore renewable energy. Absorption cooling may in certain cases be regarded as surplus heat, and is therefore not included as a renewable energy source; see definition of surplus heat in the Renewable Energy Directive, but contributes to energy efficiency in the cooling sector. Compression cooling is driven by electricity. The electricity system in Denmark is expected to be completely renewable from around 2027.

Because the energy source for producing district cooling is predominantly environmentally friendly, it is primarily greenhouse gas emissions from coolants that may result in greenhouse gas emissions from district cooling.

[14] Proposal for the Danish Finance Act for the 2021 financial year (https://fm.dk/media/18181/ffl21a.pdf)

2.2.1 Green district cooling and the five energy dimensions

Decarbonisation

A decision was taken to change the requirements for certain coolants in the Climate Agreement 2020 with the aim of reducing the use of climate-damaging HFC gases. The new limit means that the impact on the climate of filled HFC gases in a cooling facility must not exceed 5 tonnes of CO_{2e}. In addition, the CFC tax will be increased by approximately DKK 30 per tonne of CO_{2e}, so that the emission of these greenhouse gases is equated with CO_2 for tax purposes. In addition, the ceiling on the tax of DKK 600/kg will be lifted, so that the tax for all gases corresponds to the cost of damage to the climate. Finally, CFC taxes will be indexed in the future so that the tax is not eroded. In addition, the de minimis limit on imports of refrigerants will be removed, so that a tax must always be paid when importing taxable refrigerants.

The adjustments are estimated to reduce CO_{2e} emissions marginally across the entire energy system. However, the effect may be more pronounced for the district cooling sector, which makes extensive use of heat pumps. The effect of stricter requirements for refrigerants on greenhouse gas emissions in the refrigeration sector has not been calculated.

General energy efficiency

No further initiatives have been determined for energy efficiency for district cooling in Denmark since the reporting of NECP.

Energy security

No further initiatives have been determined for energy security for district cooling in Denmark since the reporting of NECP.

Internal energy markets

No further initiatives have been determined for internal energy markets for district cooling in Denmark since the reporting of NECP.

Research, innovation and competitiveness

This energy dimension includes research, innovation and competitiveness, including contributions to private research and innovation as well as the use of clean technologies (clean tech).

Table 15 shows the projects related to refrigeration supported through EUDP in 2020.

EUDP supported projects related to cooling, 2020
Development of quick regulating heat pumps using dynamic models
Legionella safety and energy efficiency for installations and supply

Table 15 Overview of projects supported through EUDP in 2020 (source: https://ens.dk/sites/ens.dk/files/Forskning_og_udvikling/oversigt_over_stoettede_eudp_projekter_2020-i.pdf).

The Danish Government has additionally allocated funds for the public research budget, including funding for green research amounting to DKK 24.2 billion in 2021[15].

[15] Proposal for the Danish Finance Act for the 2021 financial year (https://fm.dk/media/18181/ffl21a.pdf)

3. Analysis of the economic potential for efficiency in heating and cooling

The economic potential of district heating is calculated in this section. The results are divided into socio-economic results and company-economic results. The socio-economic cost-benefit analysis primarily affects the district heating sector and individual heating to a certain extent. This is because the data for the district cooling sector and individual cooling is limited in Denmark, whereas the data for the district heating sector is well developed. The district cooling and cooling demands are also relatively limited in Denmark in relation to the demand for district heating, primarily because of the colder climate in Denmark.

3.1 Description of the baseline scenario

The analyses have been prepared for a baseline scenario. The baseline scenario takes a frozen policy approach, as data from BF20 is used.

The cost-benefit analysis is performed using the program EnergyPRO and the model aims to distribute the production units in the district heating network. Individual heating, cooling and district cooling is not a direct part of the model.

Figure 8 illustrates the central elements of the baseline scenario. The source is indicated next to each row.

Generel produktionsprioritet		Alternativ 0 - Basis			Kilde
		2020	2030	2050	
Prioriteret grundlast					
AffaldsKV	GWh	-	-	-	
Solvarme	GWh	-	-	-	ENS BF20
Geotermi	GWh	-	-	-	ENS BF20
Industrivarme	GWh	-	-	-	Rambøll vurdering
Varmepumper (elpris- og lagerstyret)					
Varmepumpe med køl	MW-v	-	-	-	Rambøll vurdering
IndustriVP	MW-v	-	-	-	ENS BF20 men med COP=4,2
OmgivVP	MW-v	-	-	-	ENS BF20 men med COP=3,2
Kraftvarme (ekskl. affald)					
Kul KV	MW	-	Udgår		ENS BF20 dvs udgår før 2030
Biogas KV	MW	-	-	-	ENS BF20
Anden bio KV	MW	-	-	-	ENS BF20
Træpille KV	MW	-	-	-	Udgår efter endt teknisk levetid
Gas KV	MW	-	-	-	
Spidslast					
Naturgaskedler		-	-	-	
Olie		-	-	-	

Figure 8 Overview of the baseline scenario (source: Rambøll).

Generel produktionsprioritet	General production priority
Alternativ 0 -Basis	Alternative 0 - Base
Prioriteret grundlast	Prioritised base load
AffaldsKV	WasteKV
Solvarme	Solar heating
Geotermi	Geothermal
Industrivarme	Industrial heating

Varmepumper (elpris- og lagerstyret)	Heat pumps (electricity price and storage controlled)
Varmepumpe medkøl	Heat pumps with cooling
IndustriVP	IndustryVP
OmgivVP	AmbientVP
Krafvarme (ekskl. affald)	Cogeneration (excluding waste)
BiogasKV	BiogasKV
AndenbioKV	Other bio KV
Træpille KV	Wood pellets KV
Gas KV	Gas KV
Spidslast	Peak load
Naturgaskedler	Natural gas boilers
Olie	Oil
Kilde	Source
ENS BF20	Danish Energy Agency, BF20
Rambøll vurdering	Rambøll assessment
ENS BF20 men med COP=4,2	Danish Energy Agency, BF20 but with COP=4.2
ENS BF20 dvs udgår før 2030	Danish Energy Agency, BF20, i.e., eliminated before 2030
Udgår efter endteknisk levetid	Eliminated following end of technical service life

The scenario is described below.

The baseline scenario is based on BF20, which contains data up until 2030. The levels in 2030 will then be maintained until 2050. BF20 addresses heat projection and therefore does not take into account the cooling sector.

The Danish Energy Agency has attempted to calculate a scenario in which the total amount of waste suitable for incineration is reduced; see *Climate Plan for a Green Waste Sector and Circular Economy, June 2020*[16]. It has not yet been decided which waste handling facilities will be closed. It has therefore not been possible to perform an analysis of such a scenario, which is why the Danish Energy Agency has considered the development in the baseline scenario as the only scenario calculated. The Danish Energy Agency can draw on good experience from the baseline scenario, including because the analysis period is longer than normal (2021-2050), whereas it is primarily calculated up to and including 2030 in the Danish projections. An extension of the analysis period therefore constitutes an important tool in calculating the potentials for efficient heating.

Sensitivity assessments have been prepared using the baseline scenario, which provides an insight into alternative developments to provide the scope for determining the policy measures that can contribute to harnessing parts of the potential for efficient heat.

3.2 Method for the socio-economic analysis

A socio-economic calculation model has been set up to assess the individual technologies and different fuel types for the economic analysis of the district heating sector. The following has been used as the data source:

[16] https://www.regeringen.dk/media/9591/aftaletekst.pdf

- Socio-economic calculation assumptions for energy prices and emissions (Samfundsøkonomiske beregningsforudsætninger for energipriser og emissioner), Danish Energy Agency, October 2019;
- Danish Energy Agency and Danish Ministry of Finance guidelines for socio-economic analyses;
- Danish Energy Agency Technology Catalogue (Technology Data catalogue concerning generation of electricity and district heating - Updated April 2020).

All prices updated to 2020 price level. The operating period 2021-2050 is considered in the model and all costs are present-value-weighted over the operating period with a discount rate of 4% annually and reverted to the year 2020.

Two groups of calculations have been set up for the analysis referred to as ‘calculation groups’. Calculation Group 1 assesses the competitiveness of technologies and the CO_{2e} footprint in general, while Calculation Group 2 includes the competitive technologies specifically as heat supply facilities, which are specific facilities for district heating.

The method is described in more detail in Annex 5.3.

3.3 Macroeconomic analysis

The following section contains results from the scenario analysis as well as sensitivity analyses consisting of an increased CO_2 price and increased investment costs for heat pumps.

3.3.1 Baseline scenario (socio-economics)

For district heating, the socio-economic present value-weighted heating price per customer is DKK 384/MWh for a heating customer located in a district heating area (central) and is thus generally significantly lower than individual alternatives.

For district heating in general over the period 2021-2050, the CO_{2e} load is 75 kg/MWh heat per customer, while individual heat pumps for example have a CO_{2e} load of 14 kg/MWh. The higher CO_{2e} load of district heating is primarily due to existing heating facilities, some of which have a relatively high CO_{2e} footprint.

It should in particular be noted that when heat from waste incineration is utilised for district heating, the waste heat in the calculation method contributes with a CO_{2e} footprint of 153 kg/MWh. Alternatively, the waste heat can be cooled without being used for district heating, but the climate impact will be the same.

The socio-economic analysis shows that in the baseline scenario, cogeneration based on renewable energy provides the largest amount of district heating generation. Heating generation using this method is more or less constant until 2035, after which the production from cogeneration based on renewable energy falls slightly, and is primarily replaced by heat pumps. Fossil cogeneration makes up a small part of the total generation distribution, especially after 2029 where generation using this method is minimal.

The generation distribution for district heating in the baseline scenario is illustrated in Figure 9 distributed from 2021 to 2050. The generation distribution is divided into surplus heat, waste energy cogeneration, fossil cogeneration, renewal energy cogeneration, heat pumps, fossil fuel boilers, renewable energy boilers and other technologies. The baseline for BF20 uses the period 2020-2050. The development from BF20 is extrapolated after 2030 until 2050.

The generation distribution in the baseline scenario indicates that cogeneration based on renewable energy provides the largest amount of district heat generation. Heating generation using this method is more or less constant until 2035, after which the production from cogeneration based on renewable energy falls slightly, and is primarily replaced by heat pumps. Fossil cogeneration makes up a small part of the total generation distribution, especially after 2029 where generation using this method is minimal.

Surplus heat and waste cogeneration remain fairly constant throughout the analysis period.

District heating generated from renewable energy and fossil boilers is also fairly constant throughout the analysis period.

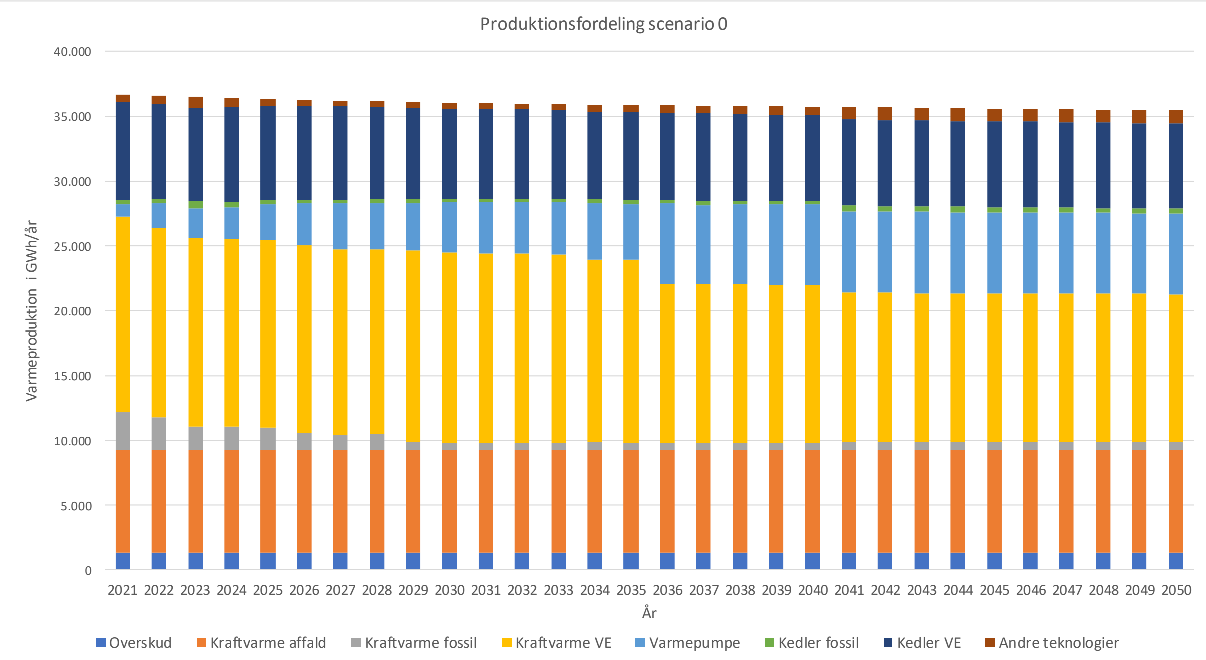

Figure 9 Generation distribution for district heating in the baseline scenario (source: Rambøll).

Varmeproduktion i GWh/år	Heating generation in GWh/year
Produktionsfordeling scenario 0	Production distribution scenario 0
Overskud	Surplus
Kraftvarme affald	Waste energy cogeneration
Kraftvarme fossil	Fossil cogeneration
Krafvarme VE	Renewable energy cogeneration
Varmepumpe	Heat pump
Kedler fossil	Fossil boilers
Kedler VE	Renewable energy boilers
Andre teknologier	Other techniques

3.4 Company-economic analysis

The following section reviews the results of the company-economic analysis for the baseline scenario, including the sensitivity analyses.

The company economic analysis generally assumes the heat sales prices experienced for each production facility in the 10 representative district heating systems with the addition of ongoing reinvestments and maintenance of the distribution system over a technical service life of 50 years.

Because a district heating company's finances are essentially unique to each district heating company, there is in practice considerable variation in heating prices for the country's district heating companies.

It must be noted that only the best alternative from a socio-economic perspective can be approved by the heating planning authority (municipal council), but company and user economics must also be favourable for the realisation of a district heating expansion project. The alternative is for heating consumers to switch to individual heating by phasing out existing individual heating.

3.4.1 Baseline scenario (company-economics)

The company-economic calculation estimates the district heating price for each of the 10 district heating systems over the period 2021-2050 and with a real interest rate of 1%; see Table. It must be noted that these are estimated values.

Baseline scenario (Sc0) Company finances	Heating purchase DKK/MWh	Distribution DKK/MWh	Sale DKK/MWh	Net GWh/year	Turnover DKK million/year
District heating, central	269	109	378	28 241	10 668
1 Greater Copenhagen	238	106	344	7 759	2 670
2 Aarhus	237	106	342	2 503	857
3 Odense	235	106	341	2 036	694
4 Aalborg	219	106	325	1 477	479
5 TVIS	300	106	406	1 431	581
6 Esbjerg	200	106	306	904	277
7 Waste	195	111	306	2 611	799
8 Biomass	312	111	423	2 798	1 184
9 Miscellaneous manufactured articles	322	111	433	594	257
10 Small towns	352	116	468	6 129	2 870

Table 16 Company-economic analysis for 30 years for the baseline scenario (source: Rambøll).

Table 16 indicates that there are large variations in the size of district heating areas. Greater Copenhagen is estimated to produce the most heat annually, corresponding to over 1 000 GWh more annually than all of the small urban areas combined. The estimated company-economic district heating price is lowest in the area covered by the TVIS partnership and Esbjerg regions, where the heating price is DKK 306/MWh. The highest estimated heating prices are in the small urban areas, where the estimated company-economic heating price is typically DKK 468/MWh. There is therefore significant spread in the estimated company-economic heating price. The present socio-economic analysis does not necessarily reflect which district heating areas have the lowest company-economic heating price in practice.

Because the district heating sector is self-contained in its regulation, the total heat generation cost and the company-economic heating price are roughly correlated. However, this is subject to the fact that the actual heat price in practice cannot be compared with Table 16, as in practice there are several economic items affecting the total heat price. Financial items, such as appropriations and depreciation, etc., are not included in this analysis, and together with several financial items and heat loss, constitute the actual district heating price in each district heating area. District heating prices are therefore unique in each individual district heating area.

3.5 Sensitivity analysis

The effect of higher CO_2 prices and higher heat pump investment costs on the baseline scenario have been investigated.

3.5.1 Sensitivity to CO_2 price

It is estimated that a higher CO_2 price may affect district heating areas receiving heat from fossil fuel facilities, e.g., natural gas district heating facilities. However, it is anticipated the effect will be limited over the entire analysis period 2021-2050, because it is expected that around 80% of district heating generation in Denmark will be based on renewable energy by 2030. The remaining share of heating from fossil fuels comes partly from fossil peaks and reserve loads, e.g., oil or gas boilers.

3.5.2 Sensitivity to heat pump investment costs

It is estimated that the district heating sector will be increasingly electrified in the future. In practice, financial incentives are available for investing in collective heat pumps, which is why the baseline scenario is sensitive to increases in heat pump investment costs. However, the specific effect of increased investment costs cannot be assessed, and will depend on the heat source used by a particular project and where the project is located in relation to the electricity system and heat sources, etc.

4. Potential new strategies and policy measures

This section describes the measures that will be taken to achieve the socio-economic potential for both the heating and cooling sector. It is noted, however, that data on the cooling sector, including the district cooling sector, is extremely limited, which has limited the possibilities for policy measures to identify the potential for cooling and district cooling. The need for cooling and district cooling is also relatively small compared with that of heating and district heating in Denmark Therefore, the focus is predominantly on initiatives to realise the socio-economic potential for efficient heating and district heating.

4.1 Measures to promote efficient heating

The *Climate Agreement for Energy and Industry, etc. 2020*[17]*, Climate Plan for a Green Waste Sector and Circular Economy and the Agreement on the Finance Act for 2021* brought about the agreement of various initiatives to promote green heating and district heating. These initiatives follow the results of this analysis, and have been decided in parallel with the preparation of this report, which is why the initiatives are used in this context as initiatives supporting the results of the analysis on the promotion of efficient heat.

4.1.1 Taxes supporting green heating

Green reorganisation of heating taxes

The tax system must support the green transition of heating consumption in Denmark. It must be more expensive to heat using fossil sources and cheaper to heat with green electricity. Therefore, the rate for space heating tax (fossil fuels) will be increased and the rate for electric heating tax will be reduced from 15.5 øre/kWh to 0.4 øre/kWh for businesses and 0.8 øre/kWh for households (corresponding to the EU's minimum rates). The changes will enter into force on 1 January 2021.

The relaxation will mean the same rate for both heating and process heat for VAT registered businesses.

4.1.2 Surplus heat

Promoting the use of surplus heat

The electric heating tax will be reduced to the EU's minimum rates, whereby the tax on electric surplus heat will be abolished. This promotes surplus heat from locations including data centres and supermarkets. In addition, the cost of utilising other lukewarm surplus heat will be reduced. The surplus heat tax will also be removed if the surplus heat is certified or subject to a corresponding agreement scheme ensuring energy efficiency improvements with the surplus heat supplier.

[17] https://fm.dk/media/18085/klimaaftale-for-energi-og-industri-mv-2020.pdf

4.1.3 Individual heating

Phasing out individual oil and gas boilers

DKK 290 million (calculated in 2020 prices and including derived tax losses) was allocated in 2020 for phasing out oil and gas boilers. The pool was implemented with DKK 35 million for the Scrappage scheme, and DKK 245 million for the Building Pool In addition, there is agreement that consumer connections to the natural gas network will be abolished and that the socio-economic requirement will be modernised; see Green district heating.

The parties are furthermore in agreement for allocations of DKK 410 million in 2021, DKK 500 million in 2022, DKK 455 million in 2023, DKK 375 million in 2024 and DKK 545 million annually in 2025 and 2026, DKK 240 million in 2027, DKK 260 million in 2028, DKK 280 million in 2029 and DKK 300 million in 2030 (calculated in 2020 prices and including derived tax losses) for subsidy pools for phasing out oil and gas boilers, including a pool for disconnection from the natural gas network and for rolling out district heating.

A total of DKK 225 million in 2021, DKK 225 million in 2022, DKK 145 million in 2023, DKK 155 million in 2024 and DKK 60 million in 2025 will be allocated for phasing out oil and gas boilers, which was agreed for the Climate Agreement for Energy and Industry, etc. 2020 and the follow-up agreement of 30 October 2020. The funds allocated include derived tax losses. In addition, the Building Pool will be allocated a total of DKK 300 million in 2021 and DKK 25 million annually from 2022. The funds include derived tax losses.

4.1.4 Energy efficiency improvement

Increased energy efficiency in buildings

The Danish Government and the Danish Social Liberal Party, Socialist People's Party, the Red-Green Alliance and The Alternative are in agreement to increase the Building Pool. The funds will strengthen the green transition by supporting energy efficiency improvements in permanent residences. A total of DKK 300 million in 2021 and DKK 25 million annually from 2022 will be allocated. The funds include derived tax losses.

4.1.5 Green district heating

Firstly, the district heating sector generation links must be modernised to give district heating producers more free choice over their own investments. Specifically, this means that the fuel connection to natural gas and the cogeneration requirement for the district heating generators will be abolished. The socio-economic requirement will also be adjusted to enable approval of district heating projects without a comparison with fossil alternatives, which amongst other things will ensure that regulation does not unnecessarily delay conversions of natural gas areas to district heating areas. There is also an agreement that the purchase obligation for district heating must be modernised to enable increased utilisation of surplus heat and own renewable energy generation.

Secondly, the parties to the agreement agree that the ambitious CO_2 reduction targets in the Climate Act have created a need for a new model for regulating the district heating sector to ensure a cost-effective and climate-efficient restructuring of the sector. The parties behind the agreement agree that in the second half of 2020, negotiations will commence concerning a new future-proof economic regulation that takes into account Denmark's new climate goals and ensures efficiency and future consumer-friendly prices. The framework for geothermal energy must also be considered. Prior to these negotiations, the Danish Government will present various models without unnecessary administrative burdens for this with the involvement of the sector.

Thirdly, a number of initiatives are being launched to illustrate a fossil-free district heating sector and ensure that regulation keeps pace with technological developments in the sector. The parties agree to lead the way towards an energy sector free of coal, oil and natural gas by 2030. With this in mind, an analysis will be initiated to illuminate the consequences of a possible ban on oil and natural gas for district heating generation from 2030, including for security of supply, electricity and heat prices. The analysis must also assess how relevant initiatives in this agreement will affect security of electricity supply.

Reduction of CO_2 in the waste sector

The Climate Plan for a Green Waste Sector and Circular Economy is expected to reduce total CO_2 emissions in the waste sector by around 0.7 million tonnes by 2030. A large part of this reduction will contribute towards reducing CO_2 emissions in the district heating sector. The most important initiatives in the Climate Plan for a Green Waste Sector and Circular Economy from a climate perspective are sorting 80% Danish plastic away from incineration by 2030, reducing the volume of Danish waste, and reducing the total Danish environmentally approved capacity for incineration of waste, which must be reduced by 30% by 2030 compared with at present. This means that the total environmentally approved capacity for waste incineration must be reduced to national volumes of waste by 2030.[18]

4.1.6 Reductions in the heating sector

Table 17 shows greenhouse gas reductions in the heating sector in connection with the implementation of the new policy measures described. This is subject to the fact that the reduction levels are partial.

Greenhouse gas reductions *(million tonnes CO_2e)*	**2025**	**2030**
Green restructuring of heating taxes	*0.25*	*0.35*
Green district heating	*0.05*	*0.02*
Individual heating: Phasing out oil and gas boilers	*0.2*	*0.35*
Contribution from the Finance Act 2021	*0.06*	*0.04*
Reduction of CO_2 in the heating sector	**Approximately 0.6**	**Approximately 0.8**
Reduction of CO_2 in the waste sector		**0.7**

Table 17 Approximate estimates of greenhouse gas reductions when implementing the measures described in the heating area (source: Climate Agreement for Energy and Industry, etc. 2020, Agreement concerning the Danish Finance Act 2021 and Agreement concerning Stimuli and the Green Recovery and Climate Plan for a Green Waste Sector and Circular Economy of 16 June 2020).

4.2 Measures to promote efficient cooling

At the end of 2020, a political decision was taken to implement two initiatives that will contribute to promoting efficient cooling, including increasing knowledge about the sector. These initiatives supplement the initiatives regarding district cooling from the Energy Agreement

[18] Climate Plan for a Green Waste Sector and Circular Economy of 16 June 2020 (source: https://www.regeringen.dk/media/9591/aftaletekst.pdf)

2018, which has already been reported to the EU and is being implemented in parallel with the following.

4.2.1 District cooling

Clearer regulation of district cooling

Clearer rules will be introduced for authority approvals of district cooling projects. The rules for authority approval will be adjusted so that it must be specifically demonstrated that a district cooling project is more energy efficient than alternative cooling solutions according to EED definitions of efficient district cooling. This gives municipalities a tangible tool for handling approvals of district cooling projects.

Data requirements for district cooling

As stated previously, there is limited knowledge of the district cooling sector in Denmark. The sector is also small and the need for district cooling is limited due to the Danish climate. District cooling companies are required to disclose certain data about their generation to increase knowledge of the district cooling sector. There is no central data on the sector, including regarding turnover, fuel consumption and emissions. This data is considered necessary to regulate the sector, which is why this is seen as the primary initiative to promote efficient district cooling.

4.2.2 Reductions in the cooling sector

It is assessed that there are no CO_2 emissions associated with district cooling generation over and above any emissions from the underlying electricity and heat generation, which are typically included in district cooling generation.

5. Annexes

5.1 Technology description
5.2 Method description for calculating waste heat potential
5.3 Method description for the cost-benefit analysis
5.4 Economic potential of technologies for efficient heating and cooling and heating and cooling with renewable energy identified in the cost-benefit analysis
5.5 Projection of heating and cooling demand and supply