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Comprehensive Assessment 2024

Denmark

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Content

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Introduction

This "*comparative assessment*" stems from Article 25 (1) ofthe Energy Efficiency Directive (EED) and has been made as part of the Danish obligation to identify and reap potential forenergy efficiency in the heating and cooling sector. The assessment needs to be updated as part of the National Energyand Climate Plans (NECP) and their updates. The *latest comparative assessment* was made in 2020 and the Danish Energy Agency must report the updated assessment in summer 2024 as part of the final update of the NECP.

This *comparative assessment* is to be seen as an explanation of the NECP's section on heating and cooling-sector and consists of four parts that follow the mission statement from Annex X of the EED:

1. An overview of heating and cooling in Denmark
2. Objectives, strategies, policy measures
3. Analysis of the economic potential for efficiency in heating and cooling
4. Potential new strategies and policy measures

Mapping of the heating sector is based on data from the Danish Energy Agency's climate depreciation 2023 (KF23)[1], while data underlying the mapping of the cooling sector are based on the latest comparative *assessment* from 2020 and the Danish Energy Agency's data on district cooling.

Part 1 provides, in addition to an overview of heating and cooling needs and technologies, an identification of facilities that provide waste heat and a projected surplus heat potential, includingone per speculation on future opportunities for using waste heat from Power to X (PtX), Carbon Capture and Storage (CCS) and data centres. In conclusion, Part 1 GIS maps showing heating and cooling demand, district heating and cooling networks and heating plan areas in Denmark.

Parts 2 and 4 describe the objectives, strategies and policy measures decided since the last submission of the final NECP in 2019 and the latest comparative assessment of *2020*, in particular building on the political agreement, the *Climate Agreement on Green Power and Heat 2022*. How these contribute to the five dimensions of the Energy Union will be described.

Part 3 provides a social and company-economic analysis of the potential for district heating and individouble heating, based on a baseline scenario and an alternative scenario based on the analysis from the latest comparative assessment (2020). The analysis must be read subject to the conclusion since 2020 of a number of agreements affecting the heating area which are not included in the data for the 2020 economic analysis. The delimitation to the heating sector is due to the fact thatthe data base for the cooling sector is limited in Denmark. In addition, cooling needs are limited in Denmark in relation to heating requirements, mainly due to the colder climate in Denmark. Furthermore, the lysineis complemented by a simulated production distribution and qualitative sensitivity assessments of CO_2 price.

The approach of re-using the present 2020 analysis is due to the fact that the European Commission has-asked for an update of the previous comparative *assessment* of 2020 when it wasfacial. Against this background, the Danish Energy Agency has assessed that it was the most appropriate tofocus on an update of Parts 1 and 2 as an extension to the update of the NECP and a monitoring of the heating and, in part, cooling sector in Denmark, in which the European Commission can be informed.

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In conclusion, this *comparative assessment is* summarised and the potential to apply effectively.
district heating and cooling and high-efficiency cogeneration. The conclusion shows that Denmark is well advanced in terms of efficient district heating and cooling, with 98 % of the Danish mostefficient district heating and 100 % of Danish district heating systems being assessed efficiently under the current EED

[1] The climate status and projection is an assessment of how greenhouse gas emissions and energy consumption and production will evolve in the period up to 2035, assuming a so-called "frozen policy" scenario.

definition. With regard to high-efficiency cogeneration, it is estimated that 99 % of all cogeneration in Denmark is highly efficient under the current EED definition.

Part 1
An overview of heating and cooling in Denmark

This part of the assessment presents an overview of the Danish heating and cooling sector. This isachieved by presenting the amount of final consumption and final energy consumption, broken down by sector, settlement, services, industry and other sectors. It then presents an inventory of thecurrent final supply of heat and cooling, including a surplus heat potential and anidentification of waste heat generating installations. In conclusion, Part 1 GIS maps showing heating and cooling demand, district heating and cooling networks and heating plan areas in Denmark.

1. Heating and cooling demand in terms of final consumption and final energy consumption

Heat and cooling demand is broken down by sector and is expressed in final consumption and final energy consumption.

Final consumption is defined as *"the amount of thermal energy needed to meet the heating and cooling demand of end-users"*.

Final energy consumption is defined as *"all energy supplied to industry, transport, households, labourservices and agriculture. Final energy consumption does not include deliveries to the energy conversionsector and the energy industry itself."*

The difference between final energy consumption and final consumption is the local loss or gain of the finaluser's own production site, such as an oil or gas furnace or heat pump.

The results, broken down into heating and cooling demand respectively, are given for the years; 2022, 2025, 2030, 2040 and 2050.

1.1 Heating needs

Table 1 and Table 2 show the distribution of heat demand in final energy consumption and final consumption by sector. The figures are based on the Danish Energy Agency's KF232, which is projected to 2030. The projection follows a frozen policy approach, which means that the development is conditional on a "political frozen" absence of new actions in the field of climate and energy beyond those decided by the Danish Parliament or the EU before a given cut-off date or resulting from binding agreements. The cut-off date for a frozen policy approach in this section is 2023. It should be noted that since 2023 new projections have been published for 2024, with developments such as increased roll-out of district heating and gas phase-out, new legislativeproposals in the field of waste incineration and the inclusion of space heating in the quota sector. Thus, there may be changes in the mapping of the heating and cooling sector if the new write-upsare used. This will be included until the update of *the next* comparative assessment expected in 2027.

The heat demand in 2035 has been extrapolated to 2050 based on an expected evolution within each branche. This projection is used exclusively in this analysis and cannot be used in othercoatings.

2https://ens.dk/sites/ens.dk/files/Basisfremskrivning/kf23_hovedrapport.pdf

Heating demand, final energy consumption (GWh)					
Sector	**2022**	**2025**	**2030**	**2040**	**2050**
Residential	40.426	40.257	38.551	36.958	32.343
Services	12.809	13.320	13.272	14.329	16.161
Industry	17.996	19.089	17.033	16.831	17.510
Other sectors	3.211	2.991	2.655	2.376	2.451
Sum GWh	**74.441**	**75.658**	**71.511**	**70.494**	**68.466**

Table 1 Final energy consumption for total heating demand by sector.

Heat demand, final consumption (GWh)					
Sector	**2022**	**2025**	**2030**	**2040**	**2050**
Residential	35.826	36.555	36.074	35.995	31.501
Services	11.207	12.552	12.828	14.157	16.000
Industry	12.234	12.700	11.820	11.727	12.269
Other sectors	2.801	2.664	2.431	2.216	2.317
Sum GWh	**62.069**	**64.472**	**63.152**	**64.095**	**62.086**

Table 2 Final consumption of total heating needs by sector.

Tables 1 and 2 show that final energy consumption needs are expected to decrease by 2050 and a roughly constant need for final consumption.

Figure 1 illustrates the evolution of heat demand by final energy consumption and final consumption up to 2050. In 2022, the heat demand (final consumption) was 62.069 GWh and in 2050 the heat demand (final consumption) is expected to be 62.086 GWh. Final consumption is expected to remain roughly constant, with a slight decrease in final energy consumption, although there will be an increase in the bed of buildings. This is due to the expectation of more energy-efficient buildings with lower heating needs,together with a gradual replacement of production facilities and conversion technologies into more efficient ones.

Evolution of heat demand broken down into final energy consumption; and final consumption 2022-2050

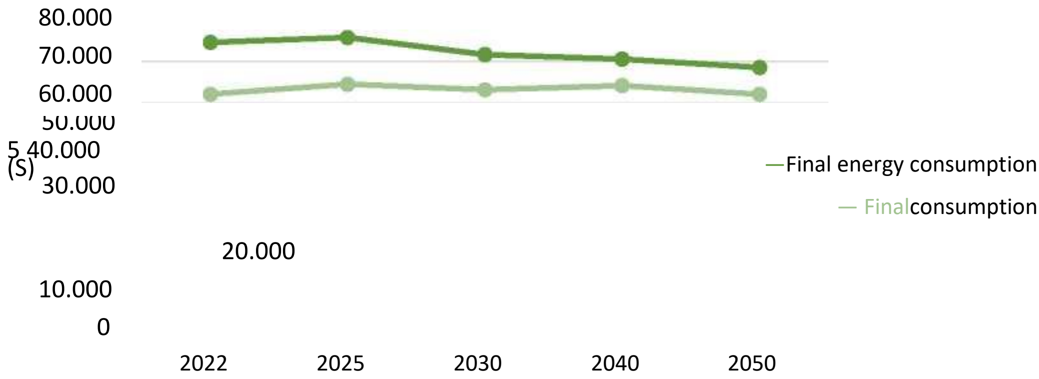

Figure 1 Evolution of heat demand by final energy consumption and final consumption 2022-2050 (source: Danish Energy Agency)

1.2 Cooling requirements

While heating demand is based on realised data, cooling demand is determined on the basis of a screeningtool and is thus based on theoretical cooling demand. This is because realised data on cooling in Denmark are deficient, which also means that this section on cooling needs is based on data from the latest *comparative assessment* from 2020. Following the most recent comparative *assessment, the* Danish Energy Agency has implemented that district cooling companies must report data on their queuelight supply. Based on new rules for district cooling, the data base for district cooling is expected to beimproved in the future, which will be taken into account in the preparation of the *next comparative assessment.*

The total technical cooling demand (final energy consumption) is approximately 2.558 GWh in 2022. 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. For the purpose of cooling production, heatpumps are referred to as cooling compressors.

Total cooling needs (final consumption) are expected to remain broadly constant by 2050. This is due to increased energy efficiency requirements for new and renovated buildings. In the household-sector, cooling demand is assumed to be limited, scattered and covered by individual cooling.

Cooling demand, final energy consumption (GWh/year)

Sector	2022	2025	2030	2040	2050
Residential	0	0	0	0	0
Services	1.301	1.298	1.292	1.267	1.248
Industry	1.186	1.183	1.176	1.150	1.130
Other sectors	71	71	70	69	68
Sum GWh	**2.558**	**2.552**	**2.539**	**2.487**	**2.446**

Table 3 Final energy consumption for cooling demand by sector.

Cooling demand, final consumption (GWh/year)					
Sector	**2022**	**2025**	**2030**	**2040**	**2050**
Residential	0	0	0	0	0
Services	6.532	6.532	6.532	6.532	6.532
Industry	5.955	5.955	5.955	5.955	5.955
Other sectors	356	356	356	356	356
Sum MW	**12.843**	**12.843**	**12.843**	**12.843**	**12.843**

Table 4 Total cooling demand in final consumption by sector.

Figure 2 illustrates the evolution of final energy consumption and final consumption of cooling demand by 2050.

Evolution of cooling demand broken down into final energy consumption; and final consumption 2022-2050

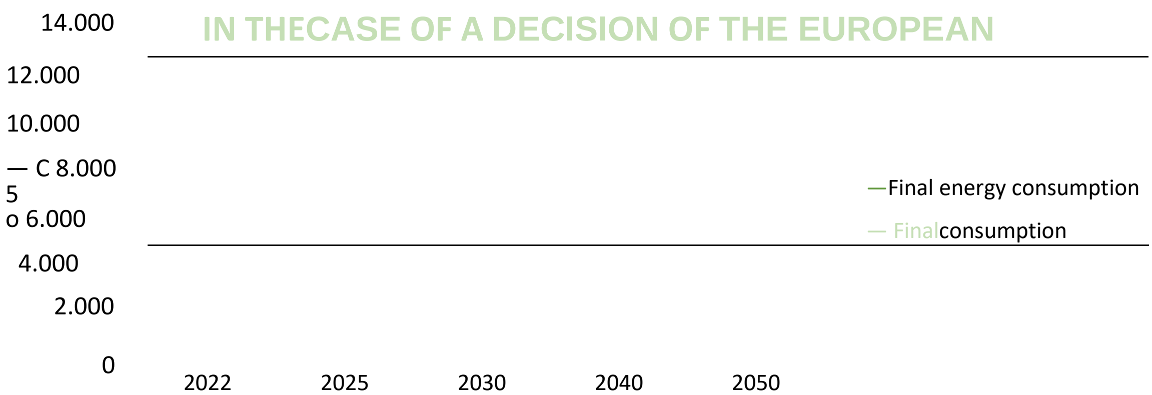

Figure 2 Evolution of final energy consumption and final consumption of cooling demand 2022-2050 (source: Danish Energy Agency)

Thedevelopment of energy consumption (electricity consumption) for cooling depends on the technologies used to reduce cooling prorata and the evolution of the efficiency of the installations. It is estimated that electricity consumption for the production of cooling is decreasing as efficient production of cooling by co-generation of heat and cooling is increasing. A small increase in the efficiency of individual cooling facilities is anticipated.

2. Inventory of current final supply of heat and cooling

2.1 Identification of heat supply by technology

The following sections present an inventory of current final energy consumption based on fossil and renewable energy sources for individual and collective heating, broken down bytechnologies in GWh/year. Table 5 indicates for on-site production and Table 6 for off-siteproduction.

Individual heat supply (on-site) GWh/year

Sector	Fuel source	Technology	2022
Residential	Fossil energy sources	Boilers (heat) Power heat	7.103
		Other technologies	169
	Renewables	Boilers (heat) Power heat	8.994
		Heat pumps	3.588
		Other technologies	344
Services	Fossil energy sources	Boilers (heat) Power heat	2.641
		Other technologies	32
	Renewables	Boilers (heat) Power heat	1.104
		Heat pumps	6.795
		Other technologies	95
Industry	Fossil energy sources	Boilers (heat) Power heat	5.258
		Other technologies	4.681
	Renewables	Boilers (heat) Power heat	1.843
		Heat pumps	6.528
		Other technologies	829
Other sectors	Fossil energy sources	Boilers (heat) Power heat	871
		Other technologies	484
	Renewables	Boilers (heat) Power heat	560
		Heat pumps	701
		Other technologies	128

Table 5 Identification of technologies for individual heat supply (on-site) for 2022.

Collective heating supply (off-site) GWh/year			
Sector	**Fuel source**	**Technology**	**2022**
Residential	Fossil energy sources	Surplus heat	822
		Cogeneration	3.557
		Other technologies	546
	Renewables	Surplus heat	539
		Cogeneration	12.370
		Other technologies	6.096
Services	Fossil energy sources	Surplus heat	377
		Cogeneration	1.631
		Other technologies	250
	Renewables	Surplus heat	247
		Cogeneration	5.670
		Other technologies	3.012
Industry	Fossil energy sources	Surplus heat	38
		Cogeneration	166
		Other technologies	26
	Renewables	Surplus heat	25
		Cogeneration	579
		Other technologies	506
Other sectors	Fossil energy sources	Surplus heat	19
		Cogeneration	81
		Other technologies	13
	Renewables	Surplus heat	12
		Cogeneration	283
		Other technologies	151

Table 6 Identification of technologies for public heating supply (off-site) for 2022.

2.2 Identification of cooling supply by technology

It is the Danish Energy Agency's assessment that the vast majority of refrigeration is producedon complete sorters refrigerating with the exclusion – especially in the case of individual cooling. During periods when there is a need for cooling and sources with lower temperatures (air, groundwater, marinewater, etc.) are available, these sources are used for free cooling – especially in the case of district cooling. It is thus estimated that 15 % to 20 % of the total cooling demand (individual and district cooling) is covered by free cooling and that cooling by absorption cooling and heat pump is limited.

Following the most recent comparative *assessment*, the Danish Energy Agency has implemented that district cooling companies must report data on their cooling supply. This is because the data relating to Denmark's district cooling supply was assessed inadequately. The data base for district cooling is thus estimated to be improved as a result of the implementation of new rules, which will be included *in later complex assessments.*

As district cooling data is confidential for market and competition reasons, this section only contains aggregated totals. The percentage distribution between technologies for district cooling production as shown in Figure 3 is therefore also based on the 2020 assessment. Denmark's total remote cooling capacity was in

2023 approximately 88 MW, with a total cooling supply, a network of 73.469 MWh. This was the total ELFOR use for the cooling supply 22.312 MWh.

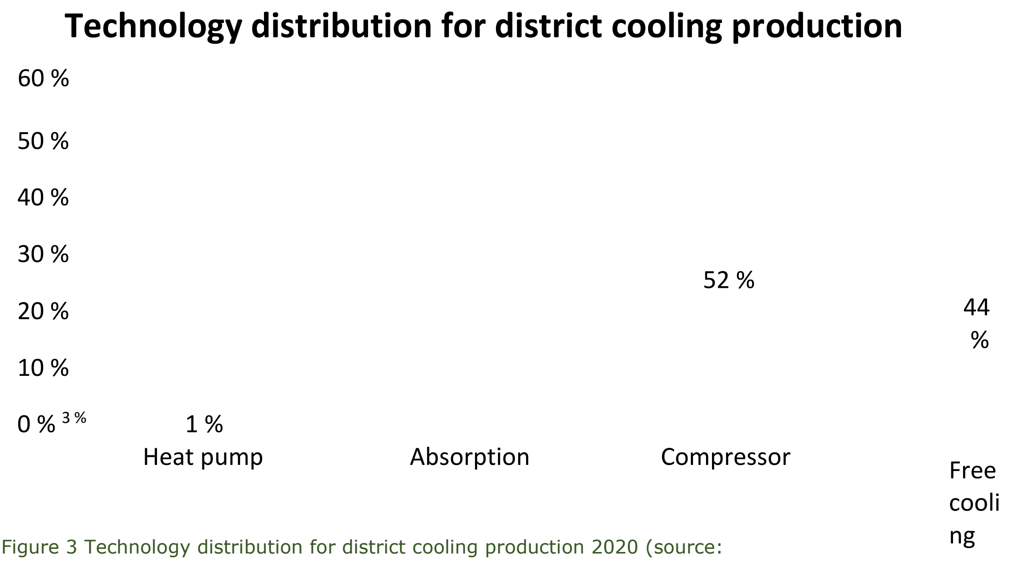

Figure 3 Technology distribution for district cooling production 2020 (source: Danish Energy Agency).

2.3 identification of installations generating waste heat[3] and their heat production

Table 7 and Table 8 show an inventory of installations producing waste heat with and without the- given thresholds from the Energy Efficiency Directive. The threshold values shall be based on the total thermal input of the plants. The calculation shows their total amount of heat disappearance,- expressed in GWh/year for 2022, on the basis of data from the Danish Energy Agency’s energy- producer density.

Installations generating waste heat including threshold (GWh/year)	**2022**
Cogeneration plants above 50 MW	13.620
Waste incineration plants above MW	5.288
Ve installations[4] above 20 MW	602
Industrial waste heat above 20 MW	786
Boilers in excess of 50 MW	179
Sum	**20.476**

Table 7 identification of installations producing waste heat including threshold values.

[3] It should be noted that the calculation of surplus heat in this section follows the definition from the Energy EffectiViity Directive and not the Danish definition, cf.the Heat Supply Act. Heat production from CHPplants, waste incineration plants and boilers is not defined in Denmark as surplus heat.

[4] Five plants will be heat pumps, solar heat and electric boilers.

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Installations generating waste heat excluding threshold (GWh/year)

	2022
Kraftvarmeanlæg	1.764
Affaldsforbrændingsanlæg	3.356
VE anlæg	2.238
Industriel overskudsvarme	375
Kedler i øvrigt	7.590
Sum	**15.324**

Table 8 identification of installations producing waste heat excluding threshold values.

It should be noted that Denmark does not have data on installations producing surplus shoulder, which is why this is not described further in this section.

2.4 Projection of waste heat used

The Danish Energy Agency's climate depreciation 2023 shows that district heating in 2024 will use 2 150 GWhof dust heat (including indirect surplus heat where heat pump was used for temperature-lift). This is expected to increase and district heating is projected to use 4 644 GWh of excessheat in 2030, see Figure 4. It should be noted that the projection is for the current Danish definitionof surplus heat. Thus, Figure 4 can only be compared with data for RES installations and industrial waste heat from Tables 7 and 8, as for the remaining types of installations different weremeals.

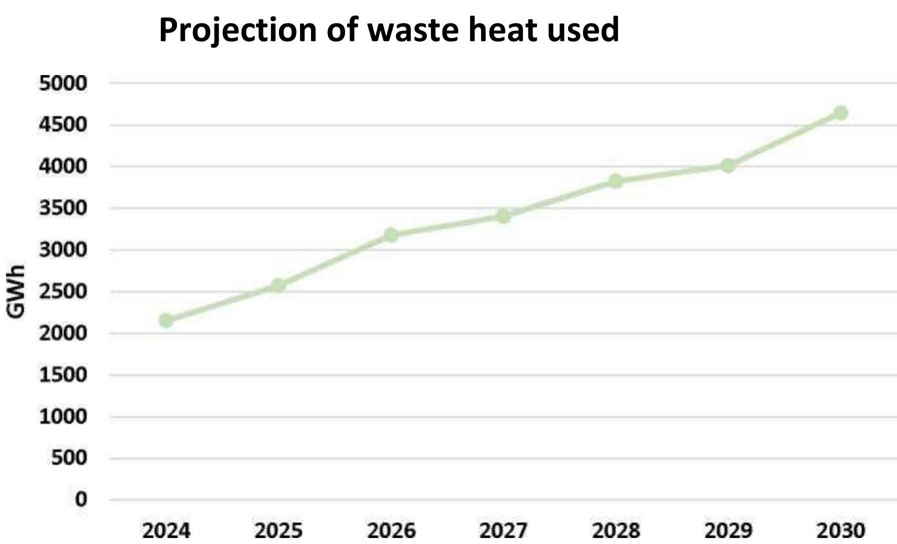

Figure 4 Provision of used waste heat 2024-2030 (source: Danish Energy Agency).

As can be seen in Figure 4, it is assumed that the use of surplus heat will increase by 2030. In addition to waste heat from installations identified in Section 2.3, it is expected that:

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there will be a significant amount of potential for waste heat from, among others, data centres, carbon capture and storage installations (CCS) and from Power-to-X (PtX)5. Their potential will be

5Power-to-X covers technologies that use power to convert water into hydrogen, which may be further described in the subsections below.

Potential for use of waste heat from data centres

There are currently 67 data centres in Denmark, calculated in 2023, and it is expected that more will be built in line with technological developments and digitalisation. The European Commission has been keen Kusto ensure energy efficiency by looking at the potential for using waste heat from, among other things, data centres. In particular, new requirements have emerged in the revised EED that, given that tacentres largerthan 1 MW have to use the excess heat, if technically and economically feasible, calculated onthe basis of a cost-benefit analysis at installation level.

Although there is a potential for using waste heat from data centres, there are a number offactors that can determine whether a waste heat project is technically and economicallyfeasible. In particular, the distance to a district heating network or a heating need is crucial. Typically, the large datacentres will be located close to electricity transmission networks or major substations, as data centresshould use a significant amount of power to operate. In these areas, there will most often not be a sufficient heatdemand or an existing district heating network, so the cost of installing district heating pipes and connecting the source of the demand must also be taken into account. Moreover, the heat source from a datacentre is typically not of high quality, as the temperature will be relatively low in volume, e.g. heat fromin the factory, which often has processes with high temperatures. In such cases, investmentin a heat pump will be needed to upgrade the temperature of the excess heat so that it becomes fairin the district heating network.

In addition, there will also be a consideration for the district heating company whether they will take the risk by replacing or deprioritising some stable heat production with a surplus heat source, which in fact depends on a process with a different main purpose. Surplus heat will always be a by-product and therefore the district heating company runs a risk by making an investment in a product that depends on a separate process in which demand and thus production may vary.

There will thus be a potential for waste heat from data centres, but it depends on local circumstances and the specific case whether it makes economic sense to exploit the surplus heat.

Potential for utilisation of waste heat from CCS

Since 2020, a number of political agreements have been concluded to support the development of a Danish market for CO_2capture and storage (CCS). Against this background, a number of CO_2fishing facilities are expected to be set up in Denmark in the coming years. Thus, a contract was awarded in May 2023 to support the establishment of CO_2 catchesat the Avedør and Asnæsværs. The offer of additional support for the capture and storage of CO_2 is expected to be published in 2024.

CO_2 catchesgenerate a significant amount of waste heat that can potentially be used in the district heatingnetwork. The upcoming CO_2 catch facilityat Avedørek plant is expected to be able to deliver approximately 34 MW of waste heat from the CO_2catch process.

The CO_2fishing gear in Avedøre shall catch 150.000 tonnes of CO_2 per year. Overall, the available CCS funding is expected to support the catch and storage of 3.2 million tonnes of CO_2 annually from 2029. Waste heat from future CO_2catch plants therefore has significant potential. Possible installations where CO_2 catchcan be

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an option is largely concentrated on the largest Danish cities, Hovedstadsområden, Aarhus, Odense, Aalborg, Esbjerg and Fredericia, which have larger existing district heating systems.

Potential for utilisation of waste heat from PtX

Power-to-X (PtX) is expected to play a key role in integrating more RES intothe energy system, while

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converted into other e-fuels and products such as ammonia, methanol, aviation fuel or plastic.

PtX fuels can be used in sectors where direct electrification is notpossible. In the production of PtX fuels, large amounts of waste heat are generated, whichcan potentially be used as district heating.

In Denmark, an *agreement on the development and promotion of hydrogen and green fuels* has adopted a policy objective of establishing 4-6 GW of electrolysis capacity by 2030. The Agreement emphasises that PtX can contribute to an integrated and flexible energy system, integrating PtX into the energy system in a way that supports and complements existing supply sectors, such as the heating sector.

If the policy objective of 4-6 GW of electrolysis capacity is achieved, excess heat could potentially be generated, corresponding to around 19.000-28.000 TJ per year. It should be noted that thespecific case determines whether or not the surplus heat will be used and it is assumed that not all the excess heat can or will be used in district heating. The PtX industry in Denmark has the ambition to set up approximately 9.5 GW of electrolyser installations in 2030 and its subsequent conversion facilities. If the sector's declared PtX projects are established, they could potentially generate around 45.000 TJ of excess heat per year. The development of PtX plants andthe production of waste heat is expected to increase further by 2050, with the development of more renewable energy and the shift away from fossil fuels. To the extent that PtX production is located at sea,vur their surplus heat cannot be used as district heating.

It is the task of PtX developers to find their desired location of their PtX plants andto give priority to flour the factors that influence the overall project, such as appropriate plain relation to the electricity grid. As a result, there is no certainty that PtX developers will locate their installations in or near district heating areas and it is thus uncertain how much of the waste heat will be used as district heating. From other major projects planned to be established outside district heating areas, examples of plans for the co-location of industry as horticulture, etc., which can exploit the surplus heat are known.

The Danish Energy Agency is aware of a number of PtX projects which will be located in a remote heating area and supply surplus heat. A good example of this are two major projects in Esbjerg, which plan to supply large quantities of surplus heat to DIN Supply. One project expects to be operational in 2027 and the other in either 2028 or 2029.

2.5 Reported share of VE and surplus heat in district heating sector 2018-2022

Denmark's share of VE and surplus heat in the district heating sector is regularly reported to theEuro pean database *Eurostat*. The evolution of the share from 2018 to the last reporting in 2022 can be found in Figure 5. In 2018, the share of VE and surplus heat was 61 %, before increasing continuously to 73 % in 2022. It should be noted that the surplus heat part represents a minor part of the total share of VE and surplus heat in the district heating sector. However, typically, the shares are reported together to Eurostat, which is why it is also calculated as a total share of VE and surplus heat in this section.

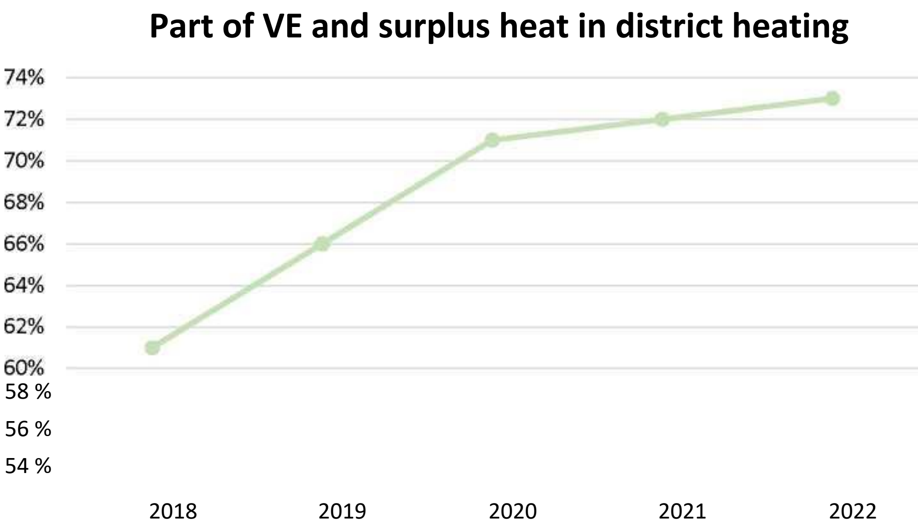


Figure 5 Five annual evolution of the share of VE and surplus heat in district heating 2018-2022 (source: Danish Energy Agency).

It should be noted that Denmark does not have data on the share of VE and surplus shoulder in the district cooling sector, which is why this is not further described in this section.

3. Aggregated data on cogeneration units

Aggregated data on district heating cogeneration units broken down into five capacity ranges

Thermal input capacity	MW	DECISION20	20-50	50-200	200-500	> 500 MW	Total
Number of installations		390	24	27	5	7	453
Fired capacity spark.	MW	5	30	208	693	873	1809
Primary energy consumption	GWh	3133	4371	10506	7704	19808	45522
Electricity generation	GWh	1013	774	2401	1630	7740	13558
Heat supply	GWh	1736	2763	7487	5756	5675	23407
Primary energy saving6	GWh	1626	2501	7404	5095	5793	22419
Effectiveness		88 %	81 %	94 %	96 %	68 %	81 %

Table 9 Aggregated data on CHP units for 2022 (source: Danish Energy Agency)

Table 9 shows that the most efficient cogeneration units are those with thermal capacitybetween 200 MW and 500 MW. At the same time, the most inefficient units are those with a capacity greater than 500 MW.

6PES (Primary Energy Savings) savings compared to separate production calculated in accordance with the EU-CHP-Eurostat tem- plate.

The majority of units are in the smallest range (less than 20 MW) and have an efficiency of 88 %. It is worth mentioning that these units also have the smallest total primary energy saving, which is due to the lower total primary energy consumption, with the highest primary energy savings being found in units with a capacity of 50 MW to 200 MW. Thus, the largest potential for energy efficiency of cogeneration units in Denmark is found in the largest units above 500 MW of capacititet.

4. Aggregated data on heat delivery to existing district heating networks

Aggregated data on heat delivery to district heating networks broken down into five ranges

Interval	GWh	0-50	50-200	200-500	500-2000	> 2000	Total
Number of district heating networks	GWh	287	50	14	7	3	361
Heat supply	GWh	4770	4531	4306	7145	15037	35825
— of which in efficient networks	GWh	4372	4207	3997	7145	15073	34794
— of which in inefficient networks	GWh	398	323	309	0	0	1030
Cogeneration (fossil)	GWh	369	401	910	2084	3380	7144
Cogeneration (biomass)	GWh	257	869	1387	3606	10141	16260
Boilers (fossil)	GWh	336	256	553	374	605	2125
Boilers (biomass)	GWh	2469	2133	1135	167	307	6211
Elkeder	GWh	293	287	86	90	262	1017
Solar heat and heat pumps	GWh	882	356	164	20	18	1440
Industrial surplus heat	GWh	103	229	64	790	349	1535

Table 10 Aggregated data on existing district heating networks supplied from cogeneration and other sources for 2022.

Table 10 shows that the largest supply of heat to district heating networks comes from biomasscombined heat and power plants, where the smallest supply comes from electric boilers. While a relatively highproportion of heat supply from fossil sources is still seen, it is still considered efficient district heating due to the high share of cogeneration in fossil boilers. In conclusion, it is worth mentioning that in 2022 there is a higher heat delivery from industrial waste heat than from solar heatand heat pum per combined, which is expected to change by 2030 with the electrification of fossil district heating production.

5. Map of heating and cooling in Denmark

Figure 6 shows the heat demand in Denmark. The heat demand is shown as heat production divided between the central plants from the Danish Energy Agency's energy producer counting and is expressed in GWh. The heat is-stribusted from central heat generators to buildings.

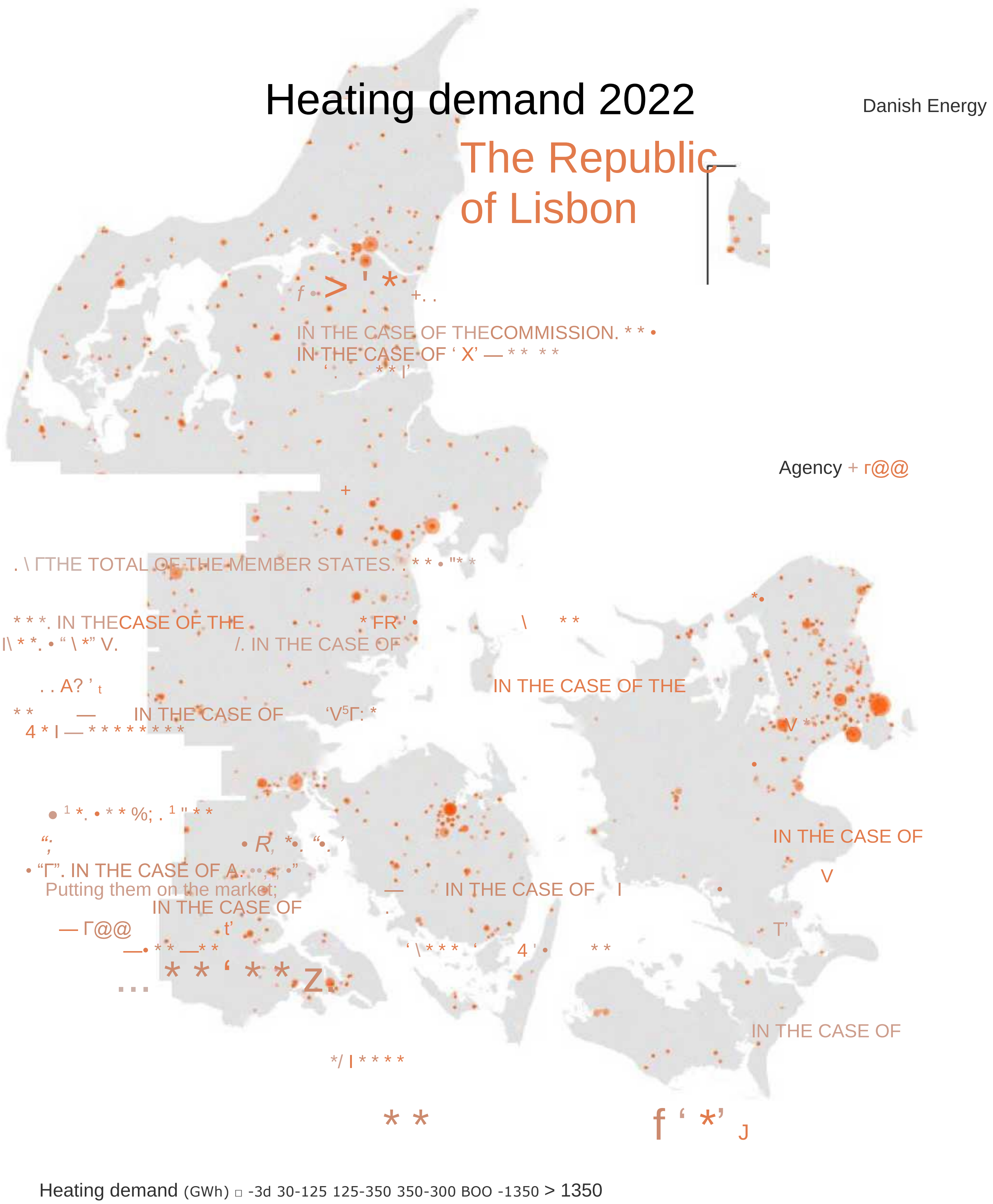


Figure 6 Heat needs in Denmark 2022 (source: Danish Energy Agency).

Figure 7 shows the cooling power demand in Denmark for 2020. The cooling power demand is distributed betweenbuildings within the timed using an external screening tool and is expressed in MW. It can be seen that the cooling demandis in the vicinity of the major cities in Denmark.

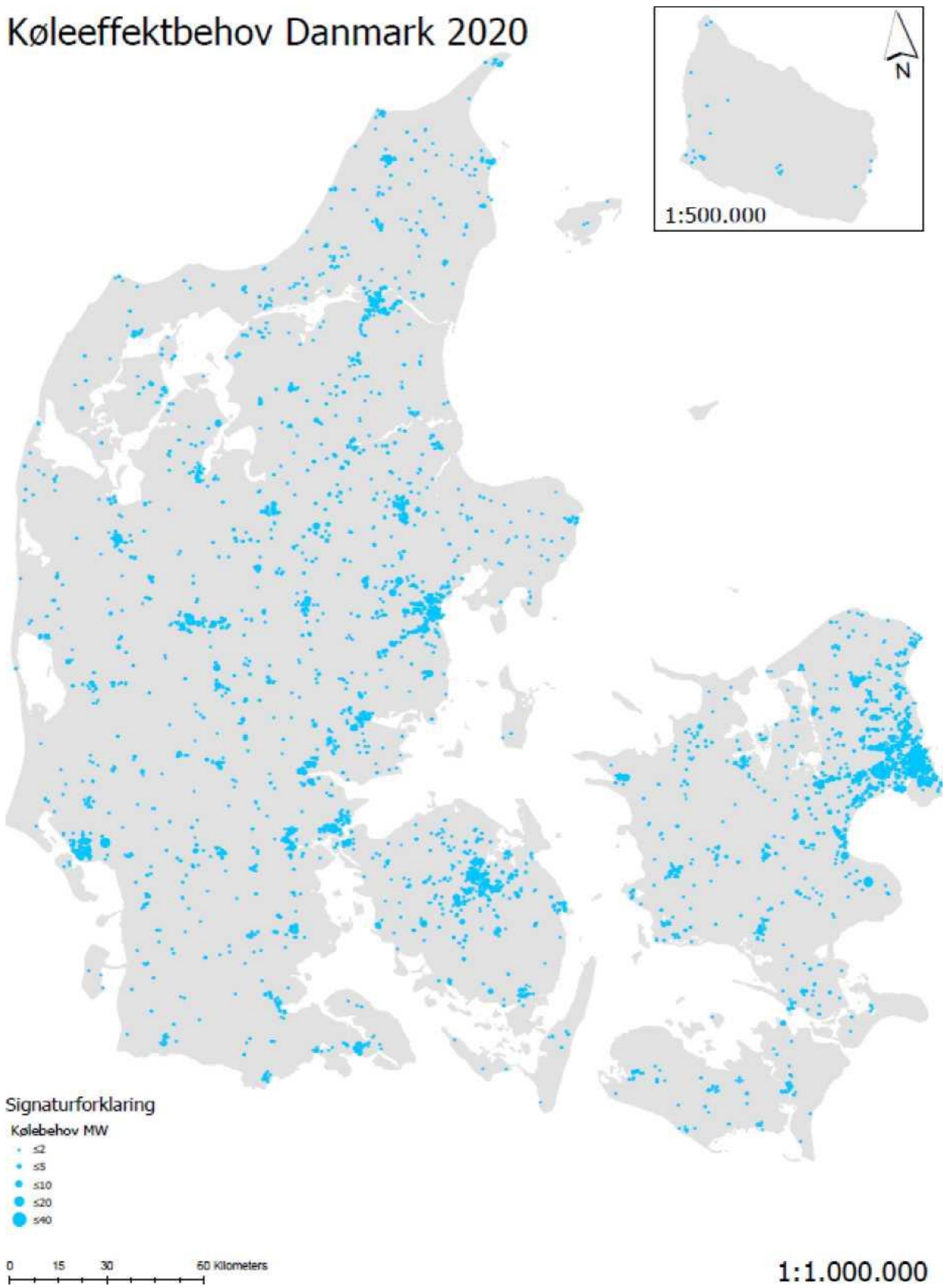


Figure 7 Cool power demand in Denmark 2020 (source: Danish Energy Agency).

Figure 8 shows heating supply areas divided into district heating and individual natural gas supply in Danmark. It should be noted that approved district heating areas include both existingdistrict heating districts and areas where a project proposal for district heating has been approved but where district heating has not yet been established.

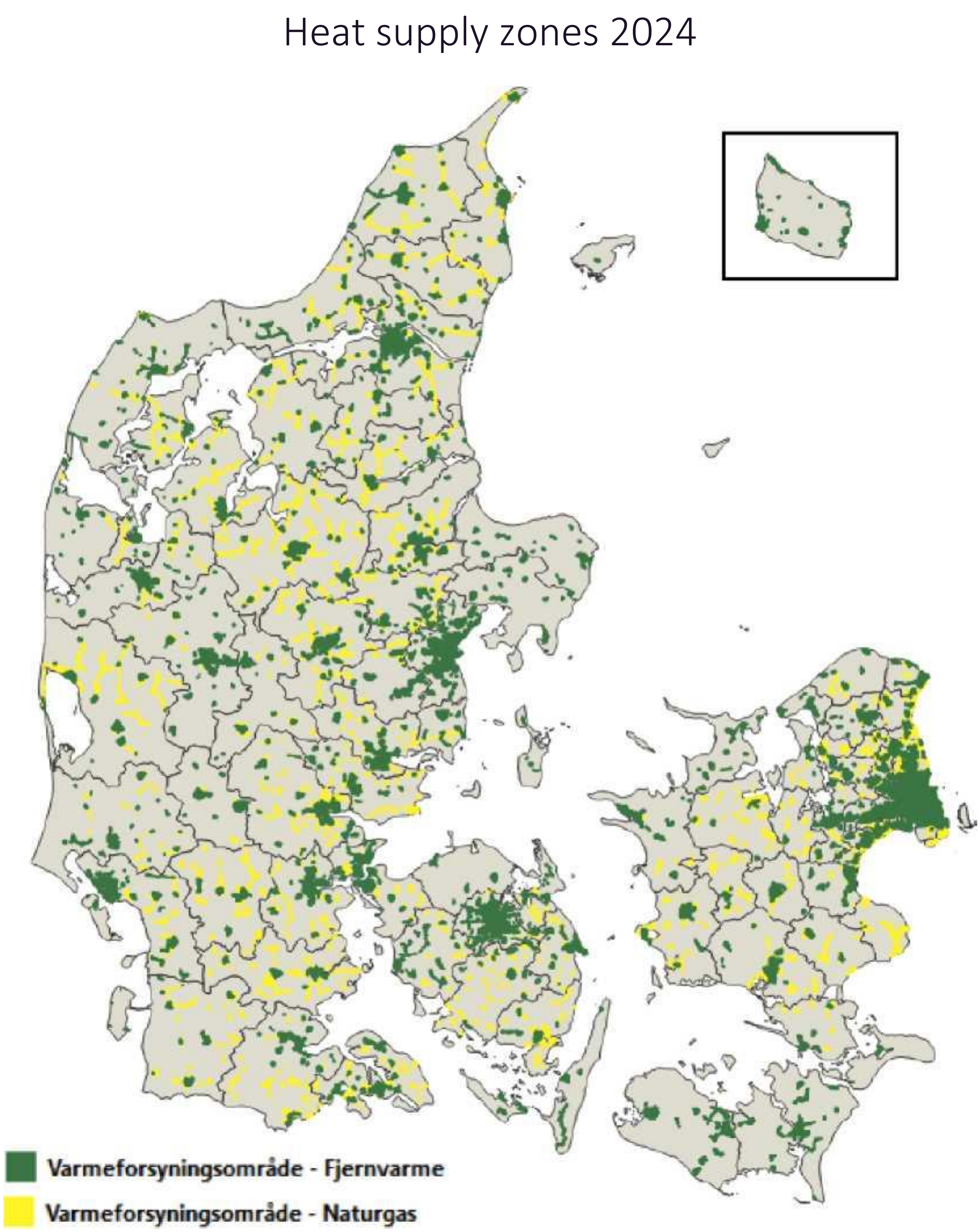


Figure 8 Geographical overview of heating supply areas

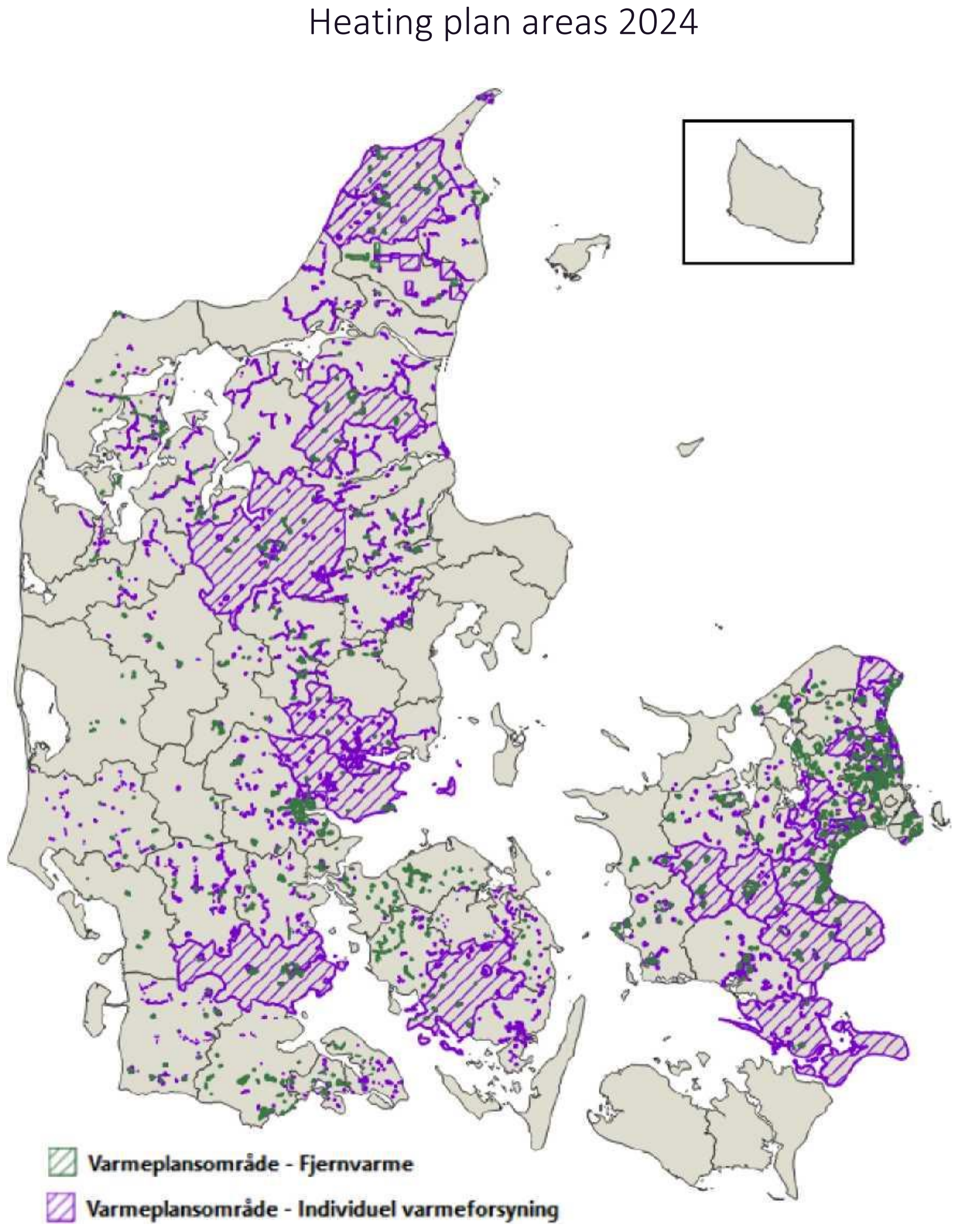
Note: Plandata.dk may be affected by errors and shortcomings, as the municipalities have had different practices for the statutory-report in Plandata.dk. For example, there are indications that information on supply areas may be missing, misreported or not updated.

Source: Plandata.dk as of 14 May 2024

The green areas in Figure 8 show district heating areas including transmission lines, while the yellow areas show natural gas areas. It should be noted that Denmark does not have data on district cooling networks, which is why this is not further geographically illustrated on a map. However, the specific district cooling areasare known, which will mainly be located in the larger cities and individual locations in North Jutland.

On the basis of a political agreement between the then S Government and the Municipality's Interests' Association (KL), the municipalities were given the task in 2022 to assess whichgas-fuelled areas in the comma had the potential to be converted into a district heating area and which are deemed to be supplied with individual heating. Figure 9 shows potential heating plan areas for remoteheat and individual supply in Denmark, based on the municipal reports of their VaR meplans in 2022 with a data retrieval from 2024. It should be noted that for the other maps, data from 2022 and 2020 were used as it was the most recent data available for the purpose of mapping heating and cooling demand respectively.

The areas planned for individual supply may be large in some municipalities, but a large part of these areas will be non-residential. Some of the municipalities have chosen to mark all areas intheir municipal border where no district heating potential has been assessed as individual heating, including areas where there is currently no gas supply. Other commonshave been more accurate in marking only areas of habitation and existing gas disappearance, so in these areas the amount of individual supply is less visible. Finally, very few municipalities have not yet reported heating plans for all gas-supplied areas,and some have reported an approved district heating project instead of a heating plan. This may have an impact on data quality. It should be noted that, as a follow-up to the heating plans, the municipalities were required, as a starting point in 2023, to draw up concrete project proposals for district heating containing a final economic and technical assessment of the possibility of district heating.



6. Forecast of heating and cooling demand trends

See sections 1.1 and 1.2.

Figure 9 Geographical overview of heating plan areas

Note: Plandata.dk may be affected by errors and shortcomings, as the municipalities have had different practices for the statutory-reporting in Plandata.dk. For example, there are indications that information on supply areas may be missing, misreported or not updated.
Source: Plandata.dk as of 14 May 2024

Part 2
Objectives, strategies and policy measures

This section describes Denmark's objectives, strategies and main policy measures for individual and collective heating and cooling. It sets out only the objectives, strategies and actions decided since Denmark's last reported final *National Energy and Climate Plan* (NECP) in 2019 and *comparative assessment* from 2020.

Objectives, strategies and policy actions are presented in relation to the five dimensions of the Energy Union, which include: decarbonisation, energy efficiency, security of energy supply, internal market, research, innovation and competitiveness. Most of the new initiatives decided since the last notification of the NECP in 2019 and the *comparative assessment* of 2 020 are contained in the *2022 Climate Agreement on Green Power and Heat,* which is therefore at the heart of the presentation. It should be noted that the recommendations of the NECSC Working Group are only recommendations and not actions decided upon. In this regard, it should be noted that the recommendations are highly targeted at private and municipal actors. The decarbonisation and energy security dimensions have been merged, as several of the initiatives are also contributing to security of supply in the heating sector.

Part 2 concludes with a similar but minor explanation for the Danish cooling sector.

7. Objectives, strategies and policy measures for the Danish heating and cooling sector

7.1 Heating sector

A broad majority in the Danish Parliament, including the parties in the current Danish government, has set a target of 70 % reduction in greenhouse gas emissions by 2030 (in line with. 1990 level). The Danish district heatingsector must contribute to this by switching from fossil heat to renewable heat. At the same time,greater consumer protection and better conditions for investment in – and roll-out of – green remoteheat must be maintained. The following agreements and their content will be affected in this section:

- *Climate agreement for energy and industry, etc. 2020*[7]
- *Follow-up agreement ifm. Climate agreement for energy and industry, etc. 2021 (promoting the use of waste heat)*[8]
- *Follow-up agreement with regard to energy and industry climate agreement, etc. 2021 (price regulation of remoteheat from geothermal plants)*[9]
- *Climate agreement on green power and heat 2022*[10]
- *Agreement on accelerated planning for phasing out gas for heating and clear message to citizens 2022*[11]
- *Agreement on Targeted Heat Check 2022*[12]

7https://kefm.dk/Media/8/8/aftaletekst-klimaaftale-energi-og-industri%20 (1).pdf
8https://kefm.dk/Media/637677403986733144/Opf%C3%B8lgende%20aftaletekst%20overskudsvarme.pdf
9https://kefm.dk/Media/637757648701105779/Opf%C3%B8lgende%20aftale%20ifm%20Klimaaf-speech% 20 for% 20energy% 20 and% 20industry% 20mv.pdf
10https://www.regeringen.dk/media/11470/klimaaftale-om-groen-stroem-og-varme.pdf
11https://kefm.dk/Media/637920925815079238/Aftaletekst%20om%20fremskyn- % 20planl% C3 % A6ke.20for% 20phase-out% 20of% 20gas% 20-% warming.pdf
12https://kefm.dk/Media/637801888446028492/Aftaletekst%20m%C3%A5lrettet%20varmecheck.pdf

- *Agreement on Winter Aid 2022*13
- *Partial agreement on the allocation of funds from agreement on targeted heat check and phase-out of black heat 2022*14
- *Addendum to the Inflation Aid Agreement 2023 – Breakdown of the framework for the decoupling scheme and the district heating pool*15

The political agreements include a set of concrete tools and actions to support the phasing outof gas, the roll-out of district heating and ensuring consumer protection. These are presented downstream, together with an explanation of how to contribute to the five dimensions of the Energy Union. It should be noted that there will be initiatives that have been completed, initiatives on which work is still ongoing and initiatives that have not yet been launched.

In addition to the agreements, a National Energy Crisis Cell (NEKST) was set up in January 2023 on the basis of the government basis of December 2022, where the working group *'Farvel for gas in Danish homes'* (composed of industry players) has drawn up recommendations on how to speed up the phase-out of gas for domestic heating and the roll-out of green heat*16*. The work of the National Energy Crisis Cell (NEKST) constitutes a new type of cooperation between public authorities, municipalities, the energy sector and other actors. Working together, with its cross-sectoral nature and recommendations, responds to the EU's vision of stakeholder involvement in the development of energy policy.

The recommendations of the working group were published on 14 March 2024. The recommendations target both municipal and private actors and the State, and the NECSC Working Group has developed a number of guidance documents and advice on process optimisation. For actions targeting the state, a number of recommendations havebeen incorporated into the general work on the sector and the follow-up *to the Climate Agreement on Green Power and Heat 2022*. To this end, there are actions that have not yet been decided politically.

The following agreements, decided since Denmark's last reported NECP in 2019, and *comparative assessment* from 2020, have an indirect impact on individual and collective heating. As thedolls only indirectly affect the heating sector and have a smaller share in increasing the efficiency of the heating-sector, they will not be further affected in this *comparative assessment*.

- *Climate plan for a green waste sector and circular economy 2020*17
- *Follow-up agreement ifm. Climate agreement for energy and industry, etc. (Sustainability requirements for woodenbio mass for energy) 2020*18
- *Agreement between the Government and the Venstre, the Radikale Venstre, the Socialist People's Party and the Konservative People's Party on: Green tax reform (8 December 2020)*19
- *Agreement between the Government and Venstre, Socialist People's Party, Radikale Venstre, Konserva tivePeople's Party on: Green tax reform for industry, etc. 2022*20

13https://fm.dk/media/26374/aftale-om-vinterhjaelp.pdf
14https://kefm.dk/Media/637889760408485776/Delaftale%20om%20disponering%20af%20mid-clay% 20 from% 20 deal% 20 on 20 m% C3 % A5loriented% 20hot-echeck% 20 and% 20phase-out Being% 20of% 20black% 20heat.pdf
15https://kefm.dk/Media/638156073944935305/Aftaletekst%20-%20till%C3%A6gsaftale%20til%20af- speech% 20 % 20inflationhj% C3 % A6lp.pdf
16https://kefm.dk/Media/638459533724126884/Nekst_Farvel%20til%20gas%20i%20danske%20hjem.pdf
17https://www.regeringen.dk/media/9591/aftaletekst.pdf
18https://kefm.dk/Media/D/8/Opf%C3%B8lgende%20aftale%20ifm.%20Klimaaf-speech% 20 for% 20energy% 20 and 20 industry% 20mv.. pdf
19https://fm.dk/media/18517/aftale-om-groen-skattereform_a.pdf
20https://fm.dk/media/26070/aftale-om-groen-skattereform-for-industri-mv-a.pdf

- *Agreement between the Government, the Venstre, the Socialist People's Party, the Radikale Venstre, the Unity List and the Conservative People's Party on: Establishment of a Green Fund 202221*
- *Agreement on long-term framework conditions for CO2 catch in the supply sector 202422.*

7.2 Green district heating and the five energy dimensions

The section examines how the initiatives in the Danish political agreements and the recommendations of the NEKST working *group Farvel for gas in Danish homes*, concluded since the last notification of the NECP in 2019 and the *comparative assessment* from 2020, contribute to achieving the objectives of the Energy Union's five dimensions.

Energy dimension: Decarbonisation and*energy security*

As a follow-up to the *Climate Agreement for Energy and Industry, etc. 2020 a number ofrates have* been implemented that have encouraged the phasing out of fossil fuels, to some extent increasing thesecurity of supply in the heating sector. Among other things, it has been decided to increase the space heating tax on fossil fuels, while at the same time reducing the electricity tax to the EU minimum rates. This has been done to promote electrification andphase out fossil heat production. In addition, with a number of agreements, DKK 6 billion has been allocatedto shoulders to phase out oil and gas furnaces from 2020 onwards. The tips include: a pool to cover costs of disconnection from the gas system, a district heating deployment pool, a pool for conversion to individual heat pumps, a pool for conversion to heat pumps on subscription,and a pool for energy efficiency improvements. In addition, companies may receive subsidies for converting into, inter alia, heat pump or district heating from the Business Pool if the conversion results in a reduction in CO_2or energy saving. The Industry Pool was implemented as a result *of Energy Agreement 2018* and received more funding from the *Climate Agreement for Energy and Industry, etc. 2020* and *Green Tax Reform Agreement 2020*. Finally, the *Climate Agreement for Energy and Industry, etc. 2020* decided toincrease fuel ties so that district heating companies are not obliged to burn natural gas. It was alsodecided to abolish the CHP requirement so that central and decentralised areas are equated so that in central areas only heat generators can also be set up. To this end, the agreement includes amoderation of the bottling obligation in order to enable the use of surplus heat and renewable energy production. Finally, consumer bonds to natural gas and the possibility to impose consumer bonds in new remote heating areaswere lifted and unnecessary barriers to the conversion of natural gas areas into district heating were removed.

In a follow-up agreement to the *climate agreement for energy and industry, etc. 2020 on price regulation of district heating from geothermal installations, the parties to the agreement* agreed to introduce a separate price regulation forgeothermal heat. The separate price regulation implies that if a number of specific conditions arefilled, the district heating company and the geothermal operator may be exempted from the current priceregression. This was decided to promote the use of geothermal heat. However, it is a prerequisite thatthe specific geothermal project can be approved by the municipality in accordance with the Heat Supply Act's requirement for a positive social economy. In addition, the project must be the most financially biasedat the time of the conclusion of the contract. It is also necessary to have aprivate-law contract between independent parties with opposing interests. The contrastand any changes thereto between the district heating company and the geothermal

21https://fm.dk/media/26067/aftale-om-etablering-af-en-groen-fond-a.pdf
22https://kefm.dk/Media/638429086843948317/Aftale%20om%20langsigtede%20ramme-Wilk% C3 % A5r% 20 for% 20CO2 catch% 20i% 20 supply sector% 20 (002).pdf

operator shall be on one

time during the contract period contains a number of consumer protection elements. If the contractis adjusted so that one or more elements are no longer included, geothermal heat shall again be subject to the regulation applicable to district heating production.

With *the Climate Agreement on Green Power and Heat 2022*, a number of actions have been agreed to encourage thephase-out of fossil fuels and to some extent enhance security of supply in the heating sector. The climate agreement decided on a political ambition that, from 2035, there should be no dwellings coveredby gas furnaces and that Danish biogas production should correspond to 100 % of total Danish gas consumption by 2030. With the agreement, it was decided that the government would present concrete actions and financing to meet its ambitions in 2026. In addition, it was agreed that a model for stopping the new installation of oil and gas furnaces would be considered. In addition, the Danishgas distribution company Evida should make an updated mapping of where gas di stribution network canbe properly closed and a model should be drawn up as to how the actual shutdown orcon conversion can take place in accordance with Danish and European legislation. In addition, it was decided that: to strengthen advice to consumers on the reduction of gas consumption and green heat options, to develop a plan to phase out fossil heating in public buildings, to simplify the permitting processfor district heating projects in 2022 and 2023, and to strengthen the transparency of the heating sector through continuous reporting of data on climate footprint, security of supply and costs.

Finally, it was decided to work towards a ban on the authorisation of new projects for remoteheaters using fossil fuels as the main fuel for base, medium and peak load for district heating, and for district heating companies to draw up a plan to phase out pipeline gas intheir own pure heat generators (gas boilers).

On the basis of the *Climate Agreement on Green Power and Heat 2022, in the summer of 2022 the Government concluded an agreement on accelerated planning for the phase-out of gas for heating and clear messages to citizens* with the Danish municipalities' interest organisation KL. In this context, in 2022 the Danish municipalities haveeasily carried out planning efforts and send letters with information on future green heating options to oil and gas firefighters in areas currently equipped with gas. The ambition is for district heating to be rolled out by the end of 2 028 in those areas where it makes sense. The agreement allocated DKK 201 million in the period 2022-2025 to the municipalities' efforts, including the developmentof heating plans, the approval of project proposals for district heating, cooperation with districtheating plants and the support and development of local small-scale joint heating projects.

The then government also entered into an agreement with Finans Denmark on the partnership "light your lighthouse", which aims to enable cheap financing for green heat sources by exempting the registration of mortgages for loans to replace oil and gas furnaces for other sources of heating in the period 2023-2028, as well as establishing a system for obtaining loans with a State guarantee to switch to other heating sourcesin rural dwellings that cannot be connected to the district heating network and where there is uncertainty as to the valuationof the dwelling and thus the free value. Finally, in June 2023, KL, Danske Regioner and the Government issued their plans for phasing out fossil heating in the communale, regional and state buildings.

Denmark has also implemented a number of initiatives to ensure sustainability and security of supply of biomass. Denmark has implemented the VE II Directive[23] (Articles 29, 30 and 31)

23 Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of theuse of energy from renewable sources

and a broad political agreement on woody biomass24 from October 2020. The Danish legal requirements on-sustainable biomass for the production of electricity, heating and cooling entered into force on 30 June 2021. The-objective of sustainability is to reduce as far as possible the risk of using "unsustainable biomass" in Denmark, i.e. biomass with a high climate or biodiversity impact. At the same time, the requirements are formulated flexibly for reasons of security of supply and consumers' heating prices.

The Danish government decided to temporarily remove the sustainability requirements for wood pellets in private households in order to address a possible shortage of wood pellets for heating in privatehouseholds. This amendment was in force from November 2022 to April 2024. In addition, the Danish Ringhas adopted a number of measures to reduce rising prices and ensure the supply of wood pellets, including theestablishment of closer contact with the industry, a focus on information for citizens and an analysis of the possibility of using alternative fuels in wood pellet furnaces, which did not show viable alternatives. In addition, the scrapping scheme, which supports heat pumps on subscription, has been extended so that households with wood pellet furnaces can also benefit from these funds.

Energy dimension: General energy efficiency

Above actions on electrification and phase-out of fossil fuels from the heatingsector are also considered to lead to energy efficiency, as it is highly expected that boilers will bereplaced by heat pumps. Denmark is thus expected to contribute to the achievement of the EU's 11.7 % energy efficiency target for 2030, as well as the indicative milestones in 2030, 2040 and 2050, due to the increased focus on the phasing out of natural gas.

Climate agreement for energy and industry, etc. 2020 also includes other initiatives that encourage energyefficiency in the heating sector. It was decided, among other things, that the tax on electricity for heat production wouldbe set at the EU minimum rates, thereby also abolishing the tax on electricity surplus heat. Inaddition, the following climate *change agreement for energy and industry, etc. 2021* adopted separate rules on the price regulation of surplus heat and tax reductions if a surplus heat supplierenters an energy efficiency scheme which is also intended to promote the use of surplus heat. The aim of price regulation is, inter alia, to increase incentives to use surplus heat where appropriate, i.e. where the total cost of using the surplus heat does not exceed alternative investmentsin renewable energy installations and thus imposes unnecessary costs on consumers.

In addition, the recent *agreement on an ambitious and responsible strategy for Denmark's digital development* of 8 February 2024, which allocated DKK 71.5 million in 2024-2027 to the establishment of a missing digitalisation-programme. The programme will provide a framework and regulation for collecting, structuringand making data available in the missing sector, with an overall objective of ensuring a green, coherent and efficient supply sector. The programme will initially focus on the heating sector, at the same time as the electricity and water sectors. The NECSC working group "Farvel for gas in Denmark" also recommends better use of data to ensure the development of an energy-efficient and resilient heating sector.

Energy dimension: Internal energy market

The energy dimension of the internal energy market is based on the improvement of interconnection, transmission infrastructure, competitive prices and stakeholder engagement policies, as wellas the fight against energy poverty.

The *Climate Agreement for Green Power and Heat 2022* has implemented a number of actions to promote-consumer protection. In particular, it was decided to introduce a price cap on consumer pricesfor district heating based on an individual renewable heat supply solution, such as a heatpump. There must be an adaptation period that takes into account green heating plans and other particularindividual framework conditions. The parties to the agreement agree that if a company cannot remain below the price cap within a reasonable period of time, consumers will be better able to choose anothersource. The Danish Utility Regulator shall carry out enhanced supervision of companies above the price cap and the Utility Regulator shall evaluate the new regulation three

24Agreement on sustainability requirements for woody biomass for energy (kefm.dk) years after implementation, including whether the regulation provides a sufficiently stable framework for investments.

It also follows from the 2022 Climate Agreement that municipal district heating companies must have a clear separation of authority and operation and that the board of directors must be composed of at least two independent members of the district heatingcompany. Companies subject to sufficient competitive pressure from otherforms of heating may, upon application, be exempted from current price regulation on the basis of criteria defined by the Utilities Regulator with the involvement of industry and business and consumer organisations. In addition, it was decided to maintain the cost-oriented regulation of the sector, but to increasethe lowest security of new green investments by adjusting the substitution price so that it does not apply with a backward effect. Heat generators may, under certain conditions, have alighter regulation. Finally, the evolution of the price of heat from individual heat pumps isfollowed sy thematically for transparency on competition in the heat market.

Policies and measures to address high energy prices

A number of separate decisions have been taken to counteract the impact of the significant energy price increases on consumers, including as a result of Russia's invasion of Ukraine. Thecontracting party behind *the Winter Aid Agreement* of 23 September 2022 agreed, inter alia, to reduce the general electricity tax to the EU minimum rate of DKK 0,8 per kWh in the first six months of 2023. A reduction in the electricity tax benefits all Danes in the form of lower electricity consumption costs. In addition, the *agreement on targeted* hot check of 11 February 2022 and the supplementary agreement of 30 March 2022concluded that a one-off heat check of DKK 6.000 would be granted to households particularly affected by the increased energy prices. Varmechecken was automatically paid on 10 August 2022 and the last additional round of applications was closed in 2024. Money has been paid to about 411.000stands. Finally, a temporary and voluntary "indoor" scheme was set up in autumn2022, under which households and businesses (under different conditions) could apply to their energy companiesfor the freezing of part of their energy bills for later payment if the price exceeded some of the limits laid down in the agreement. The purpose of the freezing scheme was to provide householdsand businesses with a breathing space and certainty against significant increases in energy prices. The scheme entered into force on 1 November 2022 for electricity and gas and on 1 January 2023 for district heating, with the possibility of freezing for one year.

Energy dimension: Research, innovation and competitiveness.

Table 11 shows which heating projects were supported through the EUDP in 2023.

EUDP supported heating projects in 2023
Prescriptive Analytics Tool for district heating networks. DTU Engineering Technology.

This project develops and demonstrates a 'Prescriptive Analytics Tool' for district heating networks. The tool will allow cost-effective status assessments and prediction, for which there are currently no existing tools. This is achieved by developing as wellas ta-powered and physics-based digital twins, combining the available thermographic automotivesequences of the district heating network with data from the existing infrastructure, such as smart meters to provide action-oriented insight into the operation and maintenance of the network.

Large scale Medium Energy Storage IEA Task Participation. DTU Construct.

The main objective is to form a community around medium storage, in order toagree on definitions, to provide an overview of existing energy storage systems of medium duration, to explore the technologies most suitable for large scale medium energy storage and to assess the resources available for these systems.

Danish participation in the IEA ES Task 43 "Storage for renewals and flexibility through standard use of building mass". AAUS.

Activation of thermal building stock takes advantage of existing structural masses in buildings (e.g. concrete elements) for cooling and heating purposes. Thanks to the inherent thermal inertia of these high-mass components, they can also play a significant role as a new type ofentry-gio storage by temporarily cooling or heating them without compromising the indoor climate and the comfort of residents.

Task 71: Life cycle and cost assessment for heating and cooling technologies. DTU Construct.

Development of life cycle assessment methodologies for energy systems for heating and cooling purposes; life cycle assessment data for different technologies and components; reference installations; and formediating, networking and political engagement.

IEA Annex: Heat pumps in a circular economy. Technological Institute.

The overall purpose of this Annex is to provide an overview of heat pumps' stature status in the context of a circular economy, to highlight the technological options available toimprove circularity and to develop best practice recommendations.

Table 11 Overview of projects supported through the EUDP in 2023 (source: https://www.eudp.dk/files/media/document/Over- Term% 20 more than 20st% C3 % B8 % 20EUDP projects% 202023-I.pdf).

7.3 Cooling sector

Denmark contributes to green district cooling by promoting renewable electricity, which can be used for cooling generation via electricity-based heat pumps and compressor coolers, and by setting requirements for cooling fluids. Removecooling is mainly produced by compression cooling and free cooling, and to a limited extent by absorptioncooling and heat pump. Free cooling uses ambient sources (e.g. lake, air, sea) to provide cooling, while absorption cooling uses heat – primarily district heating – to provide cooling. Free cooling is therefor renewable energy, which helps to advance the climate agenda both nationally and internationally. Absorption cooling can in some cases be considered as waste heat and is therefore not included as a renewable energy source within the meaning of the definition of waste heat in the RES Directive, but can contribute to energy efficiency in the queue-sector. Compression cooling and heat pumps are driven by electricity. In Denmark the elsy stemet isexpected to be almost 100 %. Ve in 2030, where fossil fuels are used only in peak and back-up facilities. As the energy source itself to produce district cooling is predominantly climate-friendly, it is rated greenhouse gasemissions from cooling fluids that generate greenhouse gas emissions from district cooling. It should be noted that, on the basis of the latest comparative *assessment of* 2020, Denmark adopted a legislative proposal on district cooling, requiring district cooling companies to report data on their district cooling supply. Data on district cooling are confidential for competition and market reasons and are therefore not further clarified in the present *comparative assessment.*

7.4 Green district cooling and the five energy dimensions

Energy dimension: Decarbonisation and energy security

With the *Climate Agreement for Energy and Industry, etc. 2020 it* was decided to amend the requirements for certain refrigeratedliquids in order to reduce the use of HFCs harmful to the climate. The new limit means that the climate load of filled HFCs in a refrigeration system should not exceed 5 tonnes of CO_{2e}. In addition, the CFC charge is increased by approximately DKK 30 per tonne of CO_{2e}, so that the emissions of these greenhouse gases are-treated in the same way as CO_2. 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 threshold on imports of refrigerants is removed, so that excise dutyis always due on imports of taxable refrigerants. The adjustments are estimated toreduce CO2eemissions marginally across the energy system. However, for the district cooling sector, which makes significant use of compressor queuesand heat pumps, the effect may be more evident. The effect of stricter requirements for refrigerants on greenhouse gas emissions in the refrigeration sector has not been calculated.

Energy dimension: General energy efficiency and the internal energy market

Since the last update of the NECP *and the comparative assessment*, no further steps have been decidedfor energy efficiency and the internal energy market for cooling in Denmark.

Energy dimension: Research, innovation and competitiveness

Table 12 shows which cooling projects were supported through the EUDP in 2023.

EUDP supported cooling projects in 2023
HVACO2 – ventilation unit with reversible CO2 heat pump. Technological Institute.
Development of energy efficient ventilation unit for the HVAC market with heat recovery andbuilt reversible heat pump with the natural refrigerant CO2. Warm climate aggregates are targetedby ejektor technology and the aggregate is expected to achieve an overall efficiency forimprovement of 25 % compared to products on the market today.
Smart Green Indoor Climate Manager. Technological Institute.
The aim is to develop, document and demonstrate a user-friendly intelligent control system for HVAC (heating, ventilation, cooling) systems in interaction with skylights based on measured and erphaclean indoor climate. The system shall ensure a healthy indoor climate with minimal fossil energy consumption, witheasy energy efficiency and energy flexibility.
Commercial solar cell refrigeration appliances for the food sector. Technological Institute.
In many parts of the world, the lack of refrigeration facilities in the commercial sector leads to huge food waste and constitutes a serious barrier to economic development. The objective of the project is therefore to develop robust and versatile refrigerators and freezers for photovoltaic installations adapted to off-grid markets.
Optimised Reversible CO2 cooling and heat pump systems. Technological Institute.
The aim of the project is to develop a new industrially built reversible cooling andheat padding unit based on the environmentally friendly, safe and natural refrigerant CO2. Project work

addresses the market for both air conditioners and industrial processes – areas with huge potential for energy savings.
OpenGIS4ET. PlanEnergi.
In the overall project, a GIS-based (map) thermal and energy planning tool is developed, tested and demonstrated. The tool is modular, built with a number of rainmodulesthat allow analysis of many aspects of the energy system (e.g. heating, cooling, charging infrastructure, sector coupling).

Table 12 Overview of projects supported through the EUDP in 2023 (source: https://eudp.dk/projekter).

8 Overview of existing policies and measures

See sections 6 and 7.

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

This section presents the economic potential for heating and cooling as calculated in 2020. Theresul is divided into socio-economic and corporate economic performance. The same economiccost-benefit analysis concerns only the district heating sector and, in part, individual heat. This is because the data base for the district cooling sector as well as individual cooling is more limited in Denmark, whereas the data base for the heating sector, including the district heating sector, iswell supplied. In addition, cooling demand in 2020 was relatively limited in Denmark in relation to heating demand, whichwas certainly due to the colder climate in Denmark. It is assumed that cooling demand will increase by 2035 as data centres are rolled out more widely than so far.

Reservation on data and calculation assumptions

It should be noted that the present analysis of the economic potential for heating and cooling efficiency has not been updated since 2020. However, there have been significant changes in the sector since 2020, with theenergy crisis of 2022 having a major impact on the sector and prices. Furthermore, since 2020, a number of agreements and legislation affecting the cooling and special heating sector have been concluded, which areset out *in Part 2 Objectives, Strategies and Policies.* The results of this analysis will therefore no longer be true and would be likely to be significantly different if the analysis were to bedated. Towards the next update of the *comparative assessment when* the NECP is to be updated in 2027, the latest available data will be used.

The approach of re-using the present 2020 analysis is due to the fact that the European Commission hasasked for an update of the previous comparative *assessment* of 2020 when it wasfacial. Against this background, the Danish Energy Agency has assessed that it was the most appropriate tofocus on an update of Parts 1 and 2 as an extension to the update of the NECP and a monitoring of the heating and, in part, cooling sector in Denmark, in which the European Commission can be informed.

The economic analysis in Part 3 is based on two scenarios *as described in Section 9*. The two scenarios are inspired by the baseline projection 2020 (baseline scenario) and the Climate plan for a green waste sector and circular economi on 16 June 2020 (alternative scenario).

It is important to note in this respect that this is outdated data and therefore results and conclusionsshould be read with very large reservations. This will change in work towards the update of the next comparative *assessment* in 2027, where the economic analysis will be based on the latest political agreements in the given year and ongoing market developments, etc. It should be noted that in the alternative scenario, in which the simulation model assumes that the amount of waste will bereduced by 30 %, this would be markedly different in future *comparative assessment*. The reason for this is that in 2020 it was considered essential to shed light on the social and corporate economy of the district heatingsector if the amount of waste in Denmark is reduced, as at that time a significant overcapacity was estimated at Danish incinerators compared to Danish waste volumes. However, the most recent projections estimate that from 2025 there will be a greater match between Danish quantities of waste for incineration and incineration capacity.

Energistyrelsen

Furthermore, the economic analysis uses calculation assumptions such as the *Socio-economic calculation assumptions for energy prices and emissions from the Energy Agency in October 2019*, the Danish *EnergyAgency's and the Ministry of Finance's then guidelines in socio-economic analyses* and the Danish *EnergyAgency's* *technology catalogues at the time*. It should be noted here that these calculation forecastshave been updated since then and that the fact that the underlying assumptions are from 2019 and 2020 has a significant impact on the results of theeconomic analysis carried out by society. Towards an OPDA ofthe next comparative *assessment* in 2027, the latest updates of the underlying calculation assumptions fromthe Danish Energy Agency will be used.

Finally, it should be noted that throughout the economic analysis, prices for 2 020 are taken as a starting point. This concerns both prices for individual heat pumps, CO_2prices, fuel prices and electricity prices. Ahead of an update of the next *comparative assessment* in 2027, the latest prices will be used.

The results from Part 3 show that in 2020 there was an estimated social and corporate economic gain in expanding the district heating sector where appropriate (e.g. in major cities). In this respect, analyser shows that there was an economic gain in improving the efficiency of the district heating sector. Today, the energy efficiencyof district heating in Denmark is very long and it is expected that district heating will beat 100 % by 2030 %. Ve, and will therefore be 100 % energy efficient with the EED definition, cf. Section 12.4. A new economic analysis to highlight a lower potential for energy efficiency in the district heatingsector was therefore deprioritised, building on the European Commission’s call for OPDA tocarry out the latest assessment.

9 Scenarios

The analyses were prepared on the basis of two scenarios: A baseline scenario and an alternative scenario. The-Baselissce nariet uses data from the base projection 2020 (BF20). The alternative scenario is inspired by the Climate Plan for a Green Waste Sector and Circular Economy on 16 June 2020 and the Climate Agreement for Energy and Industry etc. of 22 June 2020. It should be noted that the 2020 Climate Target Plan is based on the approach that there must be a Danish incineration capacity corresponding to the development of Danish waste volumes. The alternative scenario assumed that Danish waste volumes would decrease by 30 % by 2050, but the latest projections estimate that there will be no reduction in theamount of waste from 2024 to 2035. To this end, concrete actions from the Climate Target Plan involving a competitivepostponement of the combustion sector have now been implemented, which is not included in this point ofview.

The cost-benefit analysis was carried out in the EnergyPRO programme and the model aims to allocate production to the generation units of the district heating network. Individual heating, cooling and district cooling is not a direct part of the model.

Figure 10 shows differences between the base scenario and the alternative scenario. The grey fields indicate that the value differs from the base case.

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General prodlirtin authoritiesA	Alternative Q- Basis 2020 2030 2050	Option 1 – Allocation 2020 2030 2050
Priority grindast Waste KV GWh Solar thermal GWh Gentermi GWh Industry Heat GWh	— – —	IN THE CASE OF R = dLtr =ʳ= t 3e6 — — Week
V Arne PUN pe r (e 1 pr in - and 1 days of rabulls t) heat pump food kp 1 fAV-v IndustriVP MW-v Environment VP MW-v	— – —	— – —
Cogeneration (excluding waste) Kul KV MW BizgsKV MAI Other bio KV MW Trap in Ile KV MAI	— Exit	Deleted IN THE CASE OF IN THE CASE OF Outfarm2Q35

Peak load N Surga skate Olie	— – —	— Only tip load — Deleted

Figure 10 An overview of the baseline and the Alternative scenario.

9.1 Scenario 0: Baseline scenario

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

9.2 Scenario 1: Waste reduction

Scenario 1 is inspired by the *Climate Plan for a Green Waste Sector and Circular Economy on 16 June 2020*[25] and simulates a 30 % reduction in total waste for incineration in 2030. It should be noted, however, that with the latest projections, it is estimated that there will not be a decrease in thetotal fall rate for incineration by 2035, so this scenario is no longer assessed asvalid.

The EnergyPRO model simulated which units enter into force at the lower heat outputfrom waste heat. Natural gas boilers are only used for peak load production, while oil boilers are completely removed from 2030.

10 Methodology for the socio-economic analysis

For the economic analysis of the district heating sector, a socio-economic guidancemodel was developed to assess individual technologies and different types of fuels. The following has been used as the data source:

- Socio-economic calculation conditions for energy prices and emissions, EnergyAgency October 2019
- The Danish Energy Agency's and the Ministry of Finance's guidelines at the time in the socio-economic-region light
- Danish Energy Agency's technology catalogues at the time

[2525] https://www.regeringen.dk/media/9591/aftaletekst.pdf

All price levels are for 2020. 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'. In Bereg Group1, the competitiveness of technologies and $CO_{2\ e\text{-footprint}}$is assessed in general, while in Bereg,2, competitive technologies are specifically considered as heating systems, of which the starting point for district heating is concrete plants.

Particularly with the energy crisis of 2022, there have been significant changes in energy prices, with the result that the regulatoryassumptions are out of date.

10.1 Comparison of technologies

See Table 13, a technical-economic and climate (CO_2e) comparison of heat supply techniqueswas carried out. For the purpose of technical-economic comparison, the sum of each type of generating module's fund-economic-present value heat price has been estimated. The main elements of the socio-economic present value heat price are explained below.

- The present value price of the capital contribution is estimated by converting the investment per MW into

inety;

scoring per MWh when selecting the expected typical usage time of the installation (technology). It is assumed that the investment will take place in 2020. For district heating systems, it is assumed that pri-base load has a usage time of around 8.000 hours/year, while flexible base load and intermediate load have a usage time of 4-5.000 hours/year.

- The present value price of the operation contribution is the socio-economic costof the current value heat of each production installation in DKK/MWh, including costs for energy, environment, operation and maintenance, but excluding capital costs.
- Emissions costs for the climate gases are taken into account on the basis of the CO_2price forecast in the Danish Energy Agency's price assumptions at the time. Fossil energy facilities (excluding waste incineration) with an input of at least 20 MW are subject to quotas in EU ETS. The calculations generally assume that all fos Sile districtheating installations (excluding waste incineration) follow the assumed CO_2price forecast.
- Cost of damage for the emission of local pollutants: $SO_{2/SO4}$, NO_x and $PM_{2,5}$ are included, as district heating is assumed to follow SNAP 1 and individual plant SNAP 2, see Table 15 in the Danish Energy Agency's price assumptions at the time. In addition, biomass fuels do not pose a priced risk that handling and storage may lead to contamination of theomgia by biological agents (moulds, bacteria, etc.).
- Tax distortion losses from costs are expected, but tax distortions arising from State aid schemes for renewable energy are disregarded. In the revised 2023 guidance of the Ministry of Finance, tax distortions are not included in socio-economic analyses.

Technology	Total	Cm [26]	B-time	Live-time	Capital	Operation	Total	Co_{2e}
	VG[27]		*hours/year*	*year*	*DKK/MWh*	*DKK/MWh*	*DKK/MWh*	*kg/MWh*
Waste cogeneration heat	97 %	0,28	8.000	25	114	— 81	34	189
Collective solar thermal					230	15	245	0

[26] Ratio of electricity and heat generation for the technology. 'Technology Data. Generation of Electricity and District Heating". Danish Energy Agency. In English, referred to as 'Cb'.
[27] Total efficiency. The Danish Energy Agency's Technology Catalogue for Electricity and Heat "Technology Data". Generation of Electricity and District Heating".

CHP plants in bio — energy								
Woodchip back-pressure system	111 %	0,35	5.000	25	87	137	224	— 14
Straw back-pressure system	98 %	0,44	5.000	25	98	129	227	— 17
Pressure systems for woodenarrows	95 %	0,48	5.000	25	67	252	319	— 19
Generator facilities								
Biogas engine	91 %	0,86	7.500	25	28	264	292	— 34
FJV engines: pipeline gas	92 %	0,96	4.000	25	52	295	347	285
Boiler heaters								
Woodchip, district heating facility	110 %		5.000	25	61	286	347	5
Straw, district heating facility	100 %		5.000	25	77	283	360	7
Wood pellet, district heating facility	92 %		5.000	25	63	414	477	6
Mains gas, district heating facility, IFK	98 %		5.000	25	13	405	418	156
Mains gas, district heating facility, UFK	98 %		5.000	25	13	410	423	156
Oil, district heating facility	91 %		5.000	25	15	711	726	294
Large heat pump equipment (electricity)								
Geothermia 1 300 m	500 %		8.000	25	32	210	242	8
	500 %		5.000	25	8	131	138	8
Co-generation heatpumps								
Surplus heat pump	420 %		4.500	25	30	160	190	9
Ambient heat pump	320 %		4.000	25	50	193	243	12
District heating distribution								
New client centrally	94 %			25/50	84	10	94	
New customer marginally ideally	82 %			25/50	144	10	154	
New customer marginal (75pct.)	78 %			25/50	202	10	212	
Individual facilities								
Gas boiler 1 0 – 66 MWh	97 %			20		551		157
Gas boiler 2 66 – 825 MWh	97 %			20		531		157
Gas boiler 3 825 – 3 300 MWh	96 %			20		516		160
Gas boiler 4 3300 – 8 800 MWh	95 %			20		475		161
Gas boiler 5 8800 – 110 000 MWh	95pt.			20		450		161
Oil boilers	88pt.			20		950		304
Pellet pine	85pt.			20	195	808	1.003	5
Heat pump	340pt.			20	243	372	614	12
Electric/water heater	100pt.			20		937		41

Table 13 Techno-economic and climate comparison of heat supply technologies.

‘B-time’ in Table 13 represents the typical usage time in hours per year for the technology. For base load installations, high usage time has generally been used (about 8.000 hours), as the technology will be in operation almost constant, while for medium load installations, the use time is lower. Base load technologies for example include waste cogeneration or cogeneration, while medium load technologies typically include cogeneration facilities and large heat pumps for district heating. District heating systems powered by natural gas or oil may be medium load plants as indicated in the table, but will most often only be used as peak load and back-up installations, which would significantly lower usage time and thus much higher capital costs in the case of a new plant.

10.2 Mechanisms of the socio-economic cost-benefit analysis

For a multi-installation district heating system, the combination of installations (technolo gier)with priority operation will create the final present heat price. If the technology has already been invested in before 2020, the capital contribution (sunk cost principle) will lapse or be reduced to contributions from later renovations.

In order for district heating technology solutions to be comparable to the corresponding present value costsin DKK/MWh for individual installations, i.e. a customer, the cost of heat distribution (including customer installations) has been added, where three alternative customer connections are installed:

1. New customer centrally, i.e. new customer is connected to a drop cable in the district heating area.
2. New customer marginally ideally, i.e. new customers are connected to the street and drop cable in a peripheral area for district heating, but with 100 % customer connection in the area.
3. Marginal new customer, i.e., where a new customer is connected using a street and branch line in a peripheral area to the district heating, but where a transmission line is required and where there is only 75 % customer connection.

For a marginal district heating customer (options 2 and 3 above), it will be the mostexpensive plants in the district heating system in question to cover the marginal heating demand. If sownthe marginal production mix costs DKK 410/MWh and the cost of heating distribution isDKK 212/MWh, the total cost to meet the customer’s heating needs with district heating would be DKK 622/MWh. In comparison, a heat pump solution will cost DKK 614/MWh and would therefore be more socio-economically attractive in this example.

The comparison generally assumes a heating consumer with a net heat demand of 16.7 MWh/year (single-family house), which is the weighted net heating demand that is assumed to decrease due to general heat savings from an average of 18 MWh/year in 2020 to 15 MWh/year during the analysis period.

10.3 Comparison of development alternatives during the period 2021 – 2050

An analysis is performed for specific district heating solutions in calculation group 2. To this end, 10 types of district heating systems – divided into large, medium and small cities – have beenslightly commissioned. The top 6 district heatingsystems in Denmark are referred to by the city’s name. They are thus the dominant heat supply in the city in question and cover a well-defined district heating area within the city according to the zoningof the heat supply in urban buildings required by the Heat Supply Act. The district heating systems in the medium-sized and small cities are considered in the analyses as type systems without a specific geographical indication.

The analysis covers the period 2021-2050, i.e. 30 years. However, the Danish Energy28 Agency's guidelines state the socio-economic costs over a time horizon of 20 years, which is why the Danish EnergyAgency's price forecast only goes to 2040. Constant fuel prices are assumed from 30 to 2 050 in order to calculate a 2040-year time horizon.

A combination of specific existing district heating generation facilities based on the Danish Energy Agency's Energy Producer Count from 10 has generally been established for each of the 2018 district heating systems. At the end of the life of existing plants or the conversion to green heat before the end of the life of the plant, it is assumed that investments can be made throughout the calculation period (2021-2050), which may result in a correction for scraps values in the final year 2050, i.e. if the plant still has a longer life span inthe year 2050.

A heat consumer may be located either in a district heating area or outside district heating. These are designated:

1. Central: The consumer is located in an area currently designated for district heating. Continued use of district heating in one of the 10 district heating systems is compared with conversion toin-vidular heat supply.
2. Marginal: The consumer is located in an area dedicated to natural gas, but is converted either to district heating by expansion of one of the 10 district heating systems or to individualheat disintegration, where the most economically attractive solution is generally individual airwater heat pumps.

11 Socio-economic analysis

The following sections contain results from the two scenario analyses as well as sensitivity calculationsconsisting of a revised CO_2price and plant price increases for heat pumps. It should be noted thatnear this section uses prices for 2020 and that prices in 2024 and onwards will vary from thereverse.

11.1 Scenario 0: Baseline scenario (Socio-economy)

Key figures for the socio-economic economy of the baseline scenario are shown in Table 14. Key figures are the results of the cost-benefit analysis.

For district heating, the socio-economic current weighted heating price was DKK 384/MWh for a heat customer located in a district heating area (central) and is thus generallysignificant than individual alternatives.

For district heating in general over the period 2021-2050, the CO_{2e} load is 75 kg/MWh of heat for the customer, while for example individual heat pumps have a CO_{2e} load of 14 kg/MWh. Fjernvar,while higher CO_{2e} load is mainly due to existing heating plants, some of which have a relatively high CO_{2e}footprint. In particular, when heat from waste flaring is used for remoteheat, the waste heat in the calculation method contributes with aCO_{2e}footprint of 153 kg/MWh.

28https://ens.dk/sites/ens.dk/files/Analyser/samfundsoekonomiske_beregningsforudsaetninger_for_energipriser_and_emissions_2019.pdf

Baseline (Sc0)	Install.	Distrib.	Operation	Sum	Co2e	Tax Pro-Venu
Social economy	DKK/MWh	DKK/MWh	DKK/MWh	DKK/MWh	kg/MWh	DKK/MWh
District heating	88	97	199	384	75	45
1 Copenhagen port	70	94	133	297	63	50
2 Aarhus	82	94	135	311	39	35
3 Odense	116	94	187	397	132	80
DK-4 Aalborg	158	94	27	279	225	89
5 TVIS	69	94	207	370	116	38
6 Esbjerg	107	94	152	353	152	82
7 waste	84	99	74	257	212	83
8 biomass	89	99	288	476	— 5	8
9 miscellaneous	79	99	289	467	— 16	7
10 small towns	92	104	361	556	16	19
Individual facilities						
Pipeline gas	73		531	604	157	252
Oil	81		950	1.031	304	290
Heat pumps	173		402	575	14	53
Electric heat	10		937	947	41	155
Other	80		436	516	100	187

Table 14 Techno-economic and climate comparison a consumer in Scenario 0: The baseline scenario.

The distribution of district heating in scenario 0 is given in Figure 11 from 2021 to 2050. Thepro rata distribution is divided into waste heat, cogeneration waste, fossil CHP, renewable heat, heat pumps, fossil boilers, renewable boilers and other technologies. The baseline for BF20 uses the period 2020-2030. The development from BF2030 is extrapolated after 2050 until 20.

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 represents a small part of the overall distribution of production, especially EF2029, where its production is minimal.

Waste heat and waste heat are relatively constant throughout the analysis period, andthe rest is not in line with the latest projections.

Similarly, district heating production from renewable energy and fossil boilers is roughly constant throughoutthe analysis perimeter, which is not in line with recent projections.

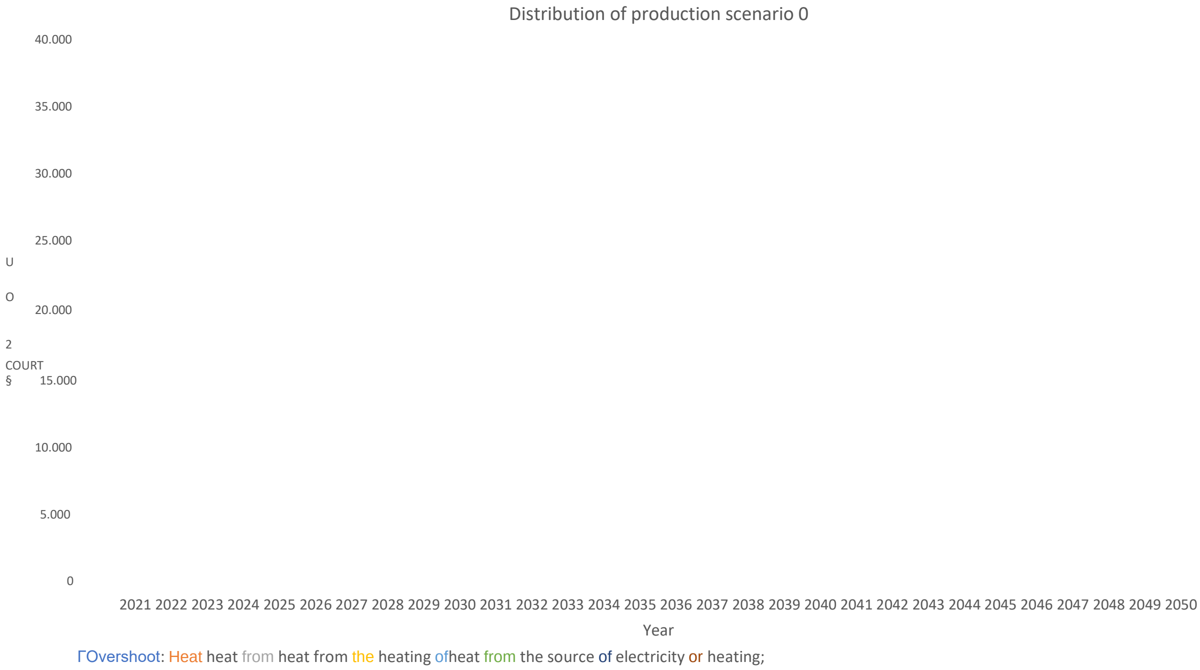

Figure 11 Production distribution for district heating in the baseline scenario.

11.2 Scenario 1: Waste reduction (socio-economic)

Key figures for the socio-economic calculation of scenario 1 are shown in Table 15. For district heating, the socio-economic price of heating has increased to DKK 390/MWh of customer, while CO_{2e} has fallen to 64 kg/MWh. The main reason is the reduction in waste incineration, as a result of the assumption in the model of a 30 % reduction in total waste for incineration in 2030, which stems from the assessments made prior to the 2020 Climate Target Plan. It should be noted in this regard that this is notthe assessment today.

Scenario 1	Install.	Distrib.	Operation	Sum	Co_{2e}
Social economy	DKK/MWh	DKK/MWh	DKK/MWh	DKK/MWh	kg/MWh
District heating	88	97	205	390	64
1 Copenhagen port	70	94	131	295	64
2 Aarhus	82	94	140	316	14
3 Odense	117	94	164	375	126
DK-4 Aalborg	159	94	— 2	250	224
5 TVIS	70	94	164	328	81
6 Esbjerg	105	94	111	311	148
7 waste	85	99	223	407	131
8 biomass	89	99	289	476	— 6
9 miscellaneous	79	99	224	402	11
10 small towns	92	104	362	557	16

Individual facilities				
Pipeline gas	73	531	604	157
Oil	81	950	1.031	304
Heat pumps	173	402	575	14
Electric heat	10	937	947	41
Other	80	436	516	100

Table 15 Techno-economic and climate comparison by consumer i (Scenario 1: waste reduction).

The distribution of production in scenario 1 is shown in Figure 12 and differs from the baseline scenario due to the reduction of waste available for waste heat generation due to the assumption in the alternative scenario. The reduced generation of district heating from waste heat is largely replaced by cogeneration from renewable energy by 2035, after which waste heat takes over the increased renewable cogeneration by 2050. It should be noted, however, that the use ofoverhead heat in district heating production requires very specific conditions, for example in relation to the location and the samework between the supplying company and the district heating company. The development of surplus heat is therefore subject to considerable uncertainty. The fossil share of cogeneration is reduced according to the baseline scenario, due to the assumption that fossil cogeneration will be deleted from 2035.

11.3 Sensitivity analysis Socio-economy

Sensitivity for higher CO_2price

Table 16 shows the socio-economic costs and CO_{2e} burden at high CO_2prices in stage 1 where waste volumes are reduced, and hence heat generation from waste cogeneration. It isfelt that a sensitivity analysis on parameters other than CO_2price and plant price increases forin-vidular heat pumps will be relevant to illustrate for Denmark. This could be, for example, quota prices. This will be analysed in the update of the next *comparative assessment.*

For the 2021-2050 analysis period, a$_{CO2}$price of DKK 1.500/tonne is assumed for both the valuation of CO_2 and as a levy (to correct tax distortion losses). Costs and CO_{2e} load for scenario 1 are also included in the table for the sake of comparison. A CO2 price of DKK 1500/tonne$_{is}$calculated, as this price level is the recommendation of the Climate Council. It is therefore not due to a political wish for a CO_2price at that price level.

The table shows, inter alia, that the socio-economic costs increase significantly for scenario 1 from approximately DKK 190 billion to approximately DKK 220 billion, while CO_2 savings are limited from around 1.86 million tonnes of CO_{2e} to around 1.72 million tonnes of CO_{2e}. The effect of increasing the cost of CO_2 is thus limited in district heating.

	Heating needs	Socio-economic cost		Co_2e load	
		Scenario 1	Scenario 1C	Scenario 1	Scenario 1C
District heating *area*	*GWh/year*	*DKK million.*	*DKK million.*	*1 000 t/year*	*1 000 t/year*
District heating	28.241	190.993	220.363	1.859	1.723
1 Copenhagen port	7.759	39.587	48.994	569	512

2 Aarhus	2.503	13.685	14.264	36	29
3 Odense	2.036	13.205	17.263	257	246
DK-4 Aalborg	1.477	6.394	11.440	330	329
5 TVIS	1.431	8.118	9.542	115	96
6 Esbjerg	904	4.856	7.027	134	122
7 waste	2.611	18.355	23.713	343	315
8 biomass	2.798	23.031	22.765	— 16	— 17
9 miscellaneous	594	4.709	4.560	— 9	— 9
10 small towns	6.129	59.051	60.794	101	101

Table 16 Societal economic costs and CO_2 burden on the increase of the CO_2price.

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Figure 12 shows the sensitivity of district heating production for scenario 1 by taking into account a CO2 priceof DKK 1.500 per tonne.

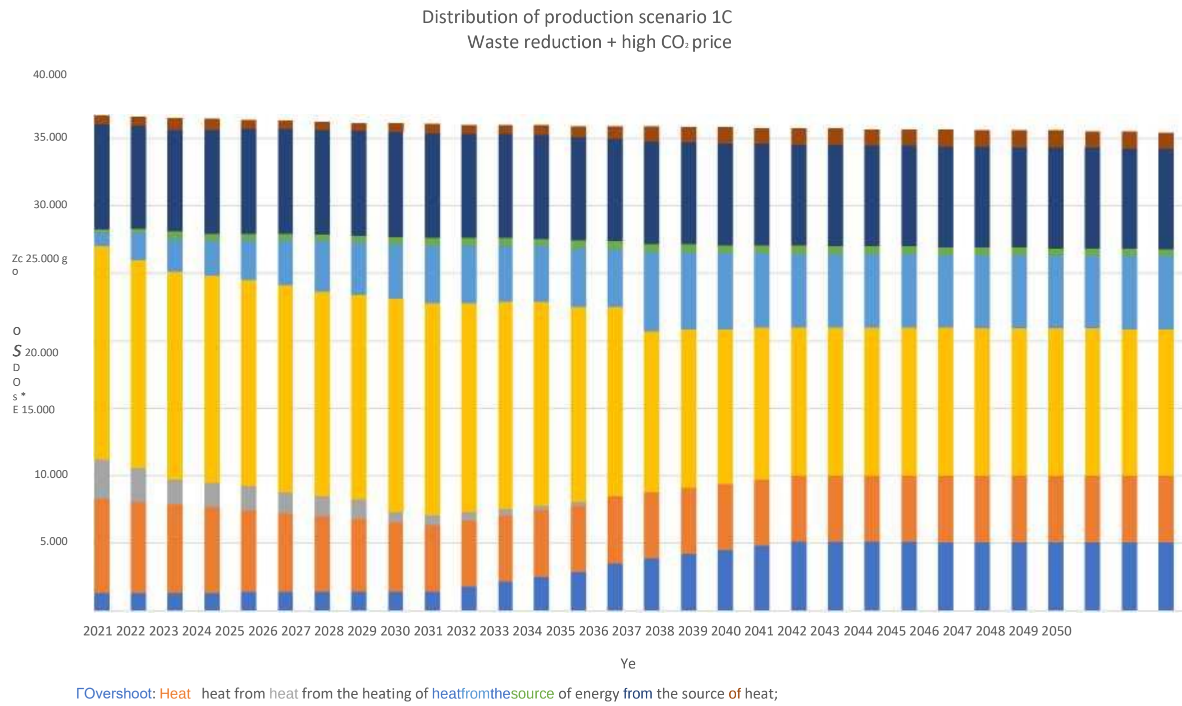

Figure 12 Scenario 1 but with CO_2 price DKK 1.500/tonne.

The sensitivity calculation analyses the sensitivity of scenario 1 to a higher CO_2price. The CO_2price is increased from DKK 214/tonne of CO_2[29] to DKK 1500/tonne CO_2. The sensitivity calculation shows that scenario 1 iscalm against a higher CO_2price as the production distribution does not change significantly. However, there is a minimal displacement of waste cogeneration heat under scenario 1, which is taken over by RES basedheat.

29The CO_2 prize wasused in the socio-economic calculation conditions for 2020. The CO_2price increases in the calculation assumptions to DKK 331/tonne of CO_2 in 2030.

Sensitivity to plant price increases of heat pumps
The high investment in heat pumps in scenario 1 allows the scenario to be particularly sensitive to the investment cost of heat pumps. A sensitivity calculation has therefore been carried out.

	Heating needs			**Socio-economic cost**
		Scenario 1	**Scenario 1 + 15 %**	**Scenario 1 + 30 %**
District heating area	*GWh/year*	*DKK million.*	*DKK million.*	*DKK million.*
District heating	28.241	190.993	193.391	195.879
1 Copenhagen port	7.759	39.587	48.994	39.685
2 Aarhus	2.503	13.685	14.264	14.236
3 Odense	2.036	13.205	17.263	14.802
DK-4 Aalborg	1.477	6.394	11.440	6.700
5 TVIS	1.431	8.118	9.542	8.118
6 Esbjerg	904	4.856	7.027	5.156
7 waste	2.611	18.355	23.713	18.471
8 biomass	2.798	23.031	22.765	23.495
9 miscellaneous	594	4.709	4.560	4.709
10 small towns	6.129	59.051	59.728	60.404

Table 17 Socio-economic sensitivity at 15 % and 30 % increase in the price of heat pumps.

As the results in Table 17 show, the investment cost of heat pumps has only a moderate impact on overall socio-economic costs. This is because part of the large heat pump expansion is carried out late in the analysis period, which is why discounting and scraping valuessuggest that the cost of capital is significantly reduced in the socio-economic present valuecalculations. A 30 % increase in the investment cost of heat pumps shows primarily an increase in socio-economic costs for the areas of Aarhus, Odense, Aalborg and Esbjerg, as well as a slight increase in socio-economic costs in areas with predominantly waste production, biomass production, while the largest increase in socio-economiccosts is seen in small towns.

12 Company-economic analysis

The following reviews the results of the corporate economic analysis for each of the scenarios including the sensitivity calculations.

The company-economic analysis assumes generally experienced heat sales prices for each productionplant in the 10 representative district heating systems, with the addition of continuous reinvestments and maintenanceof the distribution system.

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 should be noted that only the best socio-economic alternative can be approved by the heating plan (municipal council), but typically the corporate and user economy must also be gun up in orderfor a district heating expansion project to be realised. The alternative is for heat consumers to switch to individual heat by phasing out existing individual fossil heat.

12.1 Scenario 0: Baseline scenario (company-economics)

In the corporate economic calculation, a district heating price has been estimated for each of the 10 remote mesh-systems over the period 2021-2050 and at 1 % real interest rates.

Baseline (Sc0)	Heat purchase	Distrib.	Sale	Net	Revenue
Corporate economy	DKK/MWh	DKK/MWh	DKK/MWh	GWh/year	DKK/year
District heating	269	109	378	28.241	10.668
1 Copenhagen port	238	106	344	7.759	2.670
2 Aarhus	237	106	342	2.503	857
3 Odense	235	106	341	2.086	694
DK-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	322	111	433	594	257
10 small towns	352	116	468	6.129	2.870

Table 18 Corporate Economic Assessment for 30 years for the baseline scenario.

Theresult in Table 18 shows that the corporate economy of district heating is generally better in terms of the-cheapest indivi duous alternative, which is an individual air-to-water heat pump, see Table 19. Individual heatpads per are assumed to generate a user economic expenditure of approximately DKK 809/MWh excluding VAT, whose capital costsare taken into account, and approx. DKK 430/MWh excluding VAT, excluding capital costs. It shouldbe noted that prices for 2 020 are taken as a starting point and that a reservation is made that prices for 2024 may be different.

Individual air-to-water heat pump	Tariff/unit price excluding VAT	Consumption/unit	Expenditure per
Electricity consumption, COP = 3.4	DKK 1,10/kWh	4.9 MWh	5.403
Service and maintenance	DKK 1500/year		1.500
Operating expenditure	DKK 20/MWh	16.7 MWh	333
Investment	85.000		
Annual capital expenditure	4.0 % APRC	20 years	6.254
Total expenditure 1th	DKK 809/MWh		13.491

Table 19 User economics for an individual air-to-water heat pump (source: The Danish Energy Agency's technology catalogue for individual heating systems).

It should be noted, however, that this is not every place where district heating is a possible supply of heat. Remoteheat is profitable in areas with high building density, while individual heat is more favourable in converterswith low building density. It cannot therefore be concluded solely on the basis of a generalausterity analysis whether individual heating or district heating is the most economical totractive.

12.2 Scenario 1: Waste reduction (corporate economy)

Table 20 shows the corporate economic costs in Scenario 1 (waste reduction).

Scenario 1	Heat purchase	Distrib.	Sale	Net	Revenue
Corporate economy	DKK/MWh	DKK/MWh	DKK/MWh	GWh/year	DKK/year
District heating	269	109	378	28.241	10.666
1 Copenhagen port	234	106	339	7.759	2.633
2 Aarhus	244	106	350	2.503	875
3 Odense	214	106	320	2.086	652
DK-4 Aalborg	186	106	292	1.477	430
5 TVIS	259	106	365	1.431	522
6 Esbjerg	172	106	278	904	251
7 waste	276	111	387	2.611	1.010
8 biomass	308	111	419	2.798	1.172
9 miscellaneous	301	111	411	594	244
10 small towns	353	116	469	6.129	2.876

Table 20 Corporate economic costs for scenario 1.

According to the baseline scenario, scenario 1 shows that corporate economic costs remain generally unchanged. This is due, inter alia, to the fact that production technologies, such as surplus heat, which take over production from the reduced generation of waste heat, are commercially viable.

The largest change in the corporate economy is seen for those areas that mainly receive district heating from waste heat, where theprice of district heating rises from DKK 306/MWh to DKK 387/MWh, i.e. district heating increases by 26 %.

12.3 Corporate economy sensitivity analysis

Sensitivity to the CO_2price

Table 21 shows the sensitivity of the corporate economy to scenario 1 at a$_{CO2\ price}$ of DKK 1.500/tonne rather than a $CO2_{of\ DKK}$ 214/tonne of CO_2.

Scenario 1C	Heat purchase	Distrib.	Sale	Net	Revenue
Corporate economy	DKK/MWh	DKK/MWh	DKK/MWh	GWh/year	DKK/year
District heating	322	109	431	28.241	12.173
1 Copenhagen port	312	106	418	7.759	3.245
2 Aarhus	273	106	379	2.503	947
3 Odense	301	106	407	2.086	828
DK-4 Aalborg	285	106	391	1.477	577
5 TVIS	316	106	421	1.431	603
6 Esbjerg	268	106	374	904	338
7 waste	369	111	480	2.611	1.253
8 biomass	311	111	421	2.798	1.179
9 miscellaneous	302	111	413	594	245
10 small towns	367	116	483	6.129	2.958

Table 21 Sensitivity of scenario 1 with a CO_2 price of DKK 1.500/tonne.

Table 21 shows a general increase in heat prices of around 14 %, which is due to the fact that cheap waste heat is borneby other forms of production which are not as cheap. The change from scenario 1 to the sensitivity scenario with a higher CO_2 is mainly seen in Esbjerg and Aalborg, but also Odense, medium-sized areas based mainly on waste heat and Storkbenhavn experience significant heat pricestignine of over 20 %. In medium-sized areas mainly receiving heat from biomass and various sources, there is a limited increase in the price of heat.

The corporate sensitivity calculation shows a $CO2e_{reduction}$of around 7 %. This is subject to the condition that district heating companies have the same production facilities as without the increase in CO_2prices. Typically, such a marked price signal as a heat price increase of 14 % would meanthat selska bs will invest in new technologies with lower$_{CO2e}$footprint, thereby increasing the CO_{2e}reduction.

It should be noted that due to technological developments, RES heating solutions will have becomeBilli more since 2020.

12.4 Summary of the current potential for the use of efficient district heating and cooling and high-efficiency cogeneration

Efficient district heating and cooling

Denmark uses the current definition of efficient district heating and cooling systems as preservesin Article 26(1) of the Energy Efficiency Directive. The definition can be used, inter alia, to determine the share and potential for efficient district heating and cooling. With the most recent Danish calculation from 2024, which uses the most recent data from 2022, it was calculated that approximately 98 % of the Danish remoteheating systems can be defined as effective. For this, 100 % of Denmark's district cooling systems areeffek tive. This leaves less potential for Denmark's existing district heating systems to be fashioned if the definition fromthe Energy Efficiency Directive is taken as a starting point. More specifically, these are 15 district heating systems which do not comply with the definition. These are expected to comply with the definition of efficient district heating by at least 2030. Looking at the potential forthe expansion of efficient district heating, it is expected that any new or renovated remote heatingcapacity will comply with the definition. This is because all new or renovated district heating capacity will be based on at least 50 % renewable energy and/or cogeneration, thus complying with the definition of the Directive.

As a result of a 2024 report drawn up jointly by KL and the Ministry of Climate, Energy and Evida,and with input from the state gas distribution company Evida30, there is good progress in the roll-out of green heat. The report shows that in 2023 almost 40.000 private gas customers switchedfairly in favour of, among others, district heating and heat pumps, while Evida has had access to just 156 new private gas customers. At the end of 2023, there were around 302.500 private gas customers compared to around 342.000 in 2022. To this end, approximately 107.000 (35 %) of private gas customers remaining at the end of 2023 were covered by an approved project proposal for district heating, and by the end of 2023 almost 59.000 (20 %) of the remainingprivate gas customers were located in an area dedicated to individual meteringin a heating plan and would thus have to invest in an individual heat solution by-switching the gas fired. Finally, the municipalities expect to approve around 119 project proposals in 2024, which includes a minimum of 65.000 buildings with gas furnaces. The group of 122.000 private gas customers in potential district heating areas is therefore likely to decrease over the coming years.

The district cooling potential is not expected to change significantly in the period 2022-2030 and it is expected that the district cooling potential will reach 2.866 MW by 2030. The socio-economic poletenth is 2.211 MW and therefore corresponds almost to the technical potential. The minimum change isthe colder climate in Denmark, where cooling needs remain more or less constant. It is forthe waiting, as with the expectation for district heating, that any new or renovated district cooling infrastructure will be efficient as it is expected to be based on renewable energy.

High-efficiency cogeneration

The most recent calculation of high-efficiency cogeneration in Denmark, which was reported to *Eurostat* in 2023 with 2021 data, calculated that 99 % of all cogeneration is highly efficient. A new inventory and reporting will be made in 2024, but the share is not expected to decrease. The potential for efficiency of existing cogeneration in Denmark is therefore minimal and the potential for the expansion of new high-efficiency cogeneration capacity is decreasing.

Indeed, the potential for cogeneration in Denmark has decreased from 76 % of district heating demand in 2011 to 65 % in 2022 and is expected to decline further to 63 % in 2025 as a result of the integration ofrenewable energy sources into the electricity grid. Cogeneration has relatively high marginal costs

30[Denmark's global climate footprint (kefm.dk)] e.g. wind and solar cells, and are therefore considered to be less feasible in the future energysystem in Denmark. When there is a reduced market incentive to produce electricity from cogeneration, it is more economically feasible to invest only in heat generators. The decrease in cogeneration is not replaced by thermal electricity production, but by a fluctuating share ofrenewable energy.

There are no national strategies to change this development, as the level of energy security is high in the Danish electricity grid (99.99 %) and because there are more renewable alternatives to producing heat for the district heating network.

Energistyrelsen

Part 4
Potential new strategies and policy measures

See sections 7 and 8.