Assessment of local feasible renewable energy-based heating/cooling utilisation for Helsingør

(D2.2)

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The progRESsHEAT project

The project progRESsHEAT aims at assisting policy makers at the local, regional, national and EU-level in developing integrated, effective and efficient policy strategies achieving a fast and strong penetration of renewable and efficient heating and cooling systems. Together with 6 local authorities in 6 target countries across Europe (AT, DE, CZ, DK, PT, RO) heating and cooling strategies will be developed through a profound analysis of (1) heating and cooling demands and future developments, (2) long-term potentials of renewable energies and waste heat in the regions, (3) barriers & drivers and (4) a model based assessment of policy intervention in scenarios up to 2050. progRESsHEAT will assist national policy makers in implementing the right policies with a model-based quantitative impact assessment of local, regional and national policies up to 2050.

Policy makers and other stakeholders will be strongly involved in the process, learn from the experience in other regions and gain deep understanding of the impact of policy instruments and their specific design. They are involved in the project via policy group meetings, workshops, interviews and webinars targeted to the fields of assistance in policy development, capacity building and dissemination.

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1. Introduction

This fact sheet is part of the Deliverable 2.2 of the progRESsHEAT project. The fact sheet presents data and modelling results which have been collected and analysed concerning the local case municipality, Helsingør (Denmark), up to October 2016. It focuses on the assessment of local feasible renewable energy-based district heating and cooling utilisation including district heating expansion potentials based on analysis of local energy systems including the identified potential energy savings and local renewable energy resources. The goal of this report is to present and discuss the results of scenario modelling regarding: the price of district heating, heating costs, the share of district heating and heat savings, as well as share of renewables and CO_2 emissions in 2030 and 2050. For more details on the current energy system in Helsingør, please consult the Deliverable 2.1. For details on the modelling methodology, please consult the Deliverable 2.4.

The costs of district heating production are calculated with the energyPRO tool, the costs of individual supply and heat savings are calculated with the specially-developed Excel spreadsheet-based Least Cost Tool (LCT). Demand for district heating in Helsingør will increase if district heating expansion takes place or decrease if heat savings are implemented. Therefore, district heating supply costs, individual supply costs and district heating costs are compared with each other in an iterative process until definitive results are found.

The energy scenarios are assessed from two perspectives, which are discussed in detail in subsection 2.1 and in section 3. The results show that if energy taxes are excluded (simple socio-economic perspective), the scenario resulting in most heat savings, highest share of renewables and lowest CO_2 emissions is the RES2030 scenario. Moreover, the RES2030 scenario has the same average heat price as the BAU2030 scenario. The HP2030 scenario results in highest district heating share from perspective A. If energy taxes are included (private-economic perspective), the scenario resulting in highest share of renewables and lowest CO_2 emissions is the RES2030 scenario - it also results in high district heating share and low average heat price equal to BAU2030 scenario. From this perspective, the highest heat savings share is obtained in scenario HP2030. In 2050, the Combi scenario is most favourable considering the district heating share, level of renewables and CO_2 emissions, as well as heat price.

2. Main assumptions

2.1 Perspectives: simple socio-economic and private-economic

The analyses concerning current system and the one in 2030 are conducted from two perspectives: simple socio-economic (denoted with A in the scenario name) and private-economic (denoted with B in the scenario name). The year 2050 is analysed only from the simple socio-economic perspective. The simple socio-economic perspective includes externalities such as NO_X and methane taxes, CO_2 taxes and quotas, but excludes energy taxes and subsidies. The private-economic perspective includes energy taxes and subsidies. The interest rate used in this case study is 1,5 % for production capacity investments and 4 % for network investments, due to the special framework which Danish district heating companies operate within. Table 1 shows the scenarios and perspectives analysed in this work.

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Tab. 1: Scenarios and perspectives analysed in this report

Year	Scenario name	Simple socio-economic perspective	Private-economic perspective
2030	BAU2030**A**	X	
	BAU2030**B**		X
	RES2030**A**	X	
	RES2030**B**		X
	HP2030**A**	X	
	HP2030**B**		X
2050	BAU2050**A**	X	
	Combi2050**A**	X	

2.2 District heating demand profile

To create the hourly demand profile for a full year, it was assumed that between September and April, 80 % of heat demand is dependent on the outdoor temperature (17°C being the reference, as suggested by the Danish Technology Institute) and the remaining 20 % constitutes the hot water demand. Outside of the heating season 100 % of the demand is for hot water. The time series for outdoor temperature is represented by Danish Reference Year for coastal areas of Zealand, delivered with energyPRO, prepared by the Danish Meteorological Institute. Figure 1 depicts the yearly district heating demand profile in Helsingør.

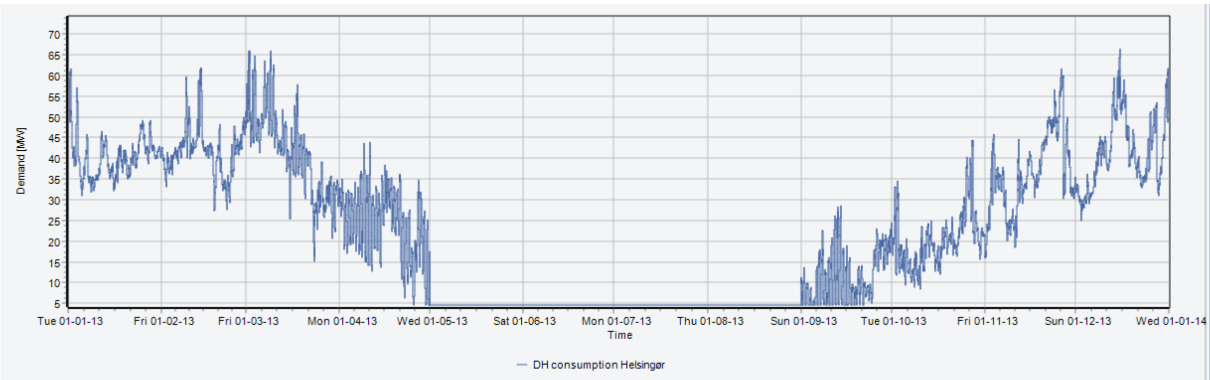

Fig. 1: Assumed district heating demand profile for Helsingør in 2013

2.3 Modelled system

2.3.1 Today

District heating in Helsingør municipality is supplied from energy units located within its boundaries and from a waste incineration and natural gas units Norfors located in neighbouring Hørsholm. In the model, two district heating grids are represented: one for Helsingør municipality and the other for Norfors (supplying Helsingør and several other municipalities), connected with a bidirectional heat capacity transmission line. Table 2 shows the setup of the district heating production system modelled in 2013. Due to data confidentiality, it is not possible to show the exact setup of the current system: however, the modelled capacities in Helsingør are presented for the future scenarios.

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Tab. 2: District heating production units supplying Helsingør municipality in 2013

Location	Fuel type	Technology type
Helsingør	Natural gas	Heat-only boiler
		CHP
		Engine
	Wood chips	Heat-only boiler
Norfors	Natural gas	Heat-only boilers
	Municipal waste	CHP
		Boiler

2.3.2 Reference scenario: Business As Usual (BAU) 2030

All units existing in 2013 are assumed to be decommissioned by 2030 due to their age. Table 3 shows the setup of the district heating production system in 2030 in BAU scenario. The district heating production in Helsingør is assumed to be based exclusively on biomass, while Norfors has a renewed capacity of the same type of energy units as currently.

Tab. 3: Assumed district heating production units in Business As Usual (BAU) scenario in 2030

Location	Fuel type	Technology type	Heat capacity	Electrical capacity
Helsingør	Wood chips	CHP	61,6 MW	15 MW
		Heat-only boiler	4 MW	
Norfors	Natural gas	Heat-only boilers		
	Municipal waste	CHP		
		Boiler		

2.3.3 No fuel oil/natural gas boilers scenario: REnewableS (RES) 2030

All units existing in 2013 are assumed to be decommissioned by 2030 due to their age. Compared to the base scenario 2030, no changes in the basic setup of district heating production system are implemented. The difference comes from prohibiting existing and new individual natural gas and oil boilers in Helsingør, as mentioned in the Danish political agreement from 2012. The implementation of such policy has not been decided yet, but it could encourage investments in either district heating, individual renewable energy supply and/or heat savings. moreover, this policy also agrees with Helsingør's goal to decrease CO_2 emissions from the municipality to 1 t CO_2 per capita by 2030 and, as a part of the Capital Region of Denmark, to achieve fossil fuel-free electricity and heat supply and in 2035.

2.3.4 Heat pumps and heat storage scenario: HP2030

Table 4 shows the setup of the district heating production system in 2030 in the heat pump and heat storage scenario. All units existing in 2013 are assumed to be decommissioned by 2030 due to their age. The district heating production in Helsingør is based exclusively on heat pumps, while Norfors has a renewed capacity of the same type of energy units as in 2013.

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Tab. 4: Assumed district heating production units in 2030 in heat pumps and storage scenario

Location	Fuel type	Technology type	Heat capacity
Helsingør	Electricity	Heat pumps	60 MW
		Thermal storage	463,5 MWh[i]
Norfors	Natural gas	Heat-only boilers	
	Municipal waste	CHP	
		Boiler	

2.3.5 Reference scenario: Business As Usual (BAU) 2050

Table 5 shows the setup of the district heating production system in BAU2050 scenario. The biomass CHP is decommissioned due to age. The units from 2030 in Norfors are decommissioned and new ones are implemented.

Tab. 5: Assumed district heating production units in Business As Usual (BAU) scenario in 2050

Area	Fuel type	Technology type	Heat capacity	Electrical capacity
Helsingør	Wood chips	CHP	61,6 MW	15 MW
		Heat-only boiler	4 MW	
Norfors	Natural gas	Heat-only boilers		
	Municipal waste	CHP		
		Boiler		

2.3.6 Combined solar heat, thermal storage and heat pumps scenario: Combi2050

Table 6 shows the setup of the district heating production system in 2050 in combined solar heating, heat pumps and thermal storage scenario. The capacities were decided in an iterative process, considering the renewable resources available in Helsingør. Heat pumps and thermal storage provide most of the load, while solar heating is mostly used in summer. The biomass boiler operates throughout the year to provide the peak load.

Tab. 6: Assumed district heating production units in 2050 in the combined scenario

Area	Fuel type	Technology type	Heat capacity
Helsingør	Electricity	Heat pumps	90 MW
	Thermal storage	Thermal storage	1 854 MWh[ii]
	Solar energy	Solar heating	95 000 m^2
	Wood chips	Heat-only boiler	10 MW
Norfors	Natural gas	Heat-only boilers	
	Municipal waste	CHP	
		Boiler	

[i] Storage capacity purposefully expressed in energy units, assumed storage volume here is 10 000 m^3

[ii] Storage capacity purposefully expressed in energy units, assumed storage volume is 40 000 m^3

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2.4 Heat demand

2.4.1 Today

As shown in D2.1, the heat supply in Helsingør municipality in 2013 consisted of 35 % district heating, 44 % natural gas, 19 % fuel oil and approximately 2 % other sources/technologies (ovens, individual biomass boilers and individual heat pumps). Table 7 depicts the heat demand for district heating in energyPRO, in Helsingør and Norfors.

Tab. 7: Heat demand input in the district heating model of Helsingør and Norfors

Demand location	Amount (GWh)
Sales of district heating in Helsingør	200,5
Grid losses Helsingør	38,1
Sales of district heating in Norfors	205,0
Grid losses Norfors	48,0

2.4.2 2030 scenarios

The starting heat demand for each scenario is shown in Figure 2. The LCT (Least-Cost-Tool) runs three iterations which result in final demand for district heating and various individual heating supply types in 2030.

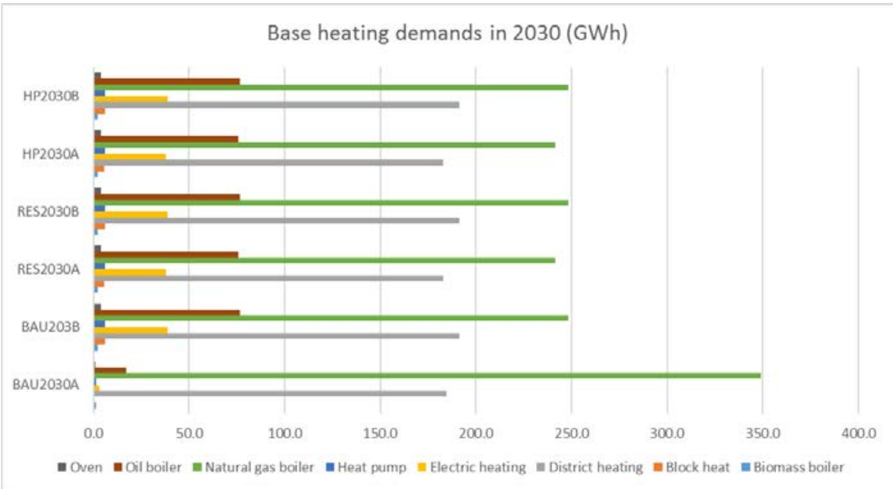

Fig. 2: Base heating demand per supply type in 2030 (GWh)

2.4.3 2050 scenarios

The starting heat demand for each scenario in 2050 is shown in Figure 3. The LCT (Least-Cost-Tool) runs three iterations, which result in final demand for district heating and various individual heating supply types in 2050. The starting district heating consumption is much higher in Combi2050 scenario than in BAU2030 to maintain consistency with HP2030 and BAU2030 scenario results, respectively.

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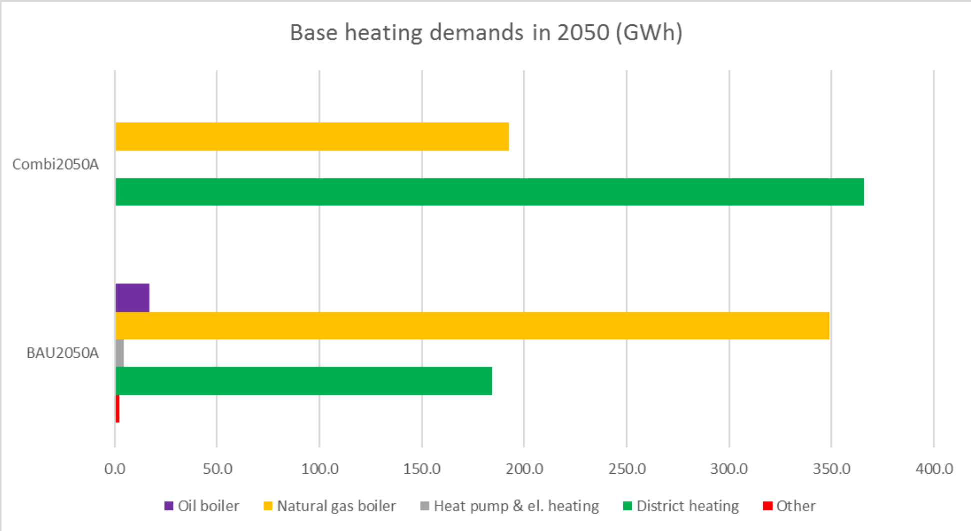

Fig. 3: Base heating demand per supply type in 2050 (GWh)

2.5 Renewable energy resources

The technically available renewable energy potentials are discussed in Deliverable D2.1.

The energy crops and forest wood available in Helsingør (44,5 GWh) can only cover between 12 % and 29 % of the demand for a biomass CHP and a boiler (depending on the level of expansion) in BAU2030 and 12-28 % in BAU2050 scenarios, therefore a substantial part of biomass would have to be imported.

The solar energy potential in Helsingør, as mentioned in D2.1, is up to 161,9 GWh on roofs and 139,4 GWh within agricultural area. Solar district heating plants are usually built on open areas such as fields, so assuming that 1 m^2 of collector produces 0.5 MWh, the installed capacity of 95 000 m^2 would result in 47 500 MWh production. Divided by the potential it would require about 34 % of available field area.

The possible heat sources for heat pumps in Helsingør could be: a nearby lake, wastewater or seawater (Ea Energianalyse, 2015). While no exact value could be found, according to (Lund and Persson, 2016), Helsingør municipality has a technical potential of heat pumps of 50-100 GWh. This potential includes the following heat sources: low-temperature industrial excess heat, supermarkets, waste water, drinking and usage water, ground water, rivers, lakes and sea water. In the HP2030 scenario we assume that up to 300 GWh of heat can be produced by an ambient heat pump, moreover in Combi2050 scenario we introduce a seawater heat pump that together with the ambient heat pump can produce up to 443 GWh of heat.

None of the scenarios foresees investing in a waste incineration plant, because we assume that the municipal waste produced in Helsingør will be transported to nearby existing incineration plants, such as Norfors.

Currently, industry (excluding commercial buildings and offices) and construction consume only 1 % of district heating and due to lacking information it was excluded from this analysis. In D2.1, the biggest industries in Helsingør were analysed to see whether they potentially could supply waste heat or receive district heating for room heating. The lack of heavy industries in Helsingør makes

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it impossible to use industrial waste heat to a large extent, that is why this energy source was not analysed in this study.

2.6 Prices, taxes and subsidies

2.6.1 Current

The costs common for the socio- and private-economic perspective are:

- Fuel purchase costs
- Unit operation and maintenance
- Annuitized network and capacity investments
- Administration costs (e.g. employment)
- CO_2 quotas, CO_2 tax, methane tax and NO_x tax

The revenue is electricity sales on the spot market.

In the private-economic analysis VAT and energy tax are added, based on the Danish Tax office (SKAT, 2016). The taxes are: energy taxes on natural gas consumption (0,37 EUR/Nm^3 or 0,39 EUR/Nm^3 in engines), CO_2 tax on natural gas consumption for heat (0,05 EUR/Nm^3 or 0,01 EUR/Nm^3 in engines), methane tax on natural gas consumption of stationary piston engines (0,05 EUR/Nm^3), NO_x tax on natural gas (per measured emissions: 3,42 EUR/kg NO_x), energy tax on heat produced from waste incineration (12,56 EUR/MWh) and supplementary energy tax on amount of waste used as fuel (15,37 EUR/MWh).

The real variable district heating price in 2013 was 73,2 EUR/MWh. (Forsyning Helsingør, 2013)

Electricity and heat capacities are taken from the Danish Energy Producers Count and applied efficiencies and costs from similar technologies found in the Technology Catalogue developed by the Danish Energy Agency. The electricity time series used is the hourly spot electricity price for Eastern Denmark from 2013. Fuel prices, shown in Table 8 come from the data collected by Fraunhofer ISI, which are based on Eurostat and wood pellet market data.

Tab. 8 Fuel prices excl. taxes in 2013

Fuel type	Price (EUR/MWh)
Natural gas	2,83
Woodchips	2,53

Figure 4 depicts the assumed heat price elements as of 2013: fuel costs represent the majority of costs, followed by energy taxes.

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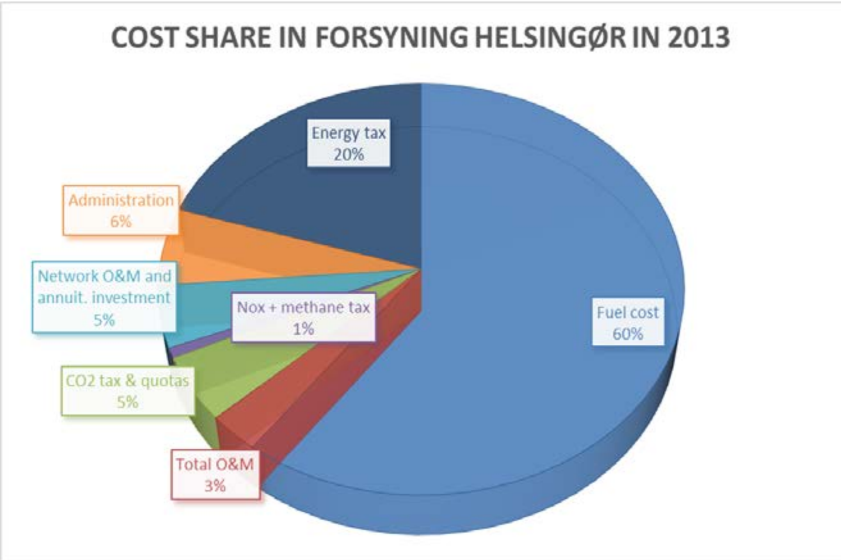

Fig. 4: Components of the district heating price in Helsingør in 2013

2.6.2 2030

In BAU2030 scenario an additional source of revenue is added to electricity sales: the subsidy for electricity production on biomass.

In HP2030 scenario, large-scale (utility) heat pumps are charged with taxes and tariffs that amount for 119 EUR/MWh consumed electricity (Energinet.dk, 2016) (Dansk Energi, 2016). The electricity price profile for 2030 is created by scaling the average price profile (2011-2015) to the average forecasted by Energinet.dk in 2030: 57.4 EUR/MWh. Fuel prices, shown in Table 9 are projected by the Danish TSO Energinet.dk.

Tab. 9 Fuel prices excl. taxes in 2030

Fuel type	Price (EUR/MWh)
Natural gas	2,67
Wood chips	2,16
Oil	63,0

2.6.3 2050

Year 2050 is calculated only from the socio-economic perspective (excluding taxes and subsidies). The electricity price profile for 2050 is created by scaling the average price profile (2011-2015) to the average prognosed for 2050 in Denmark by Fraunhofer ISI: 67,7 EUR/MWh.

Tab. 10 Fuel prices excl. taxes in 2050

Fuel type	Price (EUR/MWh)
Natural gas	3,28
Wood chips	3,39
Oil	73,0

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3. Results

3.1 Heat supply mix

In all the figures below the difference in the total heat demand is caused by implemented heat savings. In none of the scenarios, oil boilers are chosen, due to their high cost.

Figure 5 shows the resulting fuel mix for the heat supply in scenarios BAU2030A and BAU2030B. While from the socio-economic perspective natural gas will dominate in 2030, from the private-economic perspective almost all fossil fuels are eliminated and district heating is substantially expanded, both in absolute values and relatively. Biomass boilers are most viable solution for areas where expanding district heating is technically or economically infeasible.

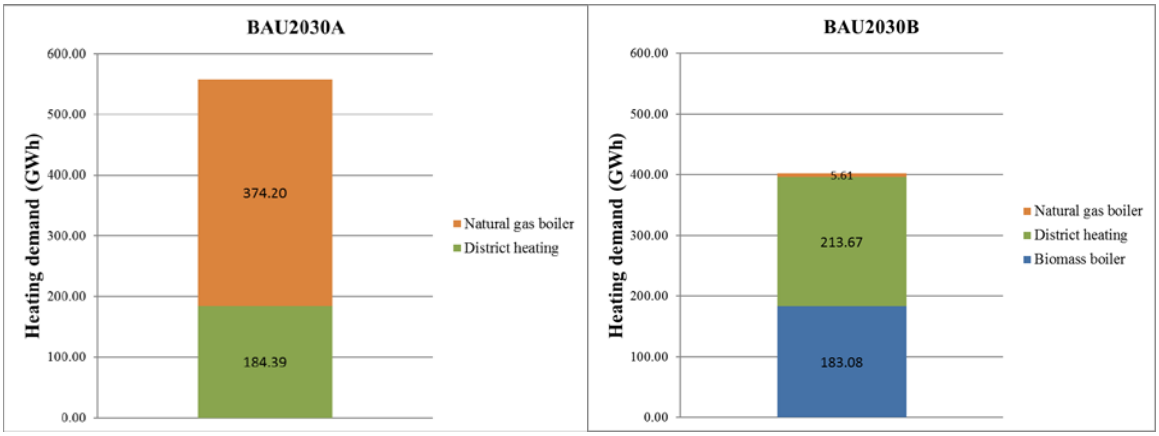

Fig. 5: Heat supply in scenarios BAU2030A and BAU2030B (GWh)

Figure 6 depicts the resulting fuel mix for the heat supply in scenarios RES2030A and RES2030B. Implementing a ban on individual oil and natural gas boilers results in switching into district heating, heat pumps and biomass. While from the socio-economic perspective heat pumps supply 50 % of the heat demand, from the private-economic perspective heat pumps do not pay off, contrarily to biomass boilers.

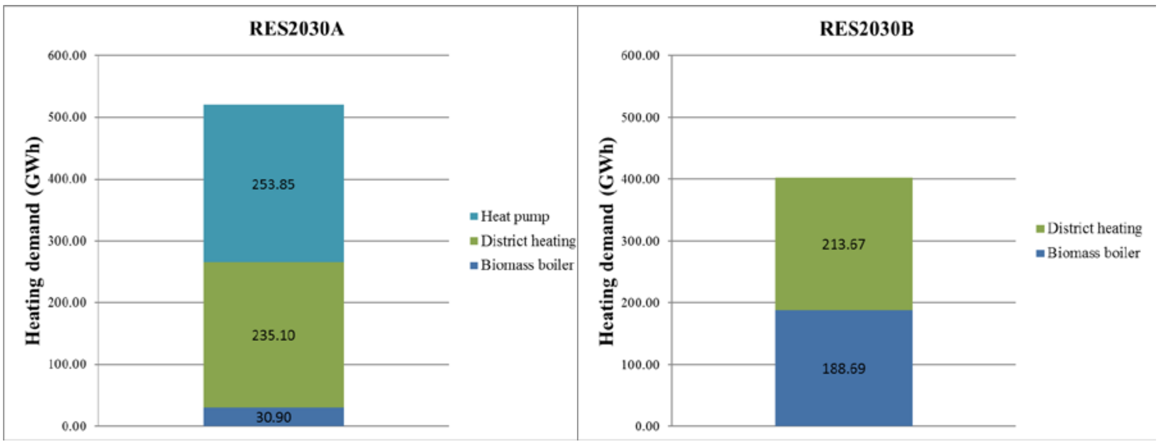

Fig. 6: Heat supply in scenarios RES2030A and RES2030B (GWh)

Figure 7 shows the resulting fuel mix for the heat supply in scenarios HP2030A and HP2030B.A substantial increase in district heating production is observed here, indicating a low district

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heating price. The situation changes completely when taxes are considered: district heating supply is substantially reduced and the heat supply is dominated by individual biomass boilers. For some buildings natural gas boilers are still an optimal solution.

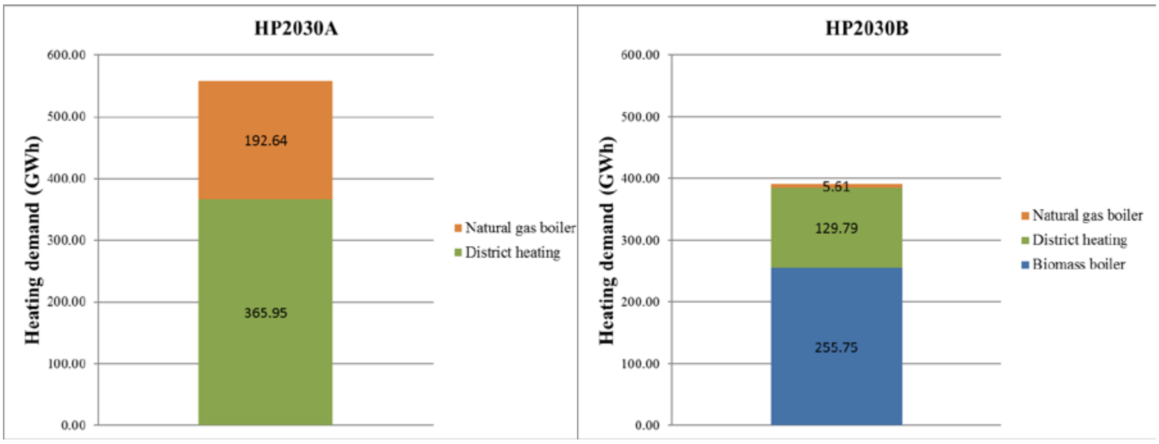

Fig. 7: Heat supply in scenarios HP2030A and HP2030B (GWh)

For 2050, Figure 8 shows the resulting fuel mix in scenarios BAU2050A and Combi2050A.While in BAU2050 about 5 % of demand would still come from natural gas, individual heat pumps could supply over 60 % of the required heat demand. As shown in Combi2050 diversifying the district heating plant portfolio would cause the heating prices to decrease so that most heat in the municipality could by supplied by district heating network.

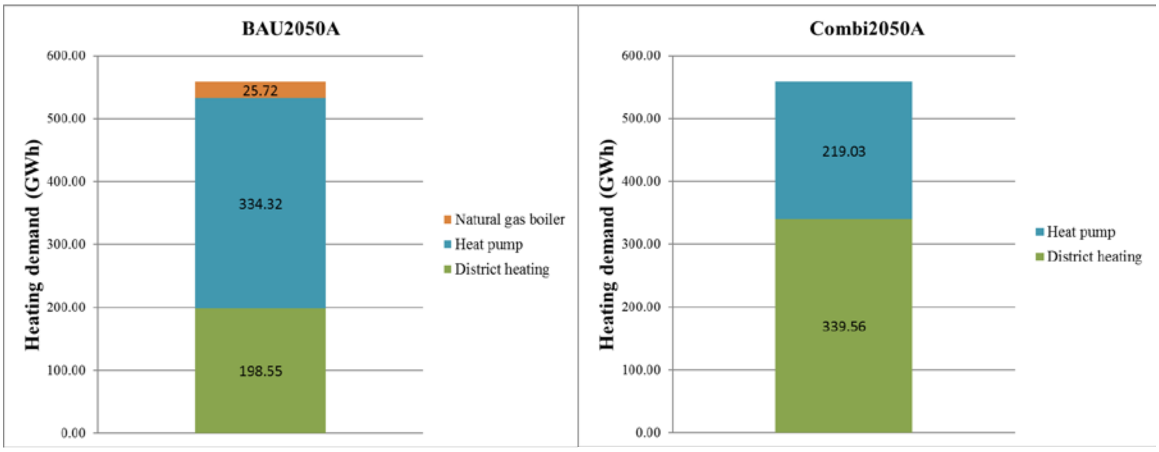

Fig. 8: Heat supply in scenarios BAU2050A and Combi2050A (GWh)

3.2 District heating price

The modelled district heating prices in 2030 are the same for BAU and RES scenario. As Figure 9 shows, the price fluctuates depending on the reduction or expansion of district heating supply.

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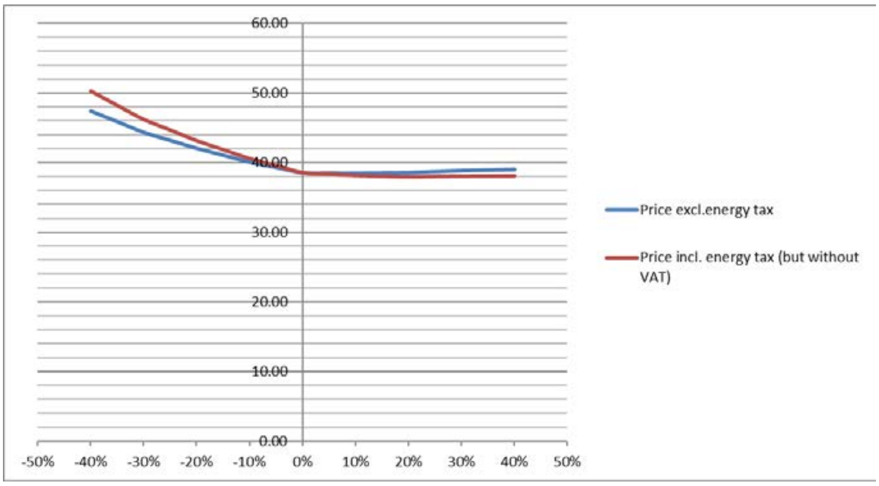

Fig. 9: Prices of district heating from the socio- and private-economic perspective in BAU and RES scenarios in 2030 (EUR/MWh)

The low variable heat price from the private-economic perspective in 2030 is caused by the tax and subsidy balancing each other. The increase of variable price with falling district heating production are due to the insufficient use of installed capacity: costs such as investment or part of fixed O&M (operation and maintenance) occur independently of production levels, while electricity revenues fall with low production. Although a decrease in prices could be expected in case of increasing district heating production, the prices stay almost the same, which may be due to additional investments required to cover the increased demand - the planned biomass CHP is dimensioned to cover the current heat demand rather than an expansion.

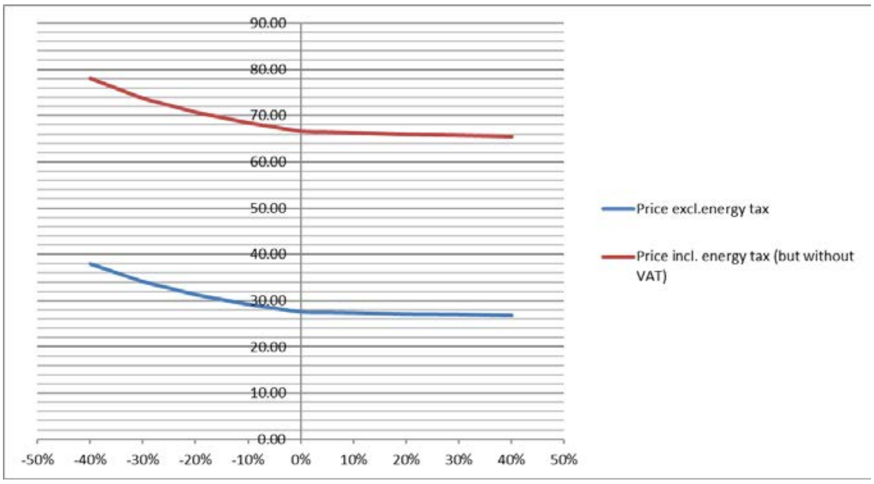

Fig. 10: Prices of district heating from the socio- and private-economic perspective in HP scenario in 2030 (EUR/MWh)

Figure 10 depicts prices in the heat pump and thermal storage scenario. The prices calculated from the socio-economic perspective are lower than in BAU2030 scenario. However, prices from the private-economic perspective are much higher than in other scenarios, which in the current taxing scheme makes the utility heat pumps unviable.

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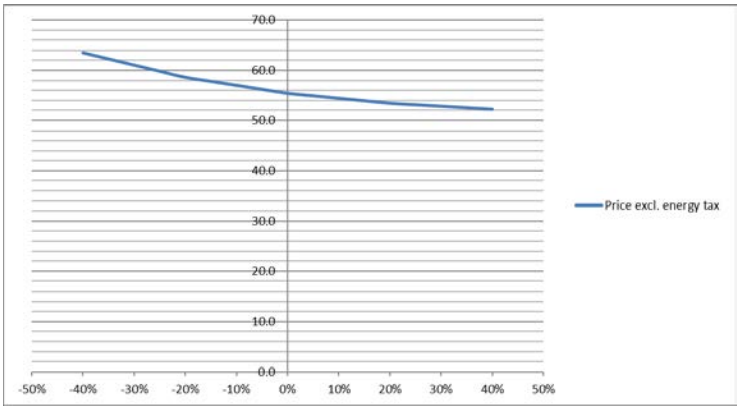

Fig. 11: Price of district heating in BAU scenario in 2050

Figure 11 depicts prices in the BAU2050 scenario, only from the socio-economic perspective. The prices calculated are much higher than in 2030 scenarios, mainly due to the high biomass prices.

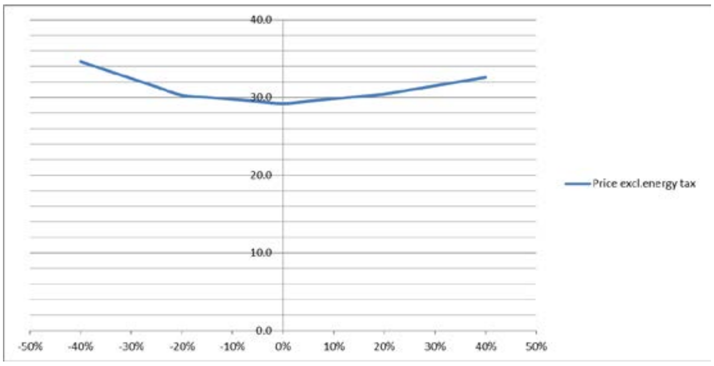

Fig. 12: Price of district heating in Combi scenario in 2050

Figure 12 shows prices in the Combi2050 scenario, only from the socio-economic perspective. The prices calculated are similar to those in 2030 scenarios and about 40 % lower than those in BAU2050 scenario.

3.3 Heating costs

Figures 13 - 17 below show the calculated average heating costs per area type in Helsingør in 2030 and in 2050.

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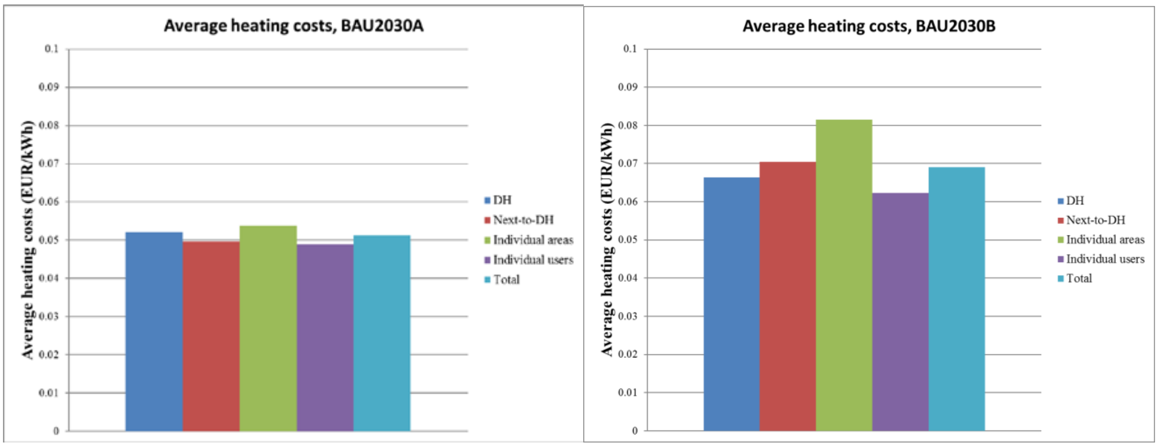

Fig. 13: Average heating costs per area type from the socio- and private-economic perspective in BAU2030 scenarios (EUR/kWh)

As Figure 13 shows, the heating costs from the socio-economic perspective are similar in all area types and the iteration process has decreased the costs only slightly, compared to the base (before the iterative process). The cost reduction is more visible from the private-economic perspective - there is a large difference of taxation between district heating and individual supply - moreover, heat savings are represented by the same cost type (no taxes or subsidies added), independently from the perspective.

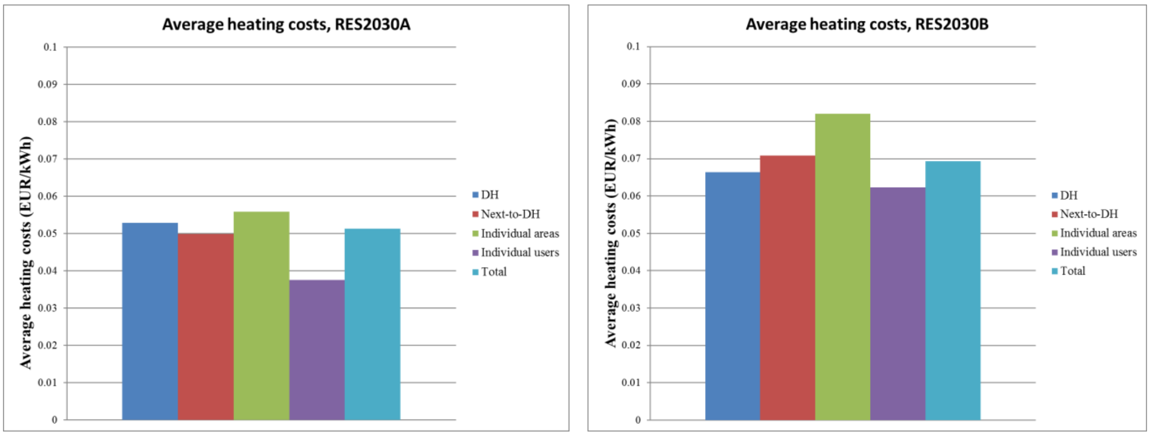

Fig. 14: Average heating costs per area type from the socio- and private-economic perspective in RES2030 scenarios (EUR/kWh)

As Figure 14 reveals, the total heating costs from the socio-economic perspective are similar in all area types, though a visible difference occurs for the cost of individual users. BAU and RES scenarios result in very similar average heating costs for the municipality of Helsingør. Therefore, forbidding natural gas and oil boilers can bring further savings in CO_2 emissions (see Figure 23) without an additional cost increase for inhabitants.

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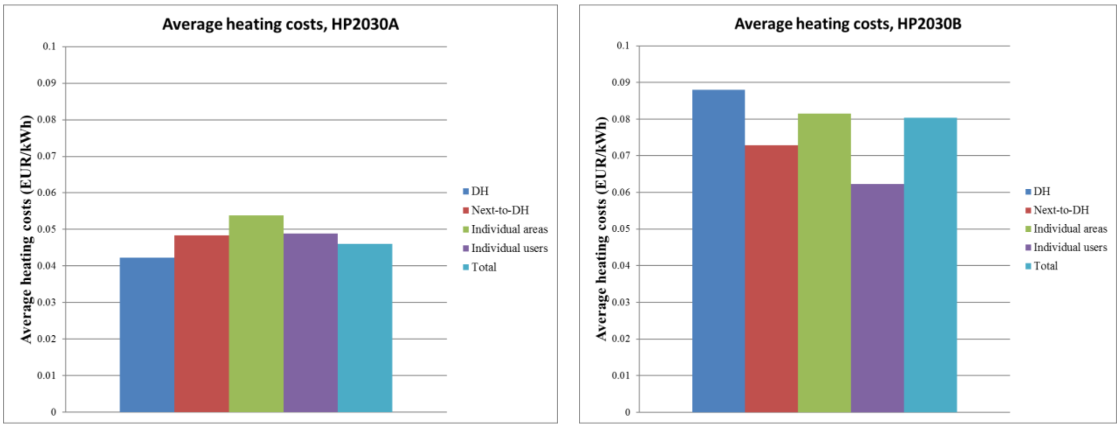

Fig. 15: Average heating costs per area type from the socio- and private-economic perspective in HP2030 scenarios (EUR/kWh)

Figure 15 shows that in HP scenario the overall cost in Helsingør decreases slightly from both perspectives. The total heat costs for Helsingør are lowest in this scenario if taxes are excluded. However, at the level of 0,8 EUR/kWh if taxes are included, this cost is highest of all 2030 scenarios, mainly due to high district heating costs.

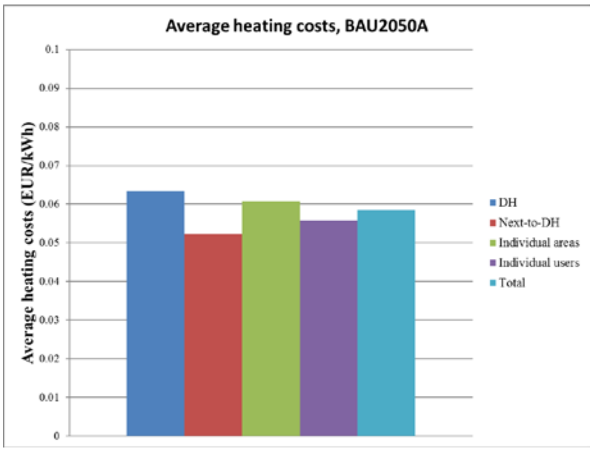

Fig. 16: Average heating costs per area type from the socio-economic perspective in BAU2050 scenario (EUR/kWh)

As Figure 16 depicts, in BAU2050 scenario the average cost in Helsingør decreases slightly after iterations. However, at the level of approximately 0,06 EUR/kWh, this cost is higher than the one in the following Combi2050 scenario.

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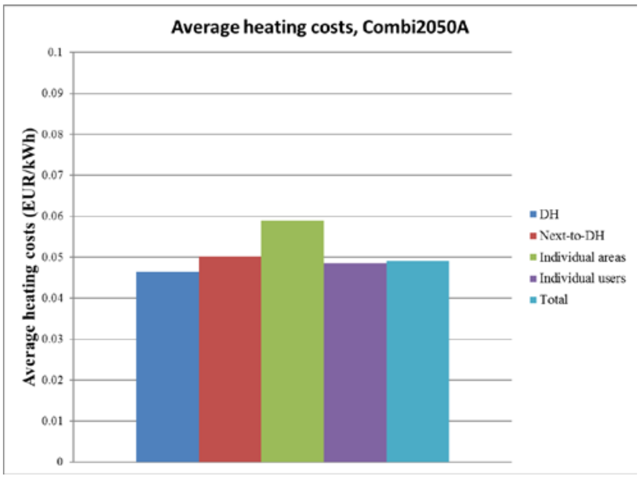

Fig. 17: Average heating costs per area type from the socio-economic perspective in Combi2050 scenario (EUR/kWh)

As Figure 17 demonstrates, the average heating costs for the whole municipality are lower by approximately 17 % in Combi2050A scenario than in BAU2050.

3.4 Share of district heating/cooling

The current share of district heating in Helsingør is 35 %. Figure 18 shows the resulting economically feasible shares of district heating, considering BAU scenario, RES scenario and HP scenario from the socio- and private-economic perspectives.

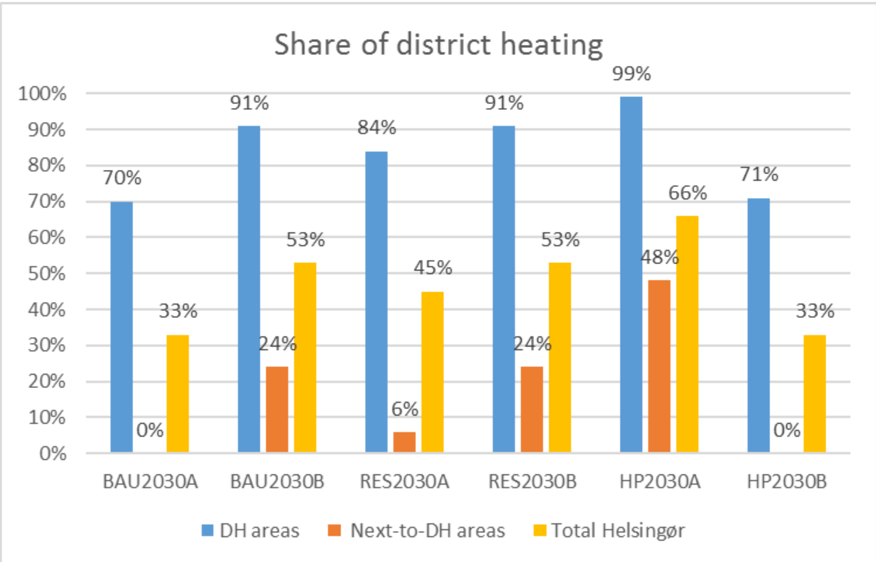

Fig. 18: Share of district heating per scenario in 2030

In none of the 2030 scenarios district heating expansion occurs in individual areas. District heating is more feasible from the private-economic perspective in BAU and RES scenarios due to biomass being exempted from taxes. In these scenarios, the share of district heating would increase to 53 %, equalling the current average national levels for Denmark. The results from the private-economic perspective are the same for both scenarios, because, under the assumptions taken in this study, even without the policy of banning individual oil and natural gas boilers, these

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technologies will be phased out due to their high price. Nonetheless, HP scenario is the one with highest district heating share (almost 100 %), because utility heat pumps and heat storage are more viable if taxes are excluded. When taxes are included, HP scenario results in lowest share of district heating.

Figure 19 shows the resulting shares of district heating in BAU2050 and Combi2050 scenarios.

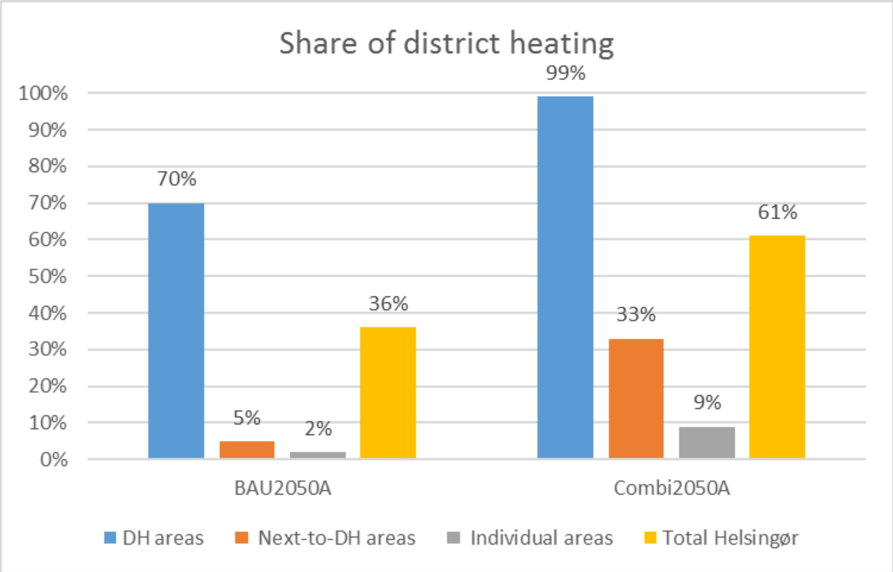

Fig. 19: Share of district heating per scenario in 2050

BAU2050A does not result in any substantial increase of the overall district heating share, compared to 2030. Combi2050 is a continuation of HP2030A scenario, where large amounts of district heating were already implemented. So while the share is higher than in the alternative scenario, BAU2050A, it is actually lower than in 2030. Contrarily to 2030, in 2050 the district heating expansion occurs in individual areas.

3.5 Share of heat savings

Figure 20 shows heat savings implemented in each 2030 scenario: no heat savings occur in BAU2030A and HP2030A. Heat savings are less feasible from the socio-economic perspective, but a potential policy of banning individual natural gas and fuel oil boilers would cause higher heat savings than in the base scenario in 2030. If taxes and subsidies are taken into account, it is feasible to save around 30 % of heat demand in each area, except for scattered buildings where savings reach 40 %. Heat savings are highest in HP2030B scenario, because their price is competitive with district heating price.

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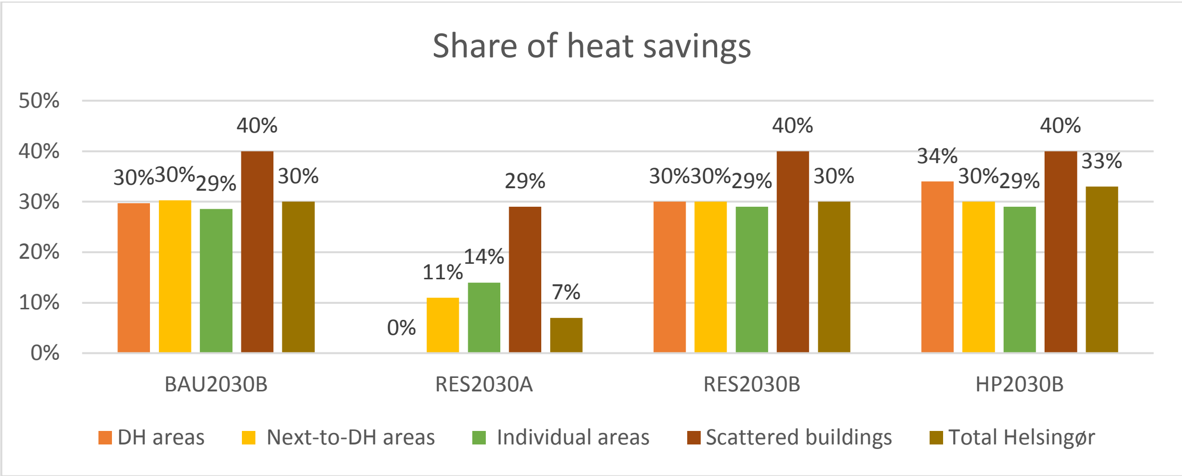

Fig. 20 Share of heat savings per scenario in 2030 (no heat savings in BAU2030A and HP2030A)

No additional investment in heat savings is allowed in 2050, since we assume that the full potential was already used in 2030.

3.6 Share of renewables

The share of renewables in heat supply in 2013 in Helsingør was about 2 % (calculated as biomass and heat pumps in individual supply). In 2030, the choice of individual supply will influence the share of renewables most, because district heating will switch primarily to renewables. In 2050, the share will either stay the same as in 2030 or increase further, if Norfors area also switches fully to renewables. We assume that in 2030 electricity in Denmark will be produced on 100 % RES.

Figure 21 depicts the share of renewables in each scenario in 2030 and Figure 22 - in 2050. The emissions assigned from Norfors are the same in all of the scenarios, since the same amount of heat is transmitted from there, independently of district heating levels in Helsingør. The share of renewables in scenarios BAU2030A and HP2030A is significantly lower than in other scenarios due to the presence of natural gas-based individual supply (see Figure 5 and 7). RES2030B scenario contains most renewables (97 %), while HP2030B and BAU2030B have a share lower by 2 %.

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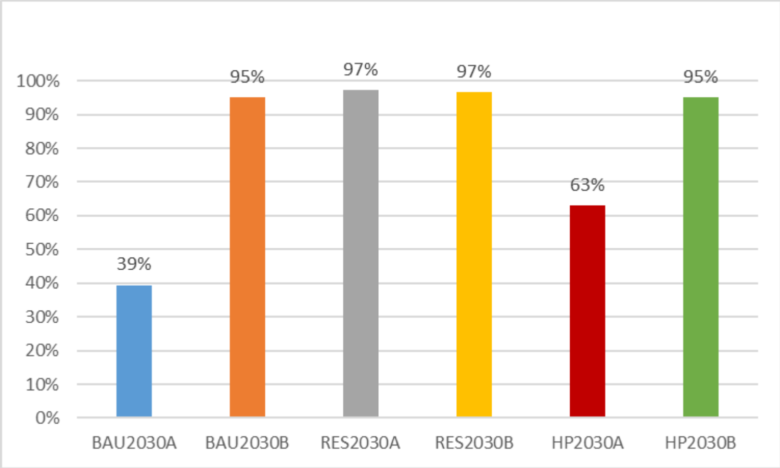

Fig. 21: Share of renewables per scenario in 2030

As Figure 22 shows, scenario Combi2050 results in 4,5 % more renewables than BAU2050 due to the lack of natural gas individual supply**.**

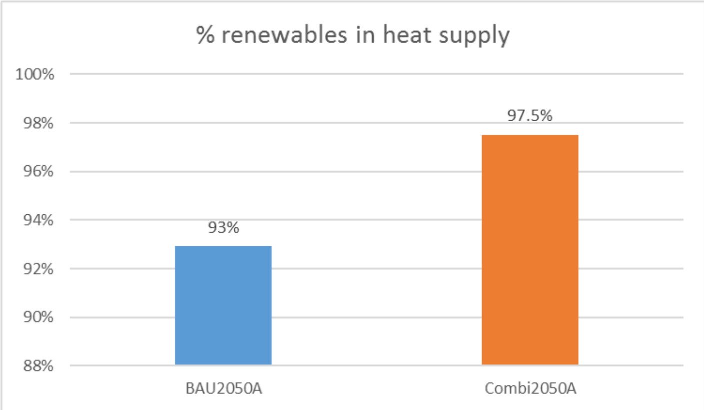

Fig. 22: Share of renewables per scenario in 2050

3.7 CO_2 emissions

The CO_2 emissions from the heat sector are calculated as a sum of emissions from district heating relative to the size of production (calculated by energyPRO) and emissions from individual supply, depending on fuels used.

As shown in D2.1, in 2013, district heating was responsible for 16,7 kt CO_2 emissions (5 % of total CO_2 emissions in the municipality), natural gas 50,8 kt (15 %) and oil 29 kt (8 %). Since district heating in Helsingør is switching to renewables (biomass, heat pumps or solar heat) in 2030, the CO_2 emissions will decrease substantially. In 2050 the emissions will either stay the same as in 2030 or decrease further, if Norfors area switches fully to renewables.

For allocating CO_2 emissions in the district heating in 2030 and 2050 we use the IEA/Eurostat method (OECD/IEA, 2005), where the fuel input is divided between the electricity and heat in proportion to their shares in the output.

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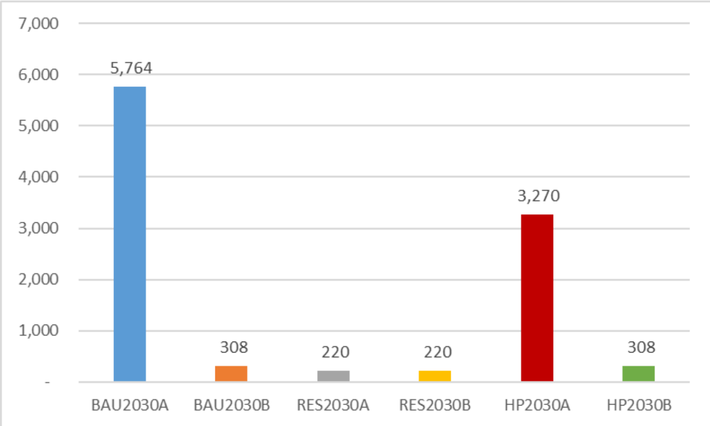

Fig. 23 CO_2 emissions per scenario in 2030 (t)

Lowest CO_2 emissions in 2030 from both perspectives are achieved in the scenarios RES2030A and RES2030B. CO_2 emissions in scenarios BAU2030A and HP2030A are significantly higher than in other scenarios due to the presence of natural gas-based individual supply (see Figure 5 and 7). BAU2030B scenario also contains some individual gas boilers, which increase the overall level of CO_2 emissions.

As Figure 24 shows, lower CO_2 emissions are achieved in the scenario Combi2050A.

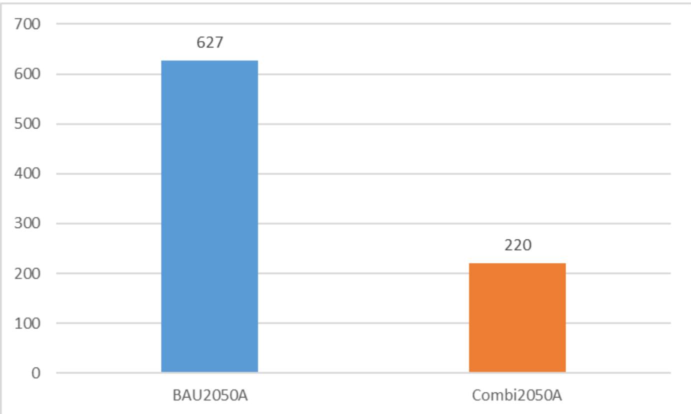

Fig. 24 CO_2 emissions per scenario in 2050 (t)

BAU2050A scenario still has some individual gas boilers (see also Figure 8), which causes higher CO_2 emissions.

4. Summary and conclusion

The goal of this fact sheet was to assess the local feasible renewable energy-based district heating and cooling utilisation including district heating expansion potentials based on analysis of local energy systems including the identified potential energy savings and local renewable energy resources. The costs of district heating production were calculated with the energyPRO tool, the costs of individual supply and heat savings were calculated with the Excel spreadsheet-based Least Cost Tool (LCT).

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The results show that in 2030, from the private-economic perspective, district heating could increase from current 35 % to 53 % in total in Helsingør. In district heating areas an increase from 70 % to 91 % is feasible and in Next-to-DH areas from 0 to 24 %. District heating is unviable in Individual areas. In 2050, Combi2050A scenario results in 99 % share of district heating in DH areas, 33 % in Next-to-DH areas and 9 % in individual areas, summing up to overall 61 %.

In 2030, from the socio-economic perspective, heat savings are less feasible, but a policy of banning individual natural gas and fuel oil boilers would encourage higher heat savings than the BAU2030 scenario. If taxes and subsidies are taken into account, it is feasible to save approximately 30 % of heat demand in each area except for scattered buildings where savings can each 40 %. No further heat savings occur in 2050.

In 2030, lowest average heating costs from the socio-economic perspective occur in BAU and RES scenarios, from the private-economic perspective - in BAU and RES scenarios in 2030. In 2050, the Combi2050 scenario results in lowest heating prices.

Lowest CO_2 emissions in 2030 from both perspectives occur in the scenarios RES2030A and RES2030B. In 2050, the lowest level of CO_2 emissions is achieved in the scenario Combi2050A.

RES2030B scenario contains most renewables (97 %), while HP2030B and BAU2030B achieve 95 % of renewables in the heat supply. In 2050, scenario Combi2050 results in highest share of renewables due to the lack of natural gas in the individual supply.

To sum up, if energy taxes are included, the scenario resulting in highest share of renewables and lowest CO_2 emissions is the RES2030 scenario - it also results in high district heating share and low average heat price equal to BAU2030 scenario. From this perspective, the highest heat savings share is obtained in scenario HP2030. In 2050, the Combi scenario is most favourable considering the district heating share, level of renewables and CO_2 emissions, as well as heat price.

Due to the difficulty of forecasting taxes, the analysis for 2050 is conducted only from socio-economic perspective. Moreover, the possible effects of climate change are disregarded in this report. This is to avoid mixing technologies and policies with climate change impact. Another reason is the uncertainty connected with the need of representing several climate change scenarios and models.

Due to climatic conditions, residential cooling is not necessary in Helsingør and was not considered in this work. However, some industrial cooling may prove necessary in the future - however, no data could be accessed from private companies that possibly could require district cooling

Since no further implementation of fossil fuels is planned in the municipality, a substantial decrease of CO_2 emissions in heat supply is very plausible, no matter which scenario will be chosen. However, in case of the biomass CHP the feasibility of district heating expansion depends very much on which prices the future district heating will be able to offer and how taxation (including tax exemption for biomass) will be shaped. Thus there are a number of uncertainties that have to be considered. Other examples are: future fuel and technology prices, as well as policies including CO_2 targets.

Assuming the prices develop as shown in this report, in most cases district heating in Helsingør will have an a technical and economic potential to expand, but we recommend that the operation

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of an already decided biomass CHP plant is closely monitored and new technologies such as heat pumps and heat storages are considered in the 10-15 years' perspective. The uncertainty connected to future biomass taxation is rather high. If electricity taxation changes in the future, considering large heat pumps is important. Many district heating companies in Denmark also invest in solar thermal installation and this technology should be considered as well. Regarding individual supply, their feasibility depends very much on future fossil fuel price. But it is visible that if district heating price decreases, some conversion to district heating is possible. Besides heat savings are also viable, especially in old buildings.

The locally available renewable energy resources should also be considered in the assessment of the viability of the scenarios. The energy crops and forest wood available in Helsingør can only cover up to 30 % of the demand for biomass CHP, therefore a substantial part of biomass would have to be imported. Thus, other scenarios benefit from less dependence on biomass and not bearing the substantial risk of the biomass price increases. Besides, looking from overall sustainability perspective, biomass should preferably be used in sectors such as heavy transport which currently does not have other CO_2-free solutions.

5. References

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