

*Dialogue on a RES
policy framework
for 2030*



D3.1a

Renewable Based District Heating in Europe

- Policy Assessment of Selected
Member States



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About the project

The aim of **towards2030-dialogue** is to facilitate and guide the RES policy dialogue for the period towards 2030. This strategic initiative aims for an intense stakeholder dialogue that establishes a European vision of a joint future RES policy framework.

The dialogue process will be coupled with in-depth and continuous analysis of relevant topics that include RES in all energy sectors but with more detailed analyses for renewable electricity. The work will be based on results from the IEE project beyond 2020 (www.res-policy-beyond2020.eu), where policy pathways with different degrees of harmonisation have been analysed for the post 2020 period. **towards2030-dialogue** will directly build on these outcomes: complement, adapt and extend the assessment to the evolving policy process in Europe. The added value of Towards2030-dialogue includes the analysis of alternative policy pathways for 2030, such as the (partial) opening of national support schemes, the clustering of regional support schemes as well as options to coordinate and align national schemes. Additionally, this project offers also an impact assessment of different target setting options for 2030, discussing advanced concepts for related effort sharing.

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This report

This report focuses on the regulatory and policy instruments aiming to stimulate the deployment of renewable based district heating in Europe. It uses the methods of country studies of selected European countries as well as case studies with the aim to identify those policy instruments that could effectively support RES based district heating. It also introduces a quantitative tool to assess the impacts of some of the available policy instruments, presently elaborated on the Hungarian DH market.

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1 Introduction

According to the NREAPs of the EU member states, renewable based heat generation will play significant role in achieving the 2020 RES targets, and they will continue to play a crucial role in the period up to 2030 as well. Renewable district heating is a major contributor in this process, but further uptake of this technology needs careful design of support and regulatory schemes.

In this study an in-depth assessment is conducted out on selected European countries with the aim to identify those policy instruments that could effectively support the development of RES district heating (DH) deployment.

This is a complex task, as RES DH is 'embedded' in the national or regional DH systems. This 'embeddedness' means that the penetration and development of RES DH systems are very much dependent on the general market structure of the heat market and the regulatory framework of the DH systems, in general. Thus, even similar policy instruments aiming to increase RES based DH generation might have very uneven effects depending on the heat market structure. This problem is further exacerbated by the fact that district heating market structures are typically heterogeneous, not only varying amongst member states but also within a country due to the divergent regional/municipal characteristics of the DH systems.

In addition, the electricity market structures also have impacts on the RES DH development, through the linkages with the CHP generation. CHP is one of the most efficient ways to produce useful energy, but as its production level is determined in two markets (electricity and heat), and thus, its regulation and promotion as a source of heating entails additional challenges.

Increasing the share of RES-based district heating is a multifaceted task for policymakers, as it can be achieved through various paths with the use of various technologies. In addition, the heat demand characteristics can differ to a great extent (volume and concentration of the heat demand), as well as, the cost structures of the various fuels used in satisfying the heat demand.

This results in very heterogeneous systems across the EU member states, where the support of RES takes various forms. The following figure illustrates the complexity of the choices for satisfying the heat demand by various heating modes.

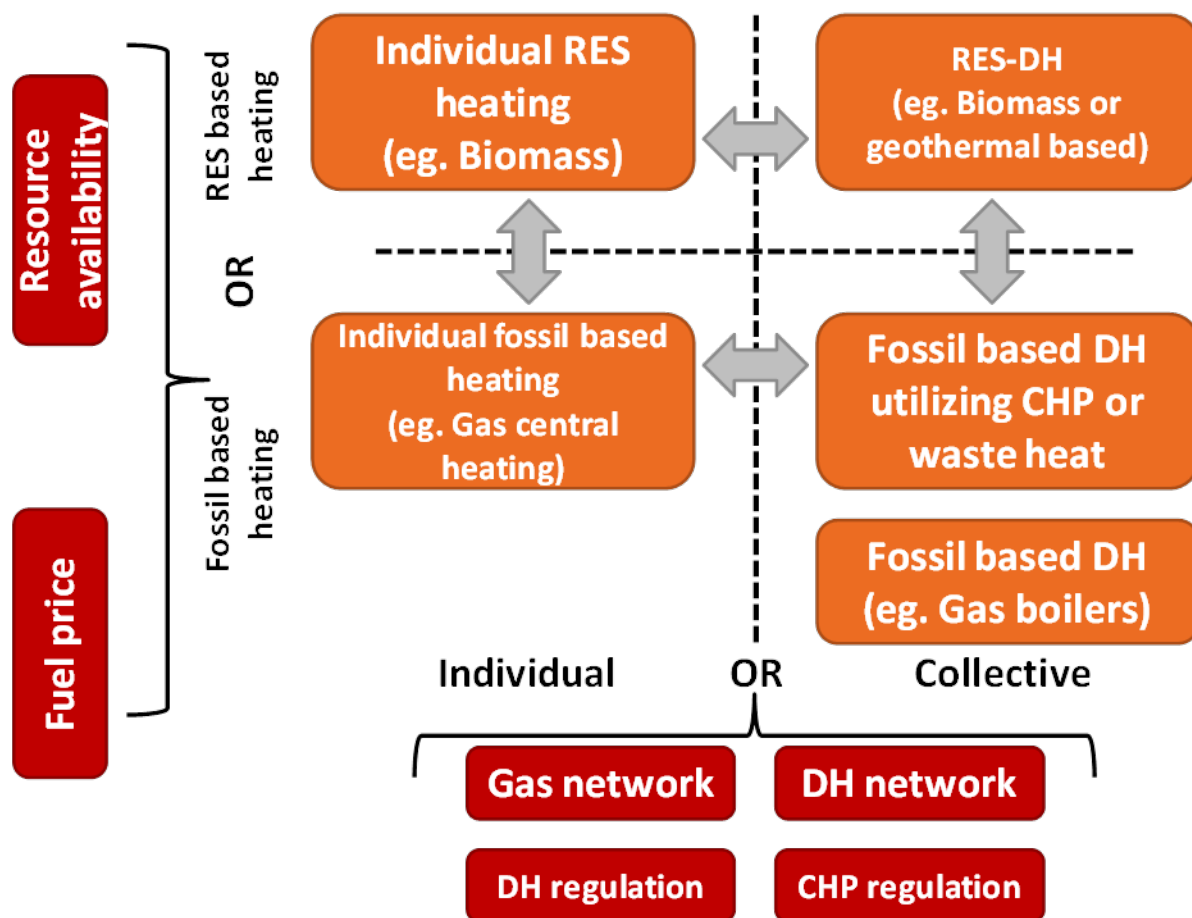


Figure 1 Approach of the policy assessment; Source: REKK

As Figure 1 illustrates increasing RES DH could be achieved by a number of combinations: from individual heating to directly to RES DH, or by converting fossil based DH to RES DH systems. Probably the latter is more feasible, as it requires the switch of the boiler from a fossil base to a renewable base, generally using biomass, and using the same distribution system. The first path (from individual heating to district heating) could be realised in various ways, e.g. in villages where the available biomass could be switched and used in a local biomass heat plant (e.g. the N hwarme system in Austria), or by expanding existing DH network to adjacent areas where the heat production is based on RES.

The present EU and national energy policies have multiple targets towards district heating. The EU level policy aims to increase DH potential with more efficient CHP production and utilization of industrial waste heat or renewables (article 24 of Directive 2012/27 on energy efficiency, EED), if they are efficient and in a cost/benefit framework they will have a positive balance. The EED directive requires MSs to carry out a cost/benefit assessment (CBA) by the end of 2015 to assess the potential of efficient DH and take the necessary measures to support their deployment. It also requires that during the process of permitting new electricity generation installations, or the ones carrying out major refurbishment, have to go through a CBA assessing the potential to convert it to a cogeneration plant. There is no specific provision in the Energy Efficiency Directive which would directly increase the share of RES in DH systems and the use of this option is driven by the provisions of the national energy policies and legislations.

This approach may result in a low priority score for RES based DH, as at the present cost and fuel price structure RES based generation probably will not perform better than fossil based CHP and waste heat. Increasing the share of highly efficient fossil based CHP might end up locking-in the DH systems in fossil based generation

for a longer period if some additional drivers (carbon value or other regulatory instruments) will not make RES competitive.

In addition, more cogeneration would entail an even higher level of integration between the electricity and heat markets, which also has its positive and negative effects on the DH markets. For example the currently low wholesale electricity prices reduce the utilisation rates of the cogeneration plants while gas prices remained relatively more expensive, which in turn also reduce heat production. These effects can be traced in the Eurostat data of CHP production which will be introduced in the following sections. On the other hand a more intertwined electricity and heat market has the advantage that support schemes will be integrated as well (e.g. the example of Germany where both RES heat and RES electricity is supported with a similar FIT instrument) that can result in a less distorted promotion of heat and electricity markets.

The DH sector faces various additional challenges in the European member states:

- Introduce competition (e.g. connect more suppliers on the same DH network) and ensure the regulatory oversight and measurability of heat consumption in individual housing units.
- Increase/consolidate returns in the sector (e.g. brings RES-H into the same support level as other RES-E use)
- Continuity (avoid cyclical behaviour) e.g. investment support is dependent on the state budget, so it might follow a stop and go pattern introducing unwanted cycles.
- Increase market opportunities (e.g. compulsory connection to DH network if available)
- Keep the existing DH users from converting into individual heating solutions
- As the regulatory environment could have a significant impact on the competitiveness of the RES based DH generation, this element will be assessed in detail within the country case studies.

Previous studies providing European wide or multiple country coverage in their assessment were also used to set up the case study structure and the focus areas of our analysis:

- EC, DG JRC: Background Report on EU-27 District Heating and Cooling Potentials, Barriers, Best Practice and Measures of Promotion (2012) Report EUR 25289 EN
- Aalborg University, Halmstadt University, Ecofys, Planenergy: HEAT ROADMAP EUROPE 2050, SECOND PRE-STUDY FOR THE EU27, carried out for Euroheat and Power (2013)
- DHC Technology Platform: District Heating and Cooling – A vision towards 2020-2030-2050
- IEA: The Implementing Agreement on District Heating and Cooling including Combined Heat and Power "IEA DHC", various publications.
- AEBIOM: EU Handbook - District Heating Markets, 2012
- Ecoheat4.eu study
- Reshaping RES Policy: <http://www.reshaping-res-policy.eu/> and <http://www.res-h-policy.eu/>

The 'value added' of this assessment to the previous studies dealing with the RES heating sector appears in three dimensions. Firstly, it gives coverage to a wider range of regulatory aspects including the regulation of DH, CHP and RES heat in general, while earlier studies were mainly focusing on the financial and non-financial support instruments. This is an important aspect, as a recent Euroheat and Power questionnaire shows amongst DH businesses of the EU more than 90% of stakeholders see the regulatory framework as insufficient to incentivize DH developments (Euroheat and Power 2014). Secondly, this assessment also includes heat market drivers beyond public support that could be decisive in the future development of RES-DH (e.g. prices, network availability). Finally, the study covers the development of the most recent years (up till 2012) whereas the earlier studies based their assessments on data up till 2009/2010.

2 Present State of RES Based District Heating in the EU

Currently, the overwhelming majority of RES DH is based on solid biomass and other RES DH technologies play only marginal role (Figure 2).

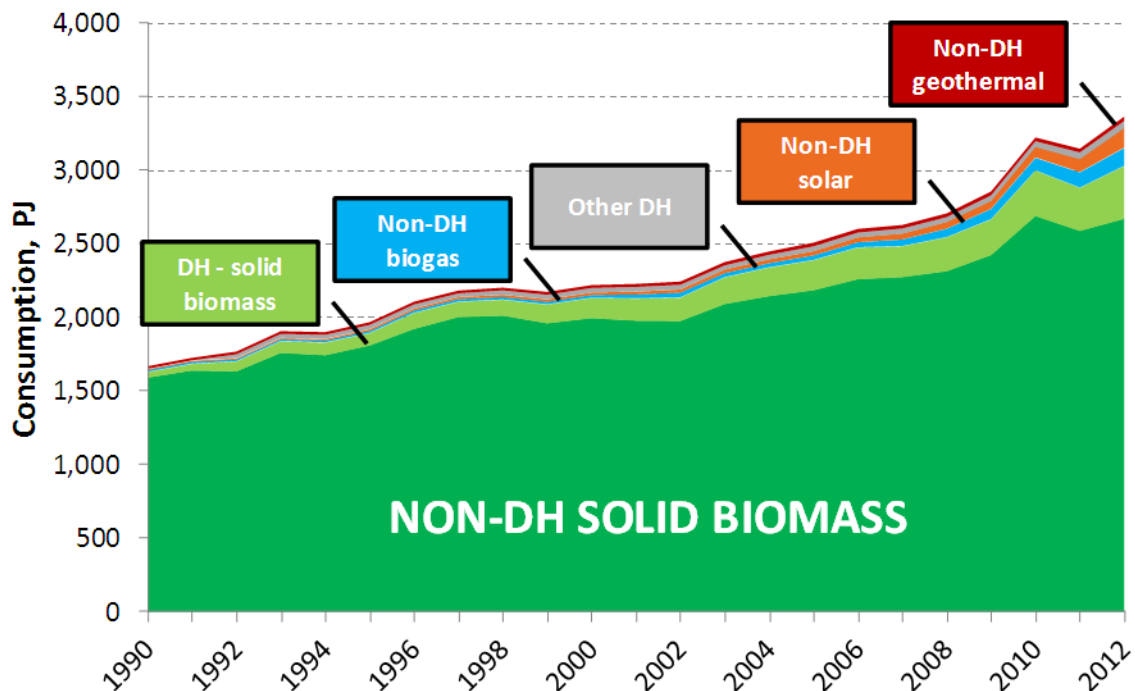


Figure 2 Market development of RES in heating sector (1990-2012) EU 27; Source: Eurostat

As Figure 2 illustrates non-DH based solid biomass dominates the renewable based heat market in Europe. In RES based district heating generation solid biomass is the leading technology; however its share was still lower than 15% of the overall RES based heat generation in 2012. As the figure illustrates, Europe hasn't achieved a significant 'breakthrough' in the RES based DH in spite ambitious targets set for 2020 in many member states (see chapter 3 for details). Only after 2008 is there a demonstrated increase in growth rates in RES heat, but it is still concentrated in individual heating. Figure 2 also suggests a preliminary hypothesis that the present incentive schemes for RES heat failed to induce faster innovation in the new technologies differing from the dominant solid biomass.

If we focus on the DH technologies of the individual member states (see Figure 3), we can observe the dominance of fossil fuels in general, and particularly of solid biomass in the RES based DH generation segment. Waste based DH generation – where a portion is assumed to be a renewable source (e.g. around 50% of the municipal waste) – represents a significant share in four countries: Germany, Denmark, France and Sweden. In Sweden geothermal is also a significant contributor to RES DH, but in the rest of the countries solid biomass represents a dominant RES DH technology with generally over 90% share of total RES DH production.

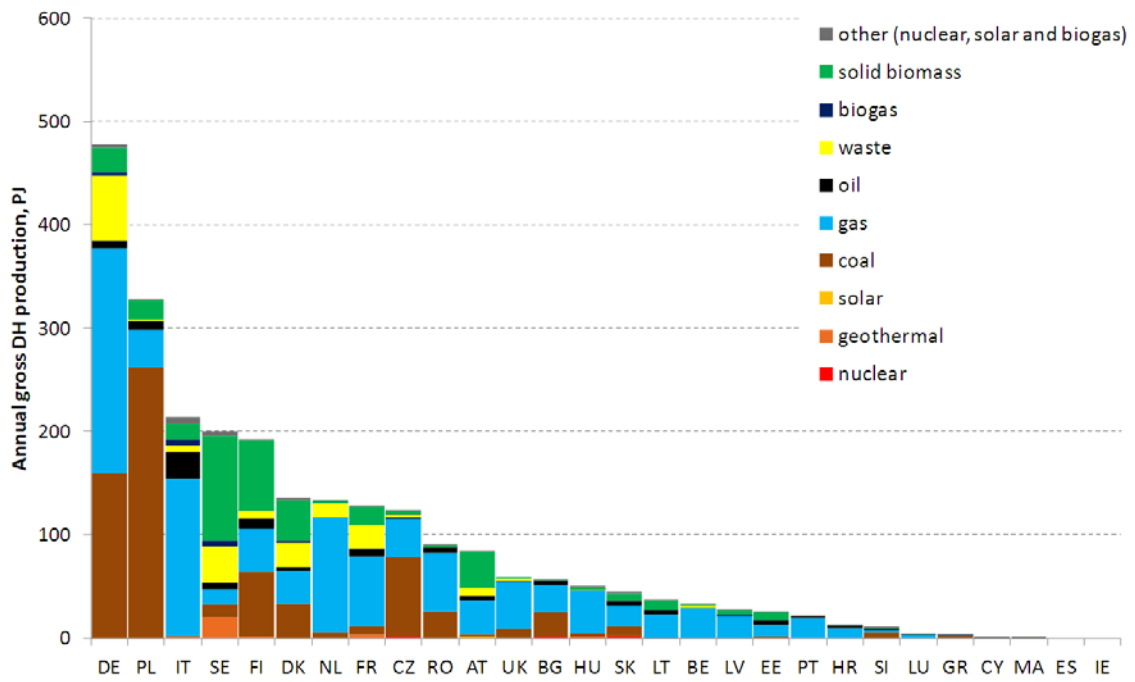


Figure 3 Technologies used in district heating in EU28, 2012; Source: Eurostat

3 Methodology

The assessment follows a three step approach moving from a European Union-wide assessment to individual DH case studies. We develop a stocktaking exercise, where we focus on the main characteristics of the present EU DH systems, concerning their situation in the overall heating sector, the relevant regulation, and main policy tools applied in their promotion. In this sense, we provide an overview of the overall DH sector – not only focusing on the RES based DH – as we think that EU countries presently have to increase efforts both in their overall DH framework (regulation, promotion) and in the RES based incentive schemes in order to build up a functioning and growing renewable DH market.

The three step approach is described in this section.

3.1 First step: EU level assessment

As the regulatory approaches of the MSs are very heterogeneous, and could also change within the different regions of the MS, in this section we assess the EU Member States' performance in the DH and DH RES field. We use Eurostat and Euroheat data for this assessment for the period of 2007-2012, which enables us to have an overview of development in the last 5 years.

This assessment focuses on the general DH market trends covering the demand and supply side developments, including the RES and waste based DH generation. Special attention will be paid to the role of CHP generation as well to the distribution losses, as it could be a determining factor to the competitiveness of the DH technology within the heat serving technology mix.

3.2 Second step: Country based assessment

As a second step, the DH heating markets of seven countries are assessed in detail, examining their regulatory framework (price regulation and legal provisions, regulatory bodies) support policies (production, investment support and tax credits) and their DH markets and technologies including RES and CHP in order to identify successful regulatory practices. Additional factors, including the availability of competing natural gas network and price competitiveness of DH based heating for the residential sector will also be explored.

The selection of the countries was based on a set of criteria, such as the size and the growth rate of the total DH market and RES based DH technologies. The planned growth rates in the RES DH according to NREAPs were also considered in the selection, and we tried to ensure a balanced geographical dispersion. The selection also covers the countries presently utilising significant DH-RES solutions:

- Austria
- Denmark
- Estonia
- Germany
- Hungary
- Poland
- Sweden

Germany and Poland represent the biggest DH markets in volume and also in the households connected to the network, while Sweden and Denmark are amongst the countries with the highest share of RES based DH, and at the same time they are amongst the countries where DH covers the highest share of the heating demand. Estonia, similar to the other Baltic States, has traditionally developed DH systems, facing challenges to maintain

a competitively priced DH network. Hungary is selected as a country from those new member states, where the past decade saw a shrinking DH market, but according to the NREAP of the country, significant growth in the RES based DH services is expected. Some new developments based on biomass and geothermal technologies took place in the past few years, where older fossil based systems were replaced by renewable technologies. Austria is an interesting choice, as it represents the dynamic development of the smaller scale biomass DH systems, interesting for the future development of the sector.

The following figure shows the ambitions of member states regarding RES DH utilisation. The countries selected for our case studies are indicated with bold lines. Poland is not included, as the Polish NREAP does not provide 2020 target number for RES based DH.

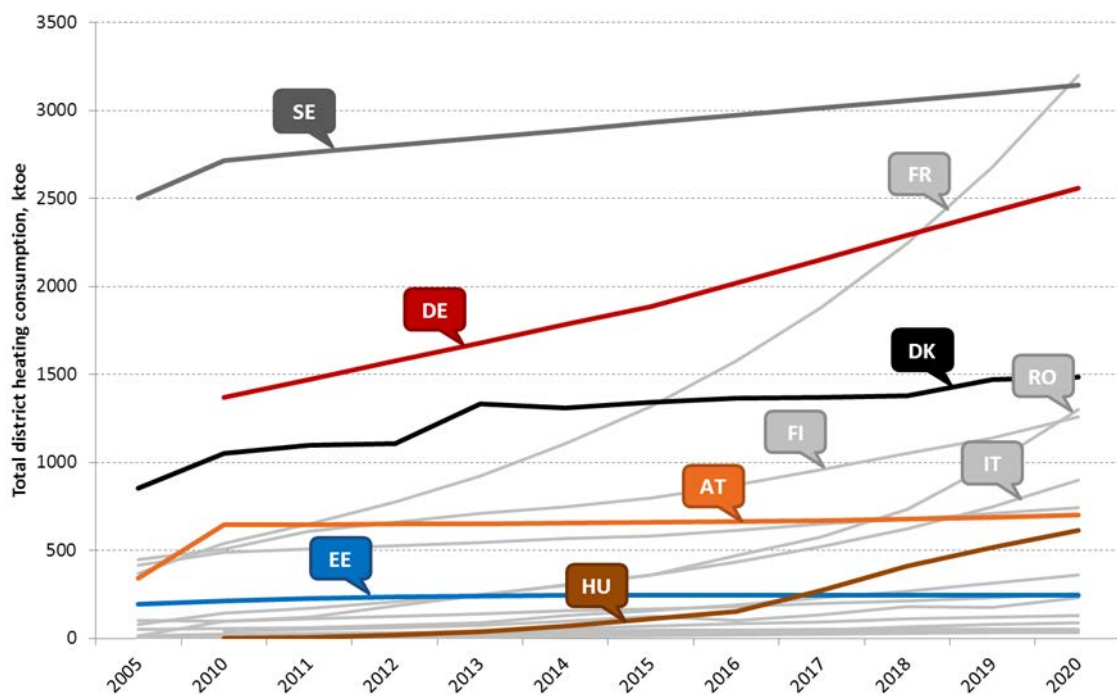


Figure 4 RES DH plans of EU member states; Source: NREAPs

3.3 Third step: case studies

In addition to the country studies four case studies of successful RES DH network expansion projects will be analysed. The selection will present successful strategies where higher number of households is connected to a DH system and/or to the conversion of existing DH systems from fossil to renewable base took place. The incentive schemes, regulation and the role of municipalities facilitating the realisation of the projects will be in the focus of the case studies. The case studies will be prepared on the basis of literature review and personal/telephone interviews.

3.4 Data Availability

Data collected with the same methodology is quite scarce on the European district heating systems, which makes it difficult to undertake a reliable European wide assessment. Eurostat provides data on the production and consumption side on a detailed level (detailed by fuel and technology), however any additional data on investment, installed capacity, prices, distribution network characteristics and details on consumers (heated

floor place, number of connected households) are absent. Euroheat provides this type of data in Europe and for some additional countries; however the Euroheat database is also limited in two dimensions. It provides data only for the years 2007, 2009 and 2011, and only 20 EU member countries are covered with many missing values, as the reporting is done on voluntary basis. Additionally, data suggests that country reporting is not consistent between the years; 2007 values differ to a great extent to the 2009 and 2011 values for many countries, which could be explained only by a different methodology.

This data issue means that this European wide assessment will be limited to the most important issues, which could be still analysed with the help of the available information:

- The general trend in DH developments: share of DH in total heat demand.
- Share of RES based DH in total DH. Are we on track to reach 2020 target of RES DH shares planned in NREAPs?
- Role of CHP in DH. Are RES and CHP competing technologies in DH?
- Which countries are the forerunners in DH developments? What can be said about their development? Is their development based on fossil fuel, CHP, or RES DH?

4 European Wide Assessment of DH Systems

The aim of this European wide assessment is to analyse the most important trends in the European DH systems. While in the assessment of the selected seven countries we will go into the details of the regulatory issues as well, this is meant to provide a wider snapshot only assessing the observable market trends in the last five to seven years on a quite aggregated scale, as the available information sources allow for it.

4.1 General trends in the EU28 DH sector

If we have a look at the final energy consumption of the district heating generated heat by sectors in the EU28, we can observe a mixed picture for 2007-2012.

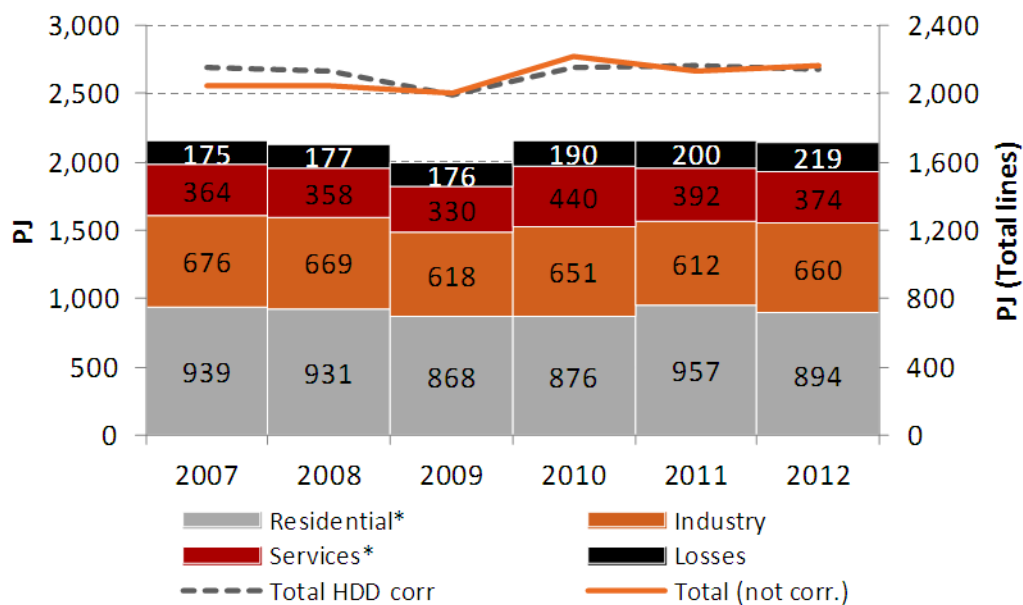


Figure 5 Final consumption of DH by sector, EU28; Source: Eurostat
*Corrected for heating degree days (HDD)

If we look at the final energy consumption by sector, we can observe that DH has a much higher market share in the residential sector. The final consumption of DH generated heat in the industry side remained rather constant, as value added in the sector also stagnated. The following figures show the DH consumption per unit of value added generated in the various industrial subsectors.

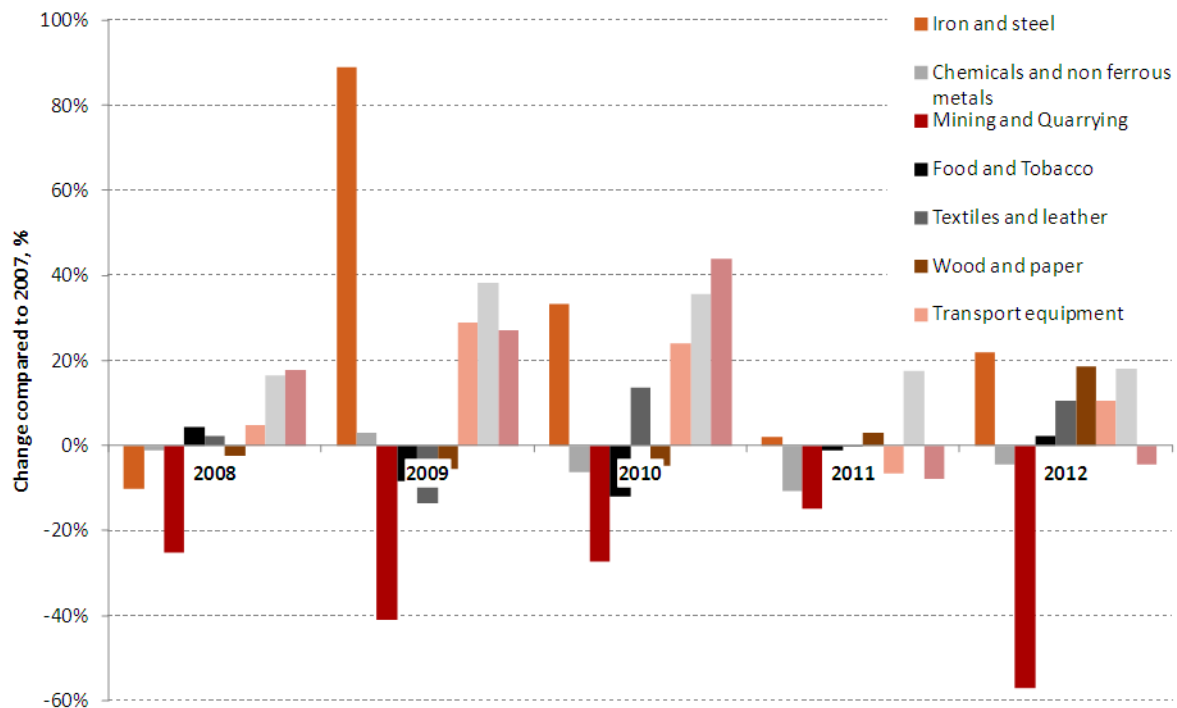


Figure 6 Change in district heating final consumption/unit of value added, EU28, 2007=100%; Source: Eurostat

If we have a look at the industrial subsectors in detail we can observe that the DH consumption per unit of value added fluctuated significantly between 2007 and 2012, but this fluctuation occurred even though there is very similar specific DH energy consumption in 2011 and 2007. It is interesting to see that the calculated specific DH energy consumption values changed significantly after the 2008 crisis, but the situation turned back to 'normal' by 2011 for most of the sectors, and harmonised growth began thereafter. The driver here was mainly a decrease in value added across sectors and the DH energy consumption was less volatile, as it did not show similar decline as the Value Added (VA). The only exception is the mining and quarrying sector, where the reduction in both VA and DH energy consumption occurred. Country-wise, only 8 out of the 28 countries managed to increase their DH share in the industry sector, accounting for an 83 PJ increase in these countries, out of which Germany alone accounts for 61 PJ.

Turning to the residential DH consumption, data on heated floor place is incomplete, as Euroheat only provides data for 9 EU countries for years 2007 and 2011. Their figures shows increasing floor space heated by DH (from 1483 to 1658 million m² for the nine EU countries), however with a very mixed picture of the countries included in their database. Sweden alone accounts for most of this increase (209 million m² increase), while many New Member states represent a decreasing trend (Hungary, Romania). Here the available information does not allow for a solid conclusion on the progress of the European wide DH market. The stagnating trend could be the result of the increasing number of heated floor space countered by the increasing energy efficiency of the buildings, but the less reliable information (only 9 countries report comparable values in the Euroheat database) makes this hypothesis rather uncertain. A more detailed look will be provided on the sectoral view of DH.

In summary European final consumption of district heating slightly increased in the 2007-2012 period due to the increasing consumption of residential and services, while the industrial consumption stagnated.

If we have a look at the supply side, we can observe an overall stagnation in the total heat energy produced for the EU 28 in the DH systems during the last five years (2457 PJ in 2012 from 2441 PJ in 2007); however, these values are not corrected for HDD. If this correction is made, DH shows a slightly decreasing trend (from 2660 PJ to 2303 PJ).

A clearer trend could be observed concerning the shares of the technologies covering DH demand in the EU28. Renewable based and waste based heat production is on a continuous growth trend in the EU for both direct and CHP based heat generation. RES heat and RES DH grew by 43% and 85% respectively in the last five years, while in the case of DH from waste and waste CHP the increase was 17% and 42% (without HDD correction, values are calculated from Eurostat data). A more mixed trend seems to emerge in the fossil based DH generation. While the fossil based DH generation shows stagnation, fossil based CHP heat generation decreases (see trend in Figure 7).

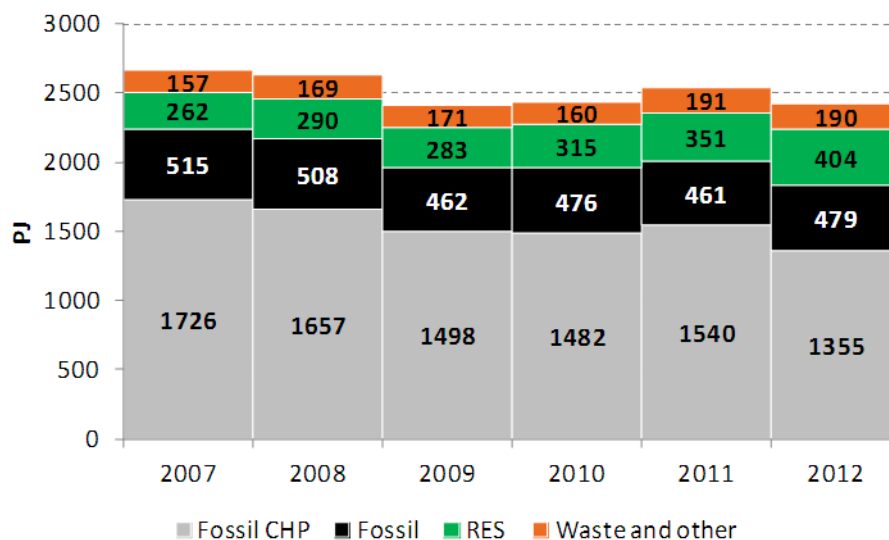


Figure 7 Overall trend in the EU 28 in DH technologies, heat production 2007-2012; Source: Eurostat 2014

This is quite unexpected, as CHP technology achieves higher overall efficiency in energy conversion, and the EU regulation also favours CHP based generation (efficient CHP and RES generation receive higher amounts of state investment support according to the EU regulation, and also periodic reporting is applied on the CHP generation, 2004/8/EC directive).

There could be many factors that can explain this unexpected trend. On the one hand, the increasing natural gas prices could reduce gas based CHP heat generation, as gas based electricity generation is also disadvantaged. On the other hand regulatory changes could also negatively affect fossil based CHP generation. This is the case in Hungary, where since 2010 natural gas based CHP generation is no longer an eligible technology for state support. Before 2010, CHP based electricity received generous FIT support even if it was fossil fuel based. The growing burden of the CHP FIT scheme resulted in an abrupt closure of the support scheme, resulting in turn in decreasing electricity and heat generation from gas based CHP.

The EUROSTAT database also shows that coal based CHP heat generation declined as well, which cannot be explained by fuel price change since EU coal prices have been decreasing. A more important factor in this case is the declining number of consumers connected to the DH network in countries like Romania and Bulgaria having high share of coal based DH generation. In addition, in these countries the energy efficiency of buildings is quite low, so significant improvements are possible, resulting in reduced heat demand. An important factor here is also the role of the ETS price in the reduction of coal based heat generation. Although the carbon price in the ETS was reduced to very low levels by 2012, which alone would not explain significant reductions in coal use, perhaps the longer term expectations concerning the carbon price dynamics could reduce investment in this technology for the long time horizon. However, the presently available information is not sufficient to quantify this impact.

The drivers of this reduction in CHP based heat generation will be observed in detail in the country assessments section in order to gain insight into this important trend. It is crucial to understand this phenomenon, as it goes

against the policy targets of the EU aiming to promote highly efficient CHP heat generation. Furthermore, the present trend shows a certain dysfunction in the heat market, as it seems that CHP production options are not utilized in spite these capacities exist and operational.

To get an overall picture of the individual member states (and not only on the selected 7 countries), changes in heat generation technologies (fossil renewable and waste based heat generation) are presented in the following figures between 2007 and 2012 in PJ values for all the EU 28 member states. In order to get a more clear-cut picture, the EU28 countries are presented in two groups, first countries with larger DH systems followed by countries with smaller sized systems.

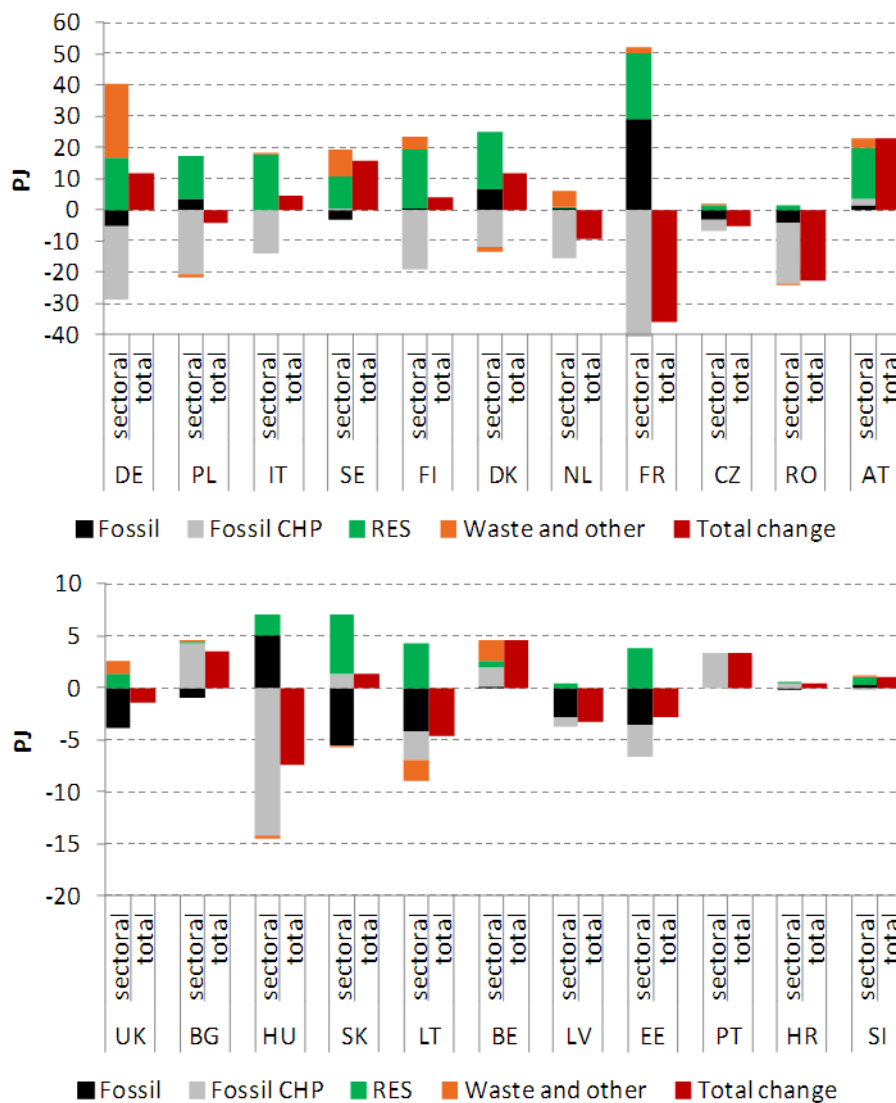


Figure 8 Fossil fuel based DH heat generation in the EU 28, Changes between 2007-2012, PJ; Source: Eurostat 2014

As Figure 8 shows, France, Denmark, Poland, Austria and Hungary showed increases in fossil based heat generation, while the rest of the countries experienced contraction. More surprising is the sharp reduction in fossil based CHP production. France shows the highest cut in fossil based CHP heat generation, and amongst the smaller sized systems this occurred in Hungary. An interesting pattern is demonstrated in France, Denmark and Hungary, where the two fossil based technology category moves in opposite directions. France is probably the most unusual case in this sense, as it accounts for more than a third of the reduction in CHP based generation in the EU28, and it has the highest growth in heat only generation. As data shows district heating generation was reduced in France in the assessed 5 years by more than 60% (by 100 PJ), and at the same time RES based

heat generation increased significantly. The figure illustrates that both changes were counterbalanced by a significant decrease in the fossil based CHP generation. Probably the most important driver in the sharp reduction in fossil based CHP was the drop in wholesale price in most of the EU electricity markets, which dragged down the use of fossil based electricity and CHP production. This trend however could be reversed if electricity market trends change and a more significant recovery takes place in Europe. In Central and Eastern Europe a more competitive gas pricing system could also reverse the present trend.

Waste incineration also increased in the EU as illustrated in Figure 8. Although significant achievements were realised in this field, the growth was focused in four countries: Germany, the Netherlands, Finland and Sweden. While in Germany both direct and CHP waste incineration increased, the Netherlands and Sweden show a more mixed picture; they saw their direct waste incineration being reduced in the observed five years, counterbalanced by the high increase in CHP based waste incineration.

RES based heat generation gained significant market share during the last five year within the EU both in non-CHP and CHP based categories. The growth in the CHP technology was more pronounced, having over 110 PJ increase in the EU28, where Finland, Denmark, France, Poland, Italy, Germany and Austria were the drivers of these developments. Although amongst the new member states only Poland reached a sizeable increase in absolute terms, Slovakia, Lithuania and Estonia made significant increases in RES based heat production. Most new member states managed to more than double their RES based heat generation in the observed five year period, with CHP based generation being the motor of the growth (see annex). Due to the size effect and the low base year values, their increase have been contributing less to the overall RES score, but it can be a signal that significant development in RES based DH generation has also started in these countries as well.

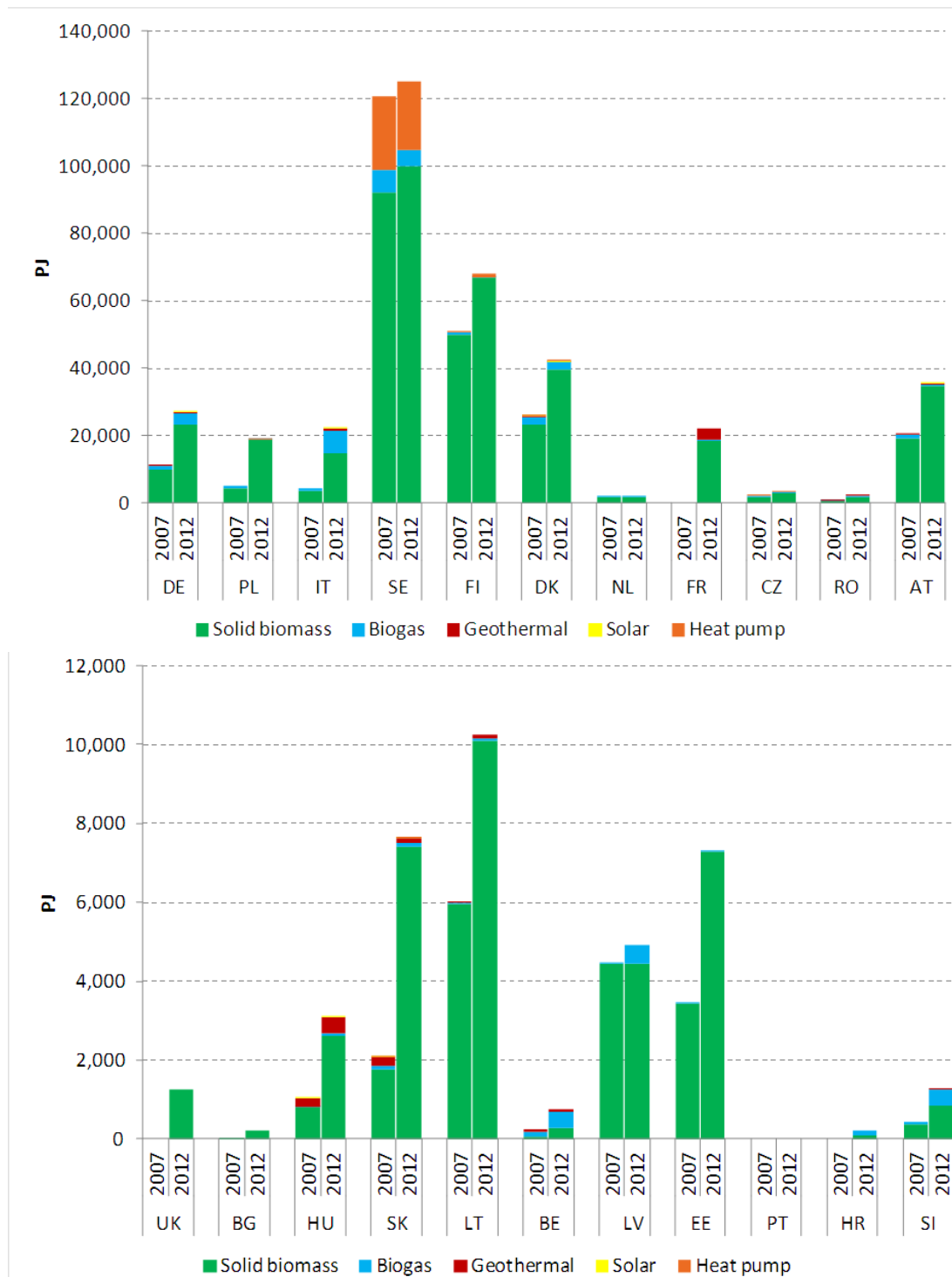


Figure 9 RES based heat generation in the EU 28, 2007 and 2012, Source: Eurostat 2014, First column: 2007, second column: 2012

As Figure 9 illustrates, RES based heat production is dominated by solid biomass in all member states, having usually more than a 90% share. Apart from this, Slovenia, Belgium, Latvia and Italy managed to increase their biogas heat production, while Hungary and France had sizeable increases in geothermal.

The previously highlighted trends in CHP based DH generation has important policy implications.

Most importantly, it highlights the need for an integrated policy approach to the electricity and heat markets. The observed trends in the EU28 suggest that the declining wholesale electricity prices, together with the pres-

ently applied support to RES electricity, would in many case negatively affect fossil fuel based (mainly natural gas) CHP generation, as the overall efficiency gain in CHP generation would not be sufficient to generate competitively priced electricity and heat. In many member states the outcome in this type of situation was significantly reduced CHP generation, where residual heat demand (left after using all RES and waste heat options) was satisfied with heat only plants. This situation, however, if sustained for a prolonged period would result in significant 'system' losses due to the lower total energy efficiency of direct heat generation. Using heat only plants to satisfy heat demand might be the lowest cost option in the heat market alone, but in an integrated electricity-heat market view it would result in wasting CHP higher efficiency potential.

4.2 Distribution losses

As data shows (see country assessments), the cost level of district heating and individual gas heating are usually very close to each other, so losses occurring during the transmission of heat are a very important factor determining the competitiveness of the district heating sector.

Additionally, according to Eurostat data energy losses in the DH systems show high variance amongst member states. Some countries (like Denmark) have distribution losses close to 20%, while other countries like Sweden can operate with close to 4 % losses in their DH systems, in spite of both countries having a very high penetration of district heating (61% vs 45% citizens use DH in the two countries). This fluctuation could also be caused by the higher share of the residential sector, but data does not support this relationship either.

This high variation underlines the importance of managing system losses, as alone it can determine the competitiveness of the DH system.

Although many factors determine the loss in the DH system (e.g. the age and length of the pipelines, their insulation, the density of cities served) increasing the population served with DH heating would have a significant negative impact on losses. New housing structures would probably be situated in less densely populated areas, so new connections usually increase the length of the pipelines required to serve them.

Figure 10 illustrates this relationship: residential DH systems with a more concentrated nature (more TJ served per km of pipeline length) are usually characterised with smaller losses. Finland and Sweden are exceptions to this rule, as their DH systems show a lower level of losses, in spite of the less concentrated DH systems. Italy is also an exception; however their reported loss level of close to zero is questionable.

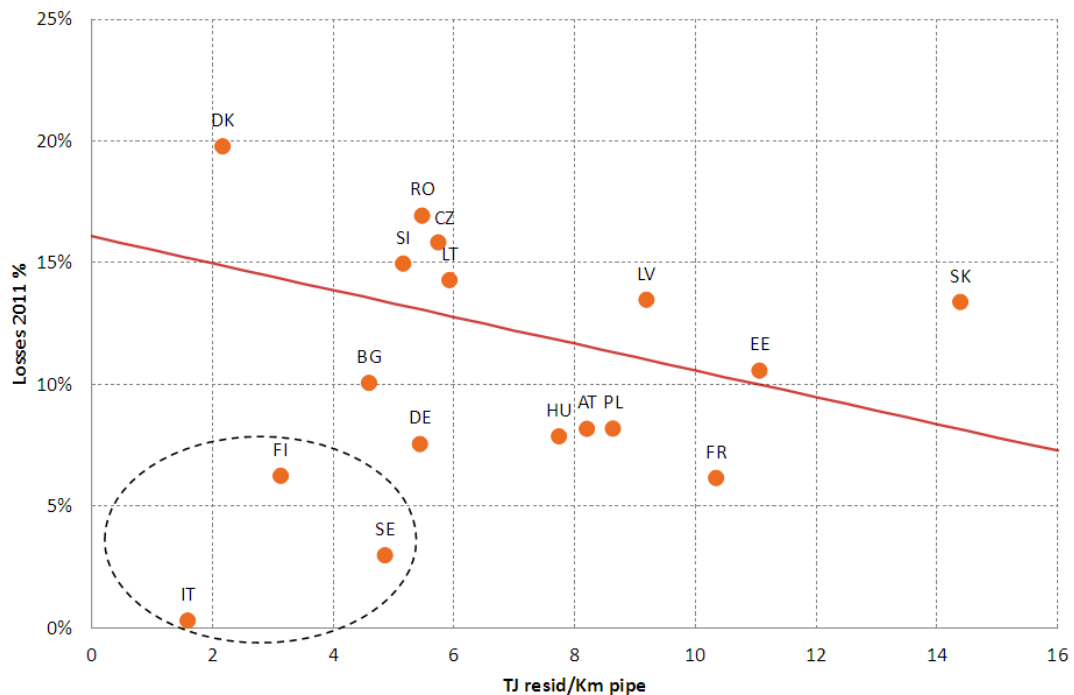


Figure 10 DH system pipeline utilisation vs distribution losses, 2011; Source: Eurostat, Euroheat

As Figure 10 illustrates, DH systems with similar pipeline utilization factors TJ of residential heat served/km of pipeline could have very diverse distribution loss values. A valid question is whether this could be explained by technological solutions (age and quality of insulation of pipelines), if it is due to the difference of the data collection methodology, or the regulation (how the losses are accounted for, and who pays for it?) but data availability does not allow such an assessment.

The importance of the distribution losses could also be highlighted with the following example from Sweden. An extensive analysis of the heating cost of various technologies in the period 1970-2010 revealed that until 2005 DH in Sweden was characterized by a higher heat cost than the main alternative of heating oil. To maintain the expansion of the Swedish DH system, heating oil was targeted for extra energy taxes and in the 90's an extra CO₂ tax was also introduced, resulting in some social cost for the user of the heating systems. Werner estimated for the period of 1980-2008, that the additional social cost of using DH in Sweden was 10% compared to the alternative use of imported fuel oil (around 44 billion SEK, or 40 SEK/MWh energy consumed). Since 2005 the cost of DH is competitive even without the CO₂ and energy taxes on heating oil, due to the significant price increase of oil, as the Figure 11 illustrates.

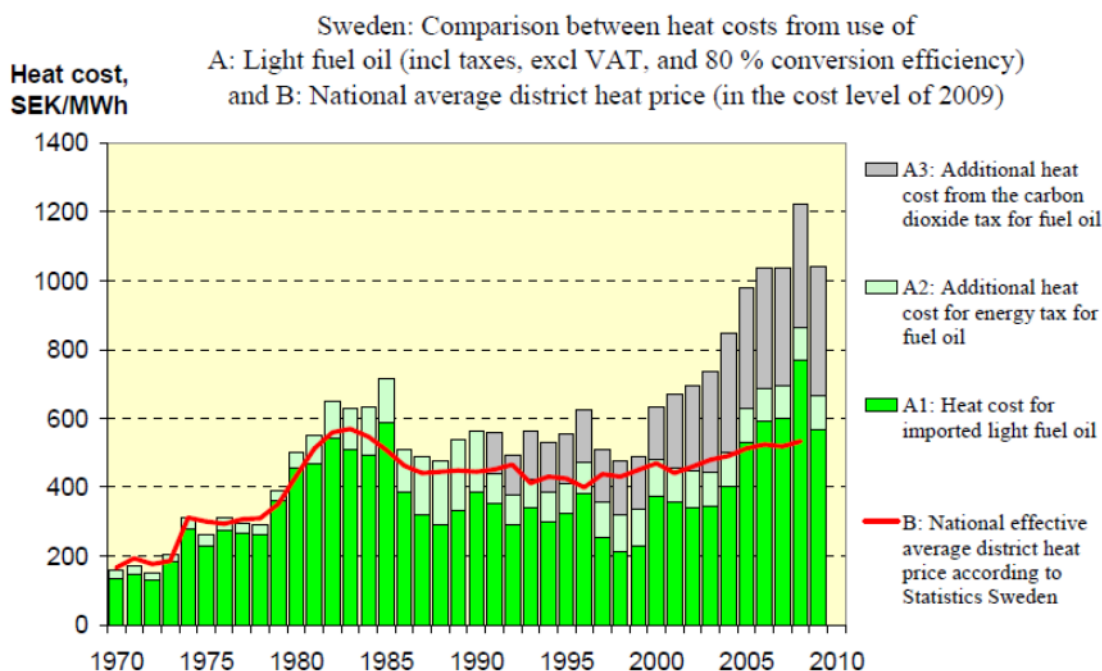


Figure 11 Swedish heating costs, 1970-2009; Source: Werner, 2012

If the distribution losses in Sweden would stay at the Danish 20% level, it could be assumed that the DH cost would remain above the cost of the alternative heating mode without the extra taxes, which would further increase the social cost of the system. The figure also raises the question of what the quality of the Swedish DH system would be without the strong and continuous policy support to encourage DH and what the longer term social cost of such policy is. It can be reasonably assumed that left to competitive market forces the Swedish DH system would not exist as it does today and would not be able to generate positive social benefit effects from 2005, when the cost imported fuel oil (without taxes) finally exceeded that of DH.

4.3 NREAP target: where do MSs stand?

Most EU member states had set targets for renewable district heating in their NREAPs. The following table illustrates where they are positioned concerning their RES based district heating in 2012, where they were planned to be in 2012, and 2020 targets according to their NREAPs.

Table 1 EU28 RES based DH targets, 2012 actual values and various indices

	2008	2012	2012	Performance 2008-2012	2020	2012 Achievement	Progress Index	Ambition
	Actual TJ	Actual TJ	NREAP TJ	*	NREAP TJ	2012 actual/ 2020 NREAP	(2020-2008)/ 12*4/ 2012 Actual	2020 NREAP/ total DH heat demand 2011
AT	24 152	35 291	27 214	++	29 391	1.20	136%	13%
BE	588	812	959	-	1 419	0.57	94%	1%
BG	110	199	586	--	3 810	0.05	15%	5%
CY	0	31	na	na	na	na	na	na
CZ	2 157	3 413	9 881	--	14 738	0.23	54%	7%
DE	12 079	26 836	65 984	--	107 182	0.25	61%	5%
DK	25 215	42 265	46 264	-	62 216	0.68	113%	40%
EE	3 318	7 492	9 839	-	10 383	0.72	132%	26%
ES	0	0	243	--	1 616	0.00	0%	0.3%
FI	54 495	69 713	27 633	++	52 754	1.32	129%	30%
FR	0	21 440	32 448	--	133 978	0.16	48%	10%
GR	0	2	na	na	na	na	na	na
HR	0	213	na	na	na	na	na	na
HU	1 067	2 920	754	++	25 665	0.11	32%	12%
IE	0	0	1 214	--	5 485	0.00	0%	6%
IT	4 477	21 827	8 709	++	37 681	0.58	140%	3%
LT	6 899	10 184	1 382	++	2 135	4.77	192%	4%
LU	65	129	419	--	1 997	0.06	18%	na
LV	4 233	5 042	5 192	-	10 760	0.47	79%	21%
MT	0	7	na	na	na	na	na	na
NL	1 590	1 992	22 106	--	31 192	0.06	17%	9%
PL	6 340	19 553	na	na	na	na	na	na
PT	0	0	na	na	na	na	na	na
RO	814	2 122	7 871	--	54 428	0.04	11%	19%
SE	116 094	127 241	117 314	+	131 507	0.97	105%	57%
SI	519	1 240	1 005	+	2 010	0.62	122%	5%
SK	2 223	7 443	3 098	++	15 072	0.49	114%	20%
UK	46	1 349	2 596	--	9 630	0.14	42%	1%
Total	266 481	408 756	392 709	+	745 049	0.55	96%	8%

*key

- ++ above 125%
- + between 100-125%
- between 75-100%
- below 75%

Amongst the EU28 three countries (AT, FI, LT) have already achieved their 2020 RES DH targets in 2012. Five additional countries (IT, HU, SE, SI, SK) are also above their targets set for the year 2012 in their NREAPs, and

Sweden is not far from its 2020 RES DH target level. The rest of the countries have to increase the rate of RES DH shares to achieve their targets, where the highest gap in absolute term could be observed for Germany and France. Hungary and Romania also need to speed up their RES DH developments in the coming years to achieve their ambitious NREAP targets for DH.

In order to capture with more precision the ambitiousness and the achievements of the EU countries, we have created two indicators to measure these properties. 'Ambitiousness' is measured as the 2020 RES DH target (in TJ) divided by the total residential heat demand in the country for 2011. In this way we measure how much of the heat demand is aimed to be covered by RES DH in a country, so we are scaling the target to the heat market size of the country. The achievement of the country is measured as the progress toward the 2020 RES DH targets of the countries, if they had followed a linear trend. It is first calculated where they should be in 2012 on this linear realization path, and then this value is compared to the actual 2012 value. At the 100% line countries are at the right speed, while smaller values indicate that they should increase their speed to achieve the targets. As a reference, the EU stands at 96% at this indicator (Index% on Figure 12), while in the ambition level the EU value stands at 9%. Another, more simple indicator is also calculated, where the 2012 SH share is measured over the 2020 NREAP target (2012 Achievement, 7th column). The Progress and the Ambition indicators are shown in Figure 12.

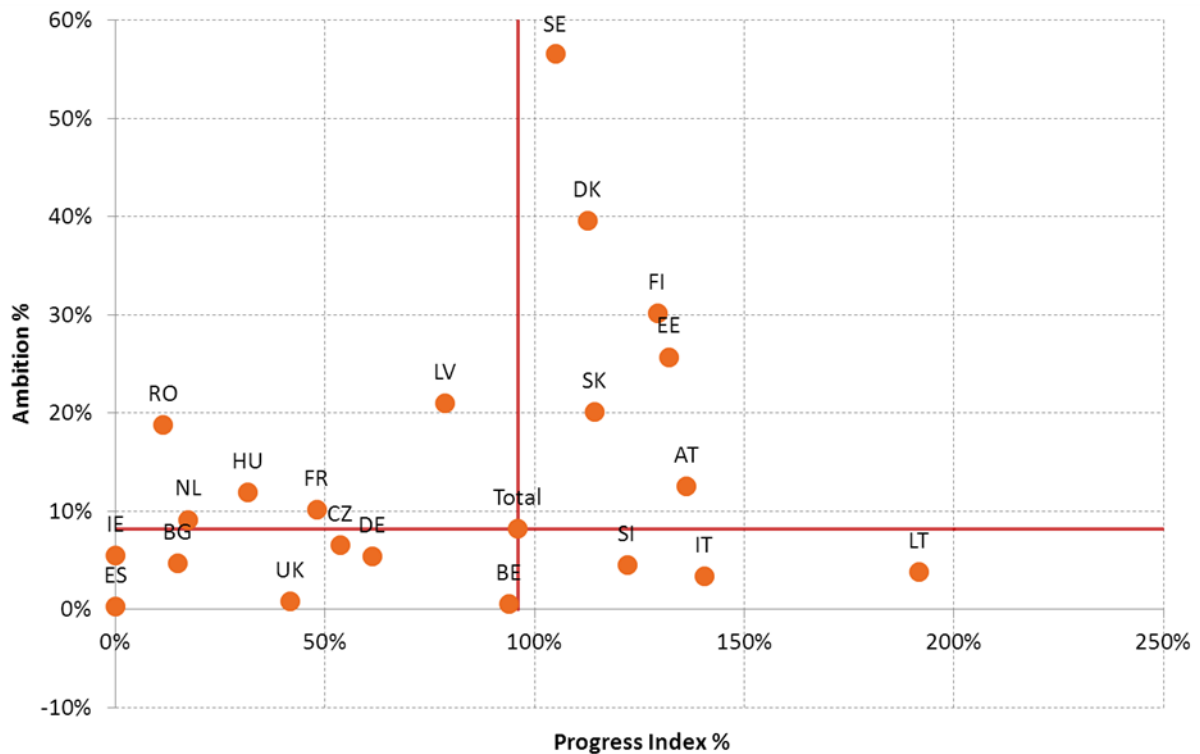


Figure 12 Achievements and ambitions of the EU member states in RES DH; Source: Eurostat 2014, own calculations

The figure shows that countries with already sizeable DH RES are more ambitious (SE, DK, FI, EE, SK, LV, AT – forerunners in RES DH) having higher than 20 % RES DH targets in their heating demand (with the exception of Austria, having only a 13% ambition level while Latvia is lagging a bit behind its target realisation), with most countries settling below this level. At the same time this group of countries performs well in achieving their 2012 target levels. Romania, Hungary, the Netherlands and France are in another group, having rather ambitious targets but lagging behind in their time-proportional achievements. They seek to achieve between 10-20 % RES DH share in the total heating demand by 2020, but they remain at only 50% of their 2012 target (linear achievement path assumed). Three exceptions are Slovenia, Italy and Lithuania, showing faster speed in achieving their 2020 targets in the period 2008-2012 (also measured on the linear path). These three countries

achieved higher growth in their RES DH in the period 2008-2012, beyond their NREAP 2012 targets would have been required, but their 2020 targets are less ambitious if measured as share of total heat consumption. The next group of countries, Germany and the Czech Republic show a more balanced performance, having smaller levels in the ambition index for the 2020 targets and in their achievements in RES deployment showing smaller aspiration levels. In the final group – UK, BG, IE and ES – there must be accelerated RES DH deployment in order for them to achieve even their less ambitious targets.

4.4 RES vs. CHP based district heating – competing or complementary solutions?

Modern district heating systems are characterised by high shares of CHP based heat generation and/or by high share of RES based heat generation, that can be both CHP and non-CHP heat based. It is interesting to see the path of development of EU member countries' DH systems, particularly their choices between RES based heat generation, higher efficiency CHP production, or a mix of the two.

Figure 13 illustrates the renewable shares of the various DH systems in Europe versus the DH share in total residential heat consumption in 2011. This value shows how developed the DH system in the given country. The red dotted lines indicate the EU28 average values.

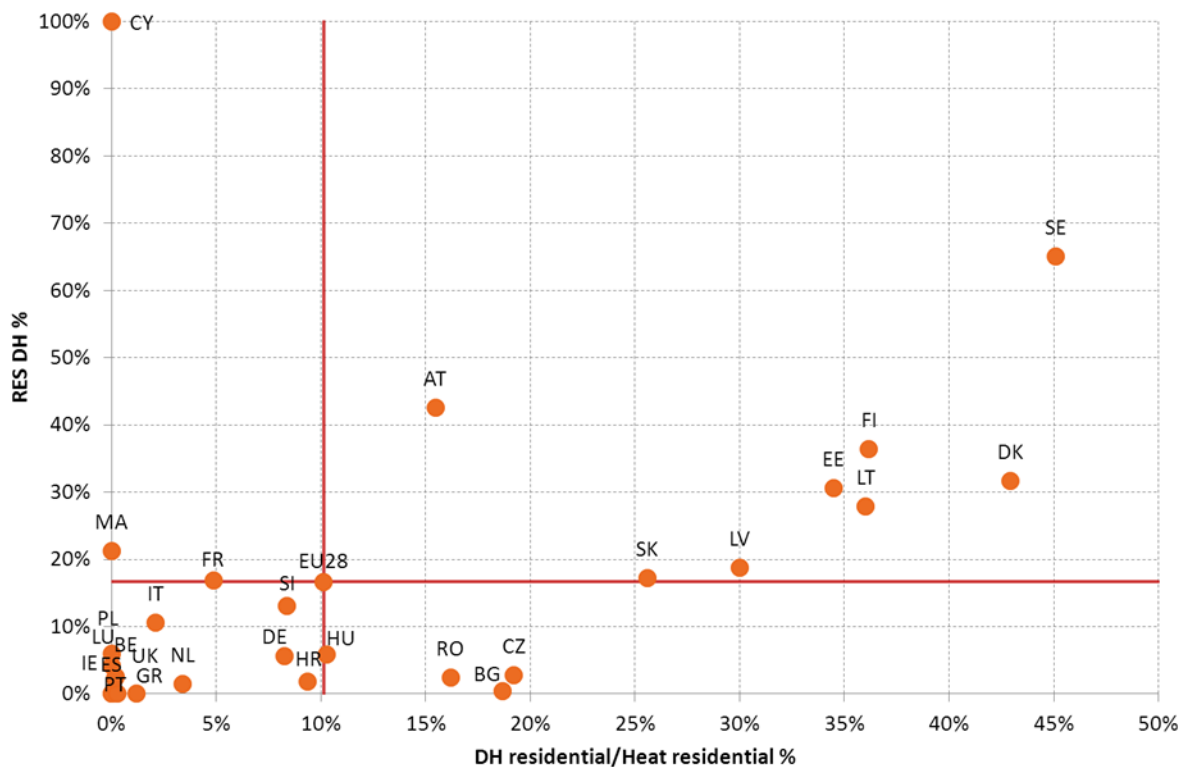


Figure 13 DH penetration vs RES DH share in the EU28, 2011; Source: Eurostat, Odysee-Mure data, own calculations

Note: Malta and Cyprus has some industrial DH use, which is partly renewable

Figure 13 illustrates that the highest RES DH shares are in the countries with high DH penetration in the heating systems. Countries with lower level DH penetration (under the EU28 average) generally show lower level RES penetration as well. Low and median level DH penetration countries (under 20 % in the residential segment) have below average RES shares, with the exception of Austria having over 40% RES penetration. The exceptions

are the Malta and Cyprus islands and France, with higher shares of RES than the EU average (France actually equals the EU average), while the DH shares are lower than the EU average. The group of the Baltic countries together with Slovakia belong to the leader countries of DH (SE, DK and FI) having a higher share of residential DH and at the same time higher than average shares of RES in their generation.

A natural question is whether higher RES shares correlate to lower CHP penetration levels, in other words do countries specialise in either RES technologies or in CHP technologies in their DH systems?

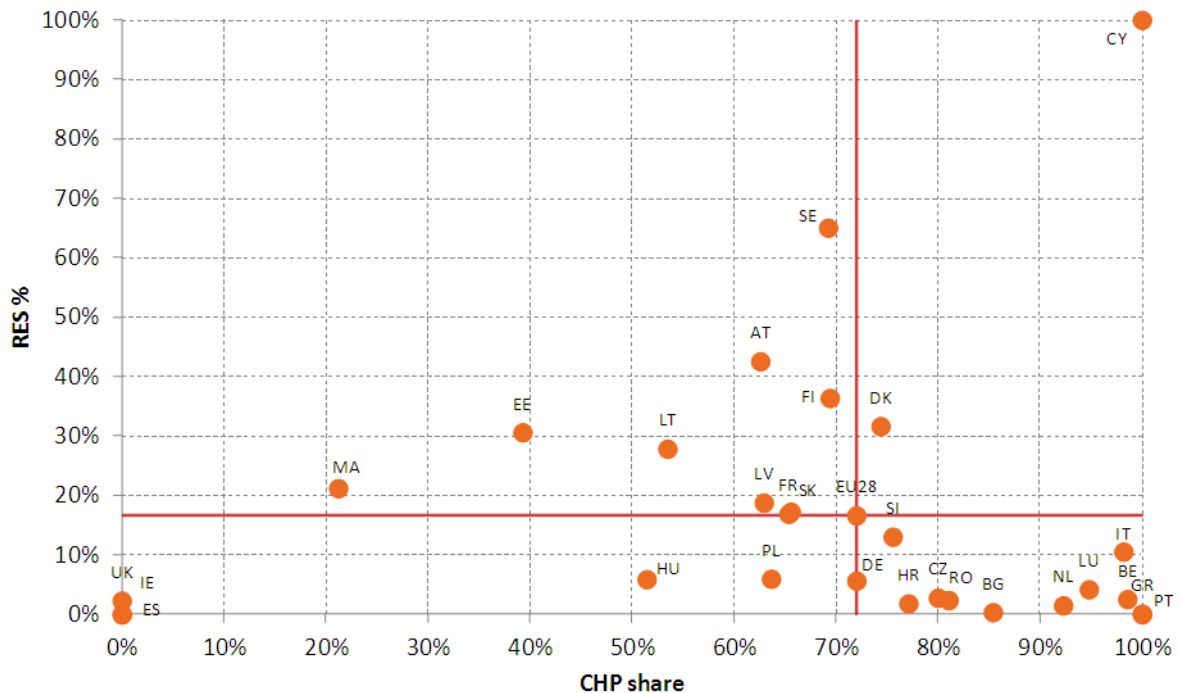


Figure 14 CHP vs RES share in EU 28; Source: Eurostat

As Figure 14 illustrates, there are certain clusters amongst EU28 countries concerning the relationship between RES and CHP based district heating. Some countries mainly specialise in CHP DH generation (CR, CZ, RO, BG, NL, LU, BE, GR, IT) having CHP shares above 80 % in their district heating systems, based mainly on fossil fuels. Other countries (LT, AT, FI, DK, SE) with a higher share of RES have still high ratios of CHP, between 50% and 80%. This shows that significant CHP shares could be complemented with higher shares of RES, but this is not always the case. Higher shares of RES and CHP based DH is characteristic of those countries with higher level of DH penetration.

5 Main Trends in DH Markets Derived from Country Case Studies

This section describes the main characteristics and trends in DH markets that are derived from the seven country case studies. It is structured in the following manner: after the general DH market trends we focus on the renewable based DH generation. Then we compare some economic indicators on the seven selected countries and the regulatory framework of the DH systems.

5.1 General overview of DH market

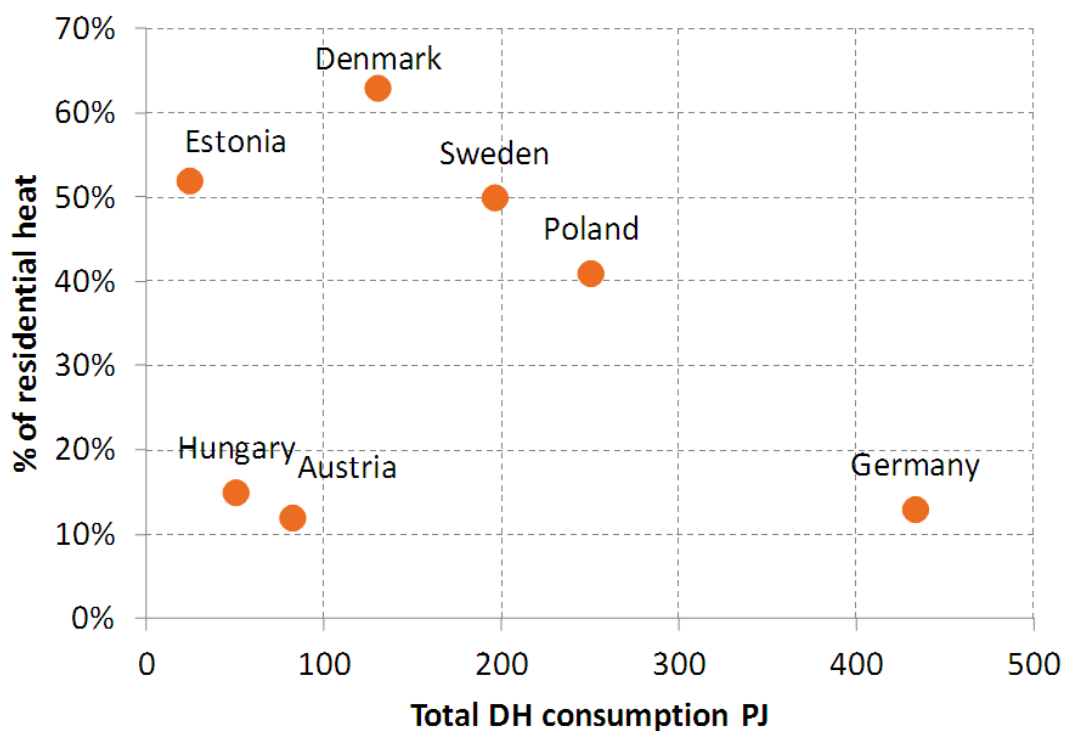


Figure 15 Heat market size; Source: Eurostat

District heating represents high shares in the residential sector in Denmark, Estonia, Sweden and Poland, all above 40%, while in Hungary, Germany and Austria DH is limited to the range of 12-15%. Amongst the sectors residential consumption is dominant in all countries, generally above 50%. Industrial use is less significant, only in Hungary it reaches 31%, while in the rest of the countries it is below 20%.

Table 2 General characteristics of the DH system

	Austria	Denmark	Estonia	Germany	Hungary	Poland	Sweden
% of CHP	63%	73%	40%	70%	51%	63%	50%
Average annual growth rate of DH consumption in past 10 years	4,6%	0,4%	0,01%	0,12%	-3,16%	-2,12%	1,02%
Length of DH network (km)	4376	30288	1450	20151	2138	19621	22800
DH sector shares % (residential, services, industry)	41%, 36%, 14%	60%, 35%, 5%	60%, 20%, 20%	47%, 35%, 18%	54%, 15%, 31%	72%, 16%, 12%	61%, 30%, 9%

Source: Eurostat, Euroheat

In the past ten years, a sizeable annual growth rate was achieved in total DH consumption in Denmark (4.6%) and Sweden (1%). Poland, despite managing to increase the number of connected flats, saw a significant reduction in residential heat consumption, mainly due to energy efficiency programs that improved the energy consumption of refurbished flats. Poland faces an extra challenge in its DH system because nearly 80% of the DH is based on coal, and upcoming changes in the EU ETS for the post 2020 period will have significant impact on the sector as DH generators are gradually incorporated into the system. This will deteriorate the economic performance of the DH plants, but will likely lead to a push for more RES based heat generation. In Hungary, the DH growth trend is even more negative, but this is partially due to a decrease in the connectivity of new flats. Denmark has been able to maintain slight growth in spite its already high level of DH penetration, while Estonia and Germany have stagnating DH consumption.

The supply-side contribution of CHP varies between 40% and 73%, with Germany and Denmark showing the highest rates. Dampened electricity demand since the economic crisis has been a major factor in the drop in CHP in many EU member states, a trend which is going against the energy policy targets of the EU. In Poland CHP generation benefits from tradable certificates for the heat generated from renewable or highly efficient CHP platforms, which generates additional income for the DH CHP units. This could be one reason why in Poland the CHP share did not show the declining trend observable in the rest of the countries.

5.2 RES and waste based DH

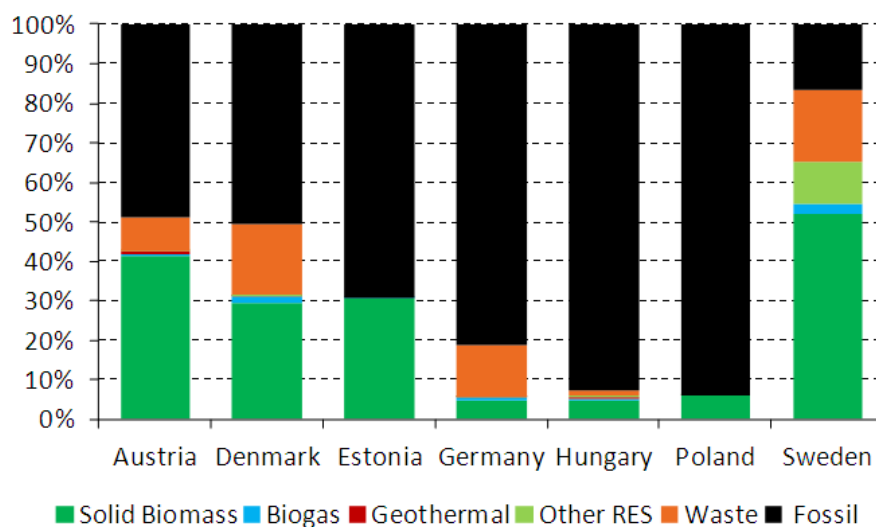


Figure 16 Shares of RES and waste based DH in total DH, 2012; Source: Eurostat

The DH systems of the selected countries represent a wide range of RES in their portfolio, ranging from 6% to 65%. In all countries the significant increase in RES based DH production was reached in the last five years. In Sweden, the share of RES did not change significantly since it increased at a similar rate to DH production itself.

Solid biomass dominates RES based district heating in all countries, sitting above 80%. Geothermal heat production is significant in Hungary, while Sweden has high share of heat pump for space heating. In Austria a significant part of RES growth comes from the small-scale biomass systems (Nähwarme systems), generally based on local or regional biomass production. In Poland a high share of biomass is used in coal plants utilising the co-firing capability. According to the present proposal on RES regulation, this option will receive less support in the future, which will probably prevent further expansion of this technical option.

In waste based heat generation the selected countries show a polarised picture, with new member states having a low share close to zero in waste based heat generation, while the rest of the countries have significant and increasing shares.

Sweden shows the highest ratio in RES based DH generation, and together with waste based generation they account for 83% of district heating. The main drivers for this high ratio were the heavy taxation of fossil fuels (a carbon tax was introduced as early as 1991), the limited availability of natural gas (as network was only developed in some parts of southern Sweden) and the prohibition of landfilling of combustible waste since 2002.

5.3 Economic indicators

Table 3 Selected economic indicators of the DH systems

	Austria	Denmark	Estonia	Germany	Hungary	Poland	Sweden
Price competitiveness of DH (yearly average heating cost for households) Eur / GJ, without VAT, 2011 ¹	DH: 2nd cheapest after gas (2318 Eur/flat) (13.96 Eur/GJ)	(2100 EUR/year) 27.8 Eur/GJ	15.4 EUR/GJ	20.28 Eur/GJ	competing with individual gas heating, high regional differences (600-1100 EUR/year) 9.6 Eur/GJ	DH: 2nd cheapest after coal/fuelwood individual (10.7 Eur/GJ)	20.6 Eur/GJ
% of losses	8.20%	20%	10.60%	8%	7.9%	12.60%	4%
Third Party Access (TPA)	Yes	Yes	tendering procedure: the cheapest option is selected	Yes	tendering procedure: the cheapest option is selected (not frequently applied)	Yes, but limited application	Under consideration

Source: REKK

DH is mainly competing with individual gas heating in the selected countries, but DH is usually amongst the two cheapest options for residential heating. Poland is an exception, where coal and firewood are the cheapest heating option for residential, but its application in more densely populated areas is limited. It is also important to note that the cost of DH and individual gas heating usually stays close to each other, which means that regulatory tools and policies affecting their costs can influence the decision on the selection between them.

In this sense even the level of distribution losses can make a significant difference. Amongst the seven countries, losses are ranging between 4-20%, showing a very large spread. The 20% loss data for Denmark stand out but is difficult to explain. The statistical meaning of losses in Denmark probably differs from other countries - in Sweden, with similar share of residential coverage and high renewable share, the loss is much lower.

The application of Third Party Access principle (TPA)² in the DH systems is quite abstract in these countries, as real competition between the various producers is quite limited due to technical realities: in many locations there is only one supplier of heat. But generally, where it is possible to have more sources of heat, access is allowed for more producers. A more conventional approach is followed in Estonia and Hungary, where access to the DH distribution network is ensured through a periodical tendering procedure, where the best offer from the heat producers is accepted for a prolonged period. This is usually carried out when previous supply contracts terminate, so in a rather infrequent manner. In Sweden TPA is only under consideration, where it has already been investigated and the final proposal of the Energy Market Inspectorate was to allow for TPA in the DH systems.

¹ Based on average efficiency gas central heating, and on the latest available Household end user prices, including taxes.

² TPA means, that the owners of DH pipelines have to give access to other, competing heat producers at a pre-determined access price, if they wish to sell heat to end users

5.4 Regulatory environment of DH

Table 4 Regulatory characteristics of the DH systems

	Austria	Denmark	Estonia	Germany	Hungary	Poland	Sweden
Type of price regulation (liberalised, cost plus, benchmarking, ability to pay)	Most widespread is cost-plus regulation by municipalities	Cost-plus	Price cap, for both producers and end users	Liberalised	Cost plus, ability to pay is also taken into account, prices set for producers and residential consumers	Cost plus, planned to be replaced by an ex post tariff control.	Liberalised
Responsible authority	Municipalities, competition authority monitors	Regulator	Competition Authority is price regulator	-	Energy Regulator	Regional ERO; under 5 MW: municipalities	Supervision by Energy Market Inspectorate
Length of regulatory period	no	Yearly corrections of prices	3 years	no	1 year (practice, not set legally)		no
Legal obligations (DH zones, connections)	no	Obligation to connect to DH, in designated zones	compulsory use of DH in designated zones, only exemption is if RES used	Optional, municipalities can decide on it	No, disconnection is allowed	Obligation on DH companies to connect customers free of charge (with conditions)	Automatic DH connections during municipal housing programs
Ownership structure	90% publicly owned (municipalities)	Public (60% by heat sales) and consumer-owned (35%)	Private ownership dominated	Private ownership dominated	Private and municipal ownership	60% municipal or state owned, 40% private	Private ownership dominated

Source: REKK

Price regulation of DH mostly follows the general regulatory approach of the individual electricity market regulation of the respective countries: in Germany and Sweden the DH regulation reflects the liberalised electricity markets, which means that DH heat providers can set their prices freely on the market. Poland and Hungary follow the cost-plus regulation in their DH systems, entailing that a price regulatory authority determines what are the justified costs of DH production and services, and sets the heat tariffs of consumers on a level to cover these costs and a reasonable return on the investments. Estonia follows the price cap system also applied in its electricity markets, meaning that a reasonable maximum level of prices are set for the DH services, where the service provider cannot charge higher rates to consumers. In Austria the frequently applied methodology is cost-plus price regulation of the municipalities, so in this case the DH market regulation does not follow the electricity market's regulatory method. The other difference appears in Denmark, where the DH regulation is based on the cost-plus method, which is different from the electricity market.

Additional elements in the regulations are the use of legal obligations that impose compulsory connection to the DH network in special designated areas. This approach is widely used, particularly in Denmark and Estonia as well as in Germany where the national legislation applied to DH also allows for it. However in Germany the imposition of this obligation is in the hand of the municipalities, and its application in Germany is only applicable in some municipalities' heat regulations. Denmark has not only introduced compulsory DH zones, but it also prohibits certain heating technologies (electric heating, oil boilers) in new installations. While Sweden does not impose legal obligations, during the 80's when municipalities were promoting sizeable building programs, the newly constructed flats were automatically connected to DH networks, designed to push the early expansion of the DH systems.

The Polish approach is unique in that DH suppliers have to connect consumers to their network free of charge. In Hungary designated zones are non-existent, and in addition flats connected to existing DH networks can be disconnected from the network upon the request of the owner if it is technically feasible. This provision was exercised by DH consumers quite frequently in the countryside and contributed to the contraction of the DH market.

Ownership structure in the assessed countries is mixed. In Denmark public ownership is fairly ubiquitous, while smaller sized systems are in hands of cooperatives. This ownership structure enables the operation of DH systems on non-profit basis; only the operation cost and the long term investments are allowed to be recovered from the regulated prices. This contributes to limiting price pressure in the DH systems, as public and cooperative ownership reduces profit expectations. However this approach is difficult to copy in other countries, as it requires the underlying Danish business culture as well. The dominance of public ownership in many Eastern European countries failed to work, as under heavy pressure to achieve price reductions companies failed to maintain the equipment and network on the necessary level, resulting in deteriorating service quality. In Germany and in the new member states private ownership is the dominant structure, however with significant differences. In Poland and Hungary larger DH systems were privatised, while smaller scale systems frequently remained in municipal ownership. In Austria municipal ownership is the dominant form similar to the electricity market model. In this way the municipalities have almost full control over their DH systems, while only the competition authority exercises ex-post monitoring of price setting. The example of Sweden also illustrates that private and publicly owned systems have different return expectations, so municipally owned systems might offer a lower priced option compared to a fully privatised system.

The Danish case study also shows that regulating waste burning is a complex task, as it involves the simultaneous regulation of three markets: electricity, heat and waste disposal. Their management shows the disadvantages of cross-financing in this segment: in case one market (heat) is too strictly regulated, it might result in upward pressure on prices in other segment, e.g. in waste treatment. But the example is more general: in a two-product operation (e.g. electricity and heat) if one is a competitive market (electricity), the other product (heat) might be priced in a less competitive manner to cover losses on the competitive segment.

5.5 Support schemes

Table 5 Support schemes

	Austria	Denmark	Estonia	Germany	Hungary	Poland	Sweden
RES support	Investment support	RES-based DH investment support, Biogas, implicit tax support	Investment support	Production (CHP RES) and investments support, federal and municipal level	Investment support	Low interest loans	CO2 taxes, RES CHP investment supports
CHP support	Investment support	none	Investment support	Production (CHP RES) and investments support, federal and municipal level	none	High efficiency plants (above 70%) receives tradable certificates	KLIMP program, RES based CHP support
General DH support	Investment support (national and federal level)	Tax advantage and investment support for RES	none	Production (CHP RES) and investments support, federal and municipal level	Lower VAT level	none	none

Source: REKK

As Table 5 indicates, investment support is the most widespread solution for both RES and CHP based DH support in the selected countries. Production support is less common, Germany applies it with respect to RES based CHP heat generation and in Poland high efficiency CHP plants receive tradable certificates for their heat production.

In Germany and Hungary direct cross-financing system exists between electricity consumption and DH consumption. All electricity consumers pay a surcharge on their electricity consumption which is used to subsidize DH production/consumption.

Another way to support DH generation is to give tax advantages to DH producers and distributors. In Hungary it takes the form of a lower level of VAT (5% instead of the normal 27%) for residential end users of DH systems, while in Denmark this support is indirect. In Denmark all types of energy consumption entail high level of energy taxation, where DH based energy generation is exempted from higher taxes. Interestingly the Hungarian tax exemption and the other forms of subsidisation of the DH system were still not able to stop the decline of the sector. Another lesson from the Hungarian subsidy scheme is that a production subsidy to the CHP producers does not automatically generate reduced prices for the consumers. If these generators are not under competitive pressure, they would not pass on the benefits of the subsidy to end users. This was the reason that the Hungarian subsidy scheme was changed, and now focused on end user price regulation instead of the producer support.

6 Policy Challenges and Lessons Learnt

Under the present market conditions (fossil fuel prices, ETS CO₂ price) renewable based DH is generally more expensive than fossil based DH, so various levels of support are needed to overcome the barrier to higher RES deployment. In addition, DH itself is in very close competition with the individual heating mode, where even minor differences in various economic factors (fossil fuel price, energy taxation) could have a significant impact on the competitiveness of DH as the country studies demonstrate.

The answer of most countries to this challenge is to support RES based DH by investment support, while direct production support is less frequently applied. Production support is applied in Germany for various RES based heat generation through a feed-in tariff scheme, similar to RES based electricity generation, which is similar in Denmark where production support is given to the biogas based heat generation. As the dominating support scheme is via investment, it indicates that support schemes are less mature for RES based heat generation in most EU countries, as most of the schemes try to tackle the problem of the financing of a smaller number of RES DH projects. This is the situation in Hungary and Poland, where few RES based DH plants were financed by national and European funds. It has to be mentioned here that supporting any type of DH system – so not only RES based ones – could help the future deployment of RES in district heating. By maintaining or increasing the size of any type of DH leaves the option open in the longer term to turn these DH systems to a RES based one, once the general economic environment become more favourable toward renewable based heating.

If we have a look at the target achievements of the MSs, it could be observed that only a handful of European countries are on track to reach their NREAP targets in RES based DH. Sweden, Denmark, Finland, Slovakia, Austria and the Baltic states are the countries that have over-achieved their interim targets. These leading countries achieved their interim targets in spite their DH systems showed high deployment of RES already. The rest of the countries are lagging behind their targets, even though many of them - Hungary, Romania France and the Netherlands - were also quite ambitious to increase their RES based DH shares up till 2020.

Concerning the technologies applied in the various MSs we could observe the dominance of the solid biomass based DH systems, having over 80% shares of this technology in the majority of the countries. This shows that up until now, the MS states failed to create support schemes inducing sufficient R&D and deployment support for immature technologies. So the *technology related policy challenges* attributed to the support scheme for RES electricity are also present in the RES heat markets.³ Present support scheme designs failed to promote less mature technologies (e.g. geothermal) in the majority of the MS, so the technology-related cost savings created by higher deployment rates have not materialised. In the RES DH field the challenge is not the adaptation of the support level to the reduction of costs, but rather to *reach the appropriate level of R&D and deployment support for less mature technologies*.

The additional policy challenge detected in the RES DH markets – and it is a shared feature of RES electricity – is *adapting to the uncertain evolution of factors affecting the competitiveness* of DH in general and RES DH in particular. In the WP 3.1 report of the Toward 2030 project these factors include resource potential, fossil fuel prices and cost of competing technologies. The same factors affect the deployment of RES DH technologies, as the country case studies indicate that the cost differences of various heating options (DH and individual) are very narrow and a rather smaller variation in the evolution of the abovementioned factors could induce significant changes in the optimal heating mix. This impact is further assessed by the DH model elaborated by REKK

³ These policy challenges are introduced in the WP 3.1 report of the Towards2030-Dialogue project: Issue paper no3: What will be the main challenges for the design of renewable electricity policy in the EU? Available at: <http://towards2030.eu/sites/default/files/Towards2030-dialogue%20Issue%20Paper%20on%20the%20Main%20Challenges%20for%20the%20Design%20of%20Renewable%20Electricity%20Policy%20in%20the%20EU%20-%20Issue%20Paper%20%233%202015.pdf>

on Hungary, where the impacts of various policy options are assessed. The model results show, that the applied policy tools (CHP or RES subsidies, other tax advantages) are significant determinants for the future energy and technology mix in the DH market. It also shows, that some of these policy tools can have negative impacts on the RES deployment in the DH systems, e.g. intensive CHP subsidies could lock out RES heat production from the technology mix of DH.

Concerning the *macroeconomic related policy challenge*, the first one - *providing support under strict fiscal conditions* – is not yet inherent to the RES DH sector in most member states, due to the immaturity of the support schemes in the sector. However, in this aspect there could be a ‘spill-over’ effect from the electricity markets, as governments might not treat support budgets for RES heat separately, but rather be cautious about the overall spending budget for all renewables, including electricity and heat. The next challenge under this heading - *difficulty in accessing credits* – might appear in the near future for the RES heat sector as well. Up until now most new capacities are supported by dedicated national and European funds, so access to credit was less of a problem for project developers. However, at higher deployment rates access to credit will require specific rules for supporting RES based DH, mainly in regions where access to credit is more limited, or where capital is more expensive due to financial market constraints, e.g. in the new member states with lower credit ratings and higher DH penetration rates. As the case studies shows, more clear rules for the price regulation in the sectors (e.g. increasing the length of very short price setting period/practice in Hungary, reducing the incentive to invest) could also help to increase the credit worthiness of the regulated companies. In the case of Denmark the issues concerning the access to credit were eased by the fact that many smaller sized DH systems are consumer owned (cooperatives), while in case of liberalised DH markets (Sweden, Germany and Austria) market based price setting increase credit worthiness of the DH companies, and at the same time these are the countries where capital is relatively cheaper and more readily available in the first place.

6.1 Heat sector specific challenges

In addition to the previously described issues that are shared with the RES electricity sector, the RES heating sector presents some additional policy challenges for the future deployment of RES heat technologies.

The EU regulation promoting the deployment of highly efficient CHP generation could have a mixed impact on RES DH deployment. Under the present market conditions (fossil fuel prices in a low ETS CO₂ price environment) fossil fuel based CHP is a lower cost option than RES based DH, if no additional support is given to RES technologies. If this situation prevails on the longer term, increasing fossil based CHP heat could reduce market opportunities for RES based heat for a prolonged period. This represents a possibility of a lock-in effect, also demonstrated by the DH model scenarios.

An additional challenge the sector faces is the reduced heat demand due to the energy efficiency refurbishments of the European housing stock. This trend is traceable in most member states, but due to the more numerous refurbishment programs in the new member states and the relatively higher energy consumption for heating, this effect is more sizeable in these countries. This poses a challenge for DH providers, as they have the objective to increase market shares in shrinking heat markets. In addition it poses a planning problem since the optimal size of heat producing plants is uncertain before the refurbishments take place.

An even more widespread issue that has to be dealt with within the DH sector is to guarantee that the heat delivered by these systems is competitively priced while a high level of energy efficiency is ensured during the operation of heat plants and distribution networks. Competitive pricing could be guaranteed in the systems where third party access (TPA) is allowed and where more capacities have access to the distribution network (e.g. in many German, Austrian DH networks). Although in theory similar TPA is ensured in Poland, due to the lack of competing capacities this TPA does not function yet. An interesting solution was applied in Hungary and Estonia, where a periodical tendering process is carried out to ensure efficient pricing of DH services. In Hungary, for example, at the time major refurbishments were undertaken by the heat provider, municipalities organ-

ised open tenders to ensure efficient pricing of the heat. The problem is the long-time intervals between tenders, as after nominating the winning tenderer, municipalities had less power to enforce competitive price setting before the new tender is open.

Another more challenging issue is the use of legal obligations to connect to the DH network in designated zones. In three out of the seven assessed countries, municipalities have the right to apply this tool - Denmark, Estonia and Germany – however German municipalities use it less frequently. In Denmark and Estonia this legal instrument has contributed significantly to the continuous increase of DH in the heat supply. The question is if this instrument could be effectively applied in other countries where it is not yet part of the system, something which should be further explored. As this would require significant tasks to be carried out at municipal level (e.g. periodical heat planning at municipal/regional level, as functioning in Denmark) the adaptability of this instrument to the established governance system (and sharing the responsibilities between municipal, regional and central authorities) is questionable. For example in Hungary, according to the latest legal rulings this obligation is not applied, in addition consumers connected to the DH networks have the right to disconnect from the system. In cases where the legal obligations apply, those authorities or the municipalities responsible for the DH service (by regulating or controlling the price and service level) must ensure that end user prices are based on the efficient operation of the DH system. The four case studies elaborated in the WP also underline the important role of the municipalities in the deployment of DH, and even more pronounced role in the spread of RES based solution. Municipalities can lower regulatory uncertainties, even in those countries, where municipalities have more limited role in regulating the DH companies (e.g. in Hungary).

Energy efficiency refurbishments in the building stock could reduce the heat demand and heat density in towns, thus reducing the market and competitive advantage of DH. In planning optimal DH plant size it is also an important issue, as DH plants should be sized according to the future energy demand, which due to the massive refurbishment rates could reduce significantly. This impact seems to be more accentuated in the Central and Eastern European countries, but present in all MSs.

6.2 Lessons learnt

One of the most important lessons learned from the assessment and from the case studies is that it is still too early to predict what type of regulatory/incentive options are the best suited to effectively promote RES DH. Compatibility with the existing regulatory, legal and market environment must be ensured, so the instruments applied will be mixed between different countries. If the energy policy of a country aims to increase RES share in DH systems significantly it might have to introduce strict legal and economic instruments in the future:

Primarily it has to prevent efficient DH and CHP from loosing market against individual fossil fuel based heat solutions, e.g. own gas boilers. It might impose a mandatory connection obligation for new buildings if DH can be provided efficiently based on RES (or where RES share is above 50%). For this purpose local authorities might have to create and regularly update long term heat plans for the territories falling under their responsibility.

As it is likely there will still be a cost difference disadvantaging RES based heat production in the short to medium term, the DH operator should be given an economic incentive to convert heat production from fossil fuels to RES based ones (biomass or waste fuels). When heat prices are regulated, examples of such incentives could be: higher level of premium for RES based generation (e.g. in the form of WACC-premium) on top of allowed normal returns to fossil based DH generation. Another issue is the treatment of heat price differences amongst zones that have different production cost levels due to the different mix of fuels (e.g. fossil and RES based ones). A predictable and fair benefit-sharing mechanism might be needed, that will account for the positive externalities of RES based DH not accounted for in the present heat markets. Germany and Hungary demonstrate a cross-financing scheme between electricity and DH heat consumers, but these schemes might not be justified in the longer term as it stipulates a cost sharing mechanism between electricity and heat consumers.

When heat prices are non-regulated and DH companies set prices freely, private investors might pick up those areas (usually densely populated city areas) where efficient production and distribution is guaranteed, leaving less densely populated, higher cost areas in the hand of municipalities struggling to maintain their operation at even break-even levels. This situation could be observed in the Polish and Estonian cases, but the Swedish case also illustrates the differing level of profitability of DH companies in private and public ownership.

Taxation of fossil fuels in heat production according to CO₂ emissions could also make RES based DH more advantageous (see e.g. the Swedish example). In Denmark tax advantages given to RES based heat producers offer similar incentives to investors, as taxation of fossil fuels are amongst the highest level in the EU.

Temporary operative and investment support to heat production (similar to electricity) based on renewable fuels including waste fuels where part of the fuel can be considered renewable is also a good initial solution. While investment support is frequently used, production based support is less widespread for heat (Germany applies it and Denmark does for biogas). In this sense RES heat including RES DH is not treated in the same way as RES in electricity markets, showing bias towards RES-E supports in many MSs.

Another step forward in price regulation of DH could be to set price caps instead of cost based regulation which would leave higher and clearer incentives to heat producers to invest in the sector (e.g. in Hungary or Poland compared to Estonia, where a price cap is already in use).

In addition, introducing higher shares of RES should not lead to a reduction of energy efficiency in DH systems. In systems where heat prices/returns are regulated, regulators should establish predictable incentive mechanisms for making the DH system more efficient and better optimized in the long term.

7 Country Studies

7.1 Situation of DH in Austria

7.1.1 The Austrian DH market

Austria was selected as a focus country due to two specific reasons. First, because they operate many small scale DH systems, which can be a very interesting solution in the future DH systems. Second, the share of solid biomass is one of the highest amongst the EU member states, and it also shows a very dynamic pattern. There are two types of “district heating” in the country: one of them is called “Fernwärme”, that is the same as the usual terminology for district heating, and the other is called “Nahwärme”. This latter refers to the small, local systems, usually with a capacity between 50 KW and a few MW, and often using lower temperature water. These Nahwärme systems are the most popular in Lower Austria and Styria, both operate around 200 Nahwärme biomass plants.⁴

7.1.2 District heating market characteristics

The share of households using district heating is quite high in Austria, especially in a few cities. In 2012 it was 28% in the whole country, while in Klagenfurt it was 30%, in Wien 36% and in Linz 60%.⁵

⁴ Fernwärme, sicher, sauber, bequem - Eine Informationsbroschüre der österreichischen Fernwärmewirtschaft, <http://www.fernwaerme.at/media/uploads/misc/fernwaerme.pdf>. In the following part of this study, we will use the expression district heating for both of them, because in the statistics there are rarely separate numbers for them.

⁵ source: https://www.gaswaerme.at/bfw/themen/index_html?uid=2737

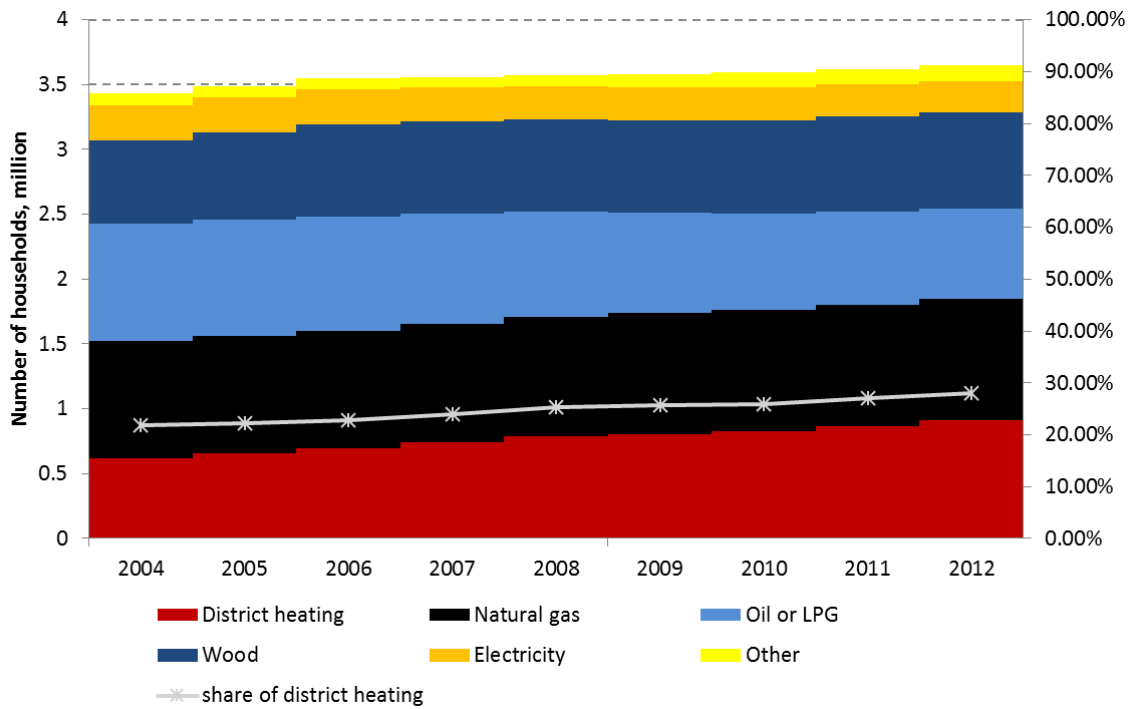


Figure 17 Share of district heating by number of flats connected in Austria
 Source: Statistik Austria – the data for the odd years are calculated as the mean of the adjacent even years

The overall share of DH from consumed space and water heating energy in the residential sector was 12% in 2012, but this number is continuously increasing. This smaller share compared to the share of DH heated flats from total housing stock is the consequence of the different size of houses: the average floor space of primarily DH heated flats is less than the average floor space of natural gas or wood heated flats.

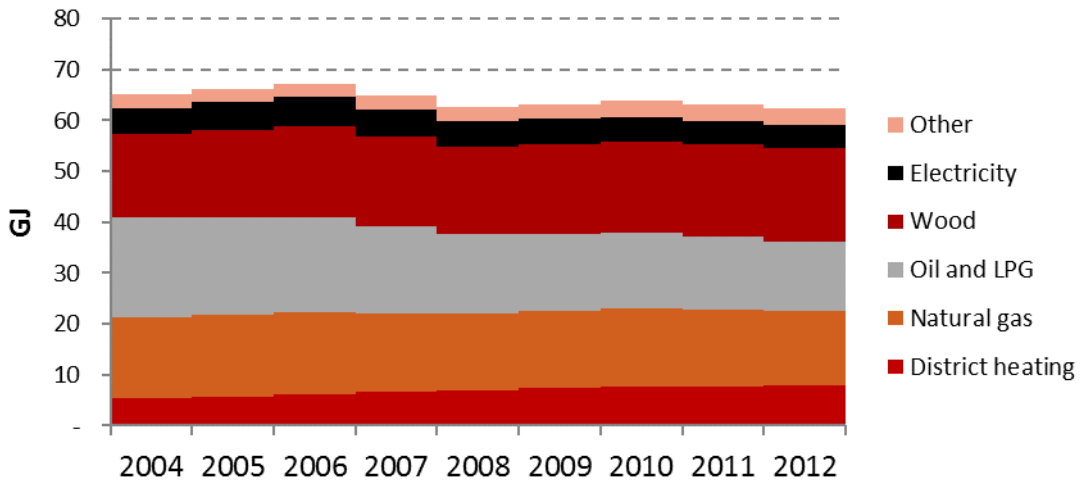


Figure 18 Average heating energy consumption (space heating and water heating) of a household in Austria
 Source: Statistik Austria - the data for the odd years are calculated as the mean of the adjacent even years

The two biggest consumers of DH are the residential sector with 41% and the services with 36%. Industry has a 14% share of total DH consumption (the remaining part accounts for losses). In 2010 a significant increase is visible in total DH consumption, from under 70 to above 80 PJ, and that latter level more or less remained the same in 2011 and 2012.

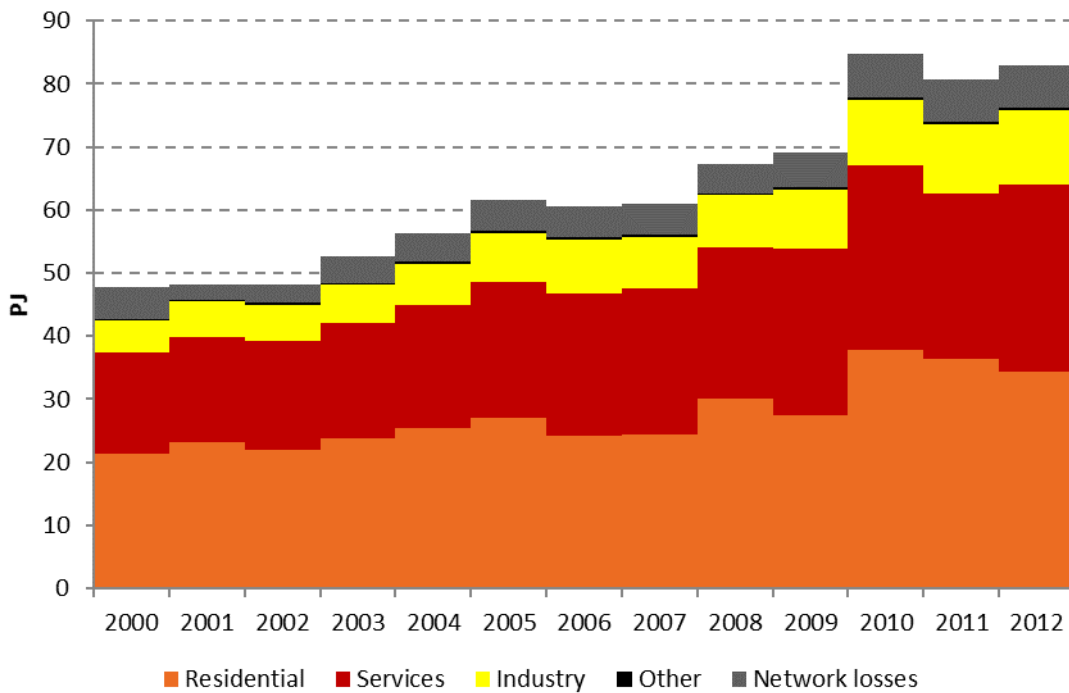


Figure 19 Network losses and main consuming sectors of district heating in Austria
Source: EUROSTAT

The two main energy sources for district heat generation are natural gas and renewable sources. Latter is mainly wood waste, and is typical particularly at the small, "Nahwärme" systems.

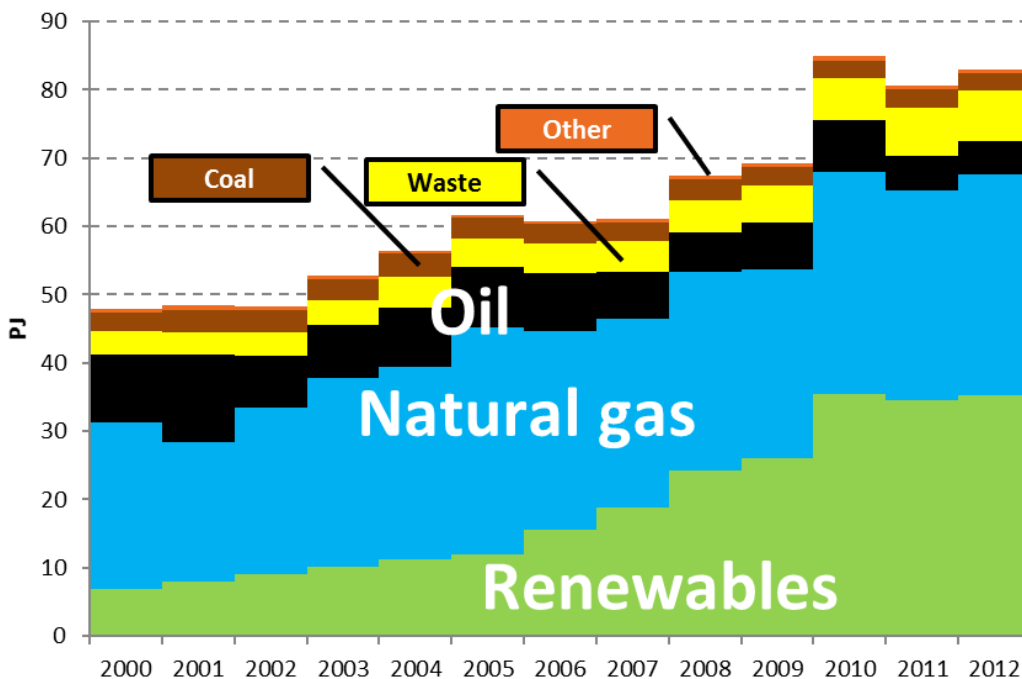


Figure 20 Main fuels used for DH production in Austria
Source: EUROSTAT and NREAP

In Austria the most important district heating organization is the Association of gas- and district heating supply companies (FGW), where the membership is regulated by law. The number of DH firms in the association was 550 in 2010,⁶ and it was slowly increasing.

The share of CHP in district heating production is quite high: in the last 10 years it was between 60% and 70%. The regulatory framework can be an explanation for this, as it facilitates the building and operation of CHP plants.⁷ The decline from 2005 is more or less visible in the total heat production as well, so even the CHP production decreased more, the increasing gas prices can be an explanation for this. Another explanation can be the switch from natural gas to biomass (mainly wood) at some plants, which can entail capacity reduction.⁸

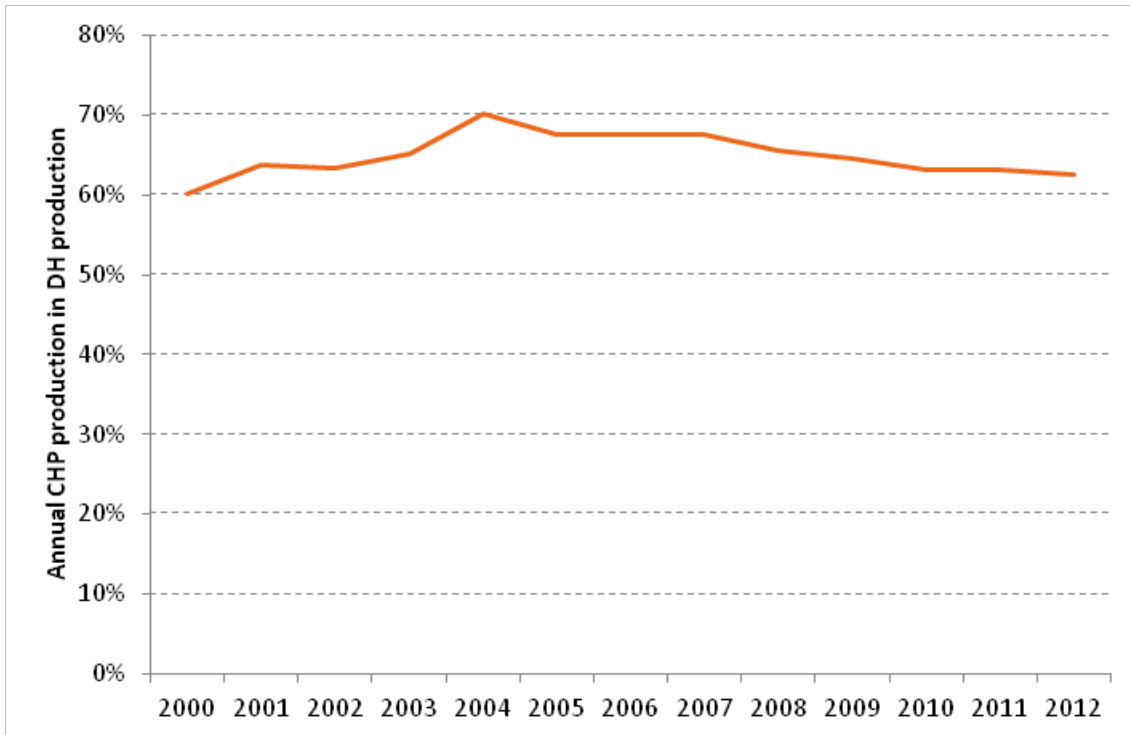


Figure 21 Share of CHP production in total DH generation in Austria
Source: Eurostat

The length of DH pipelines also increased slowly in the past years. This is in line with the increase of households using DH and also the share of DH in total heating energy consumption.

⁶ http://www.fjvu.dk/sites/default/files/district_heating_in_austria.pdf

⁷ The data from the 2013 annual report of Fachverband der Gas- und Wärmeversorgungsunternehmen (FGW) is a bit different, with higher CHP shares (between 68% and 75%) and an increase of it from 2008-2010.

⁸ Combustion and gasification of solid biomass for heat and power production in Europe, 8th European conference on industrial furnaces and boilers <http://www.bioenergy2020.eu/files/publications/pdf/Obernberger-2008-INFUB-keynote-bm-combustion-gasification.pdf>

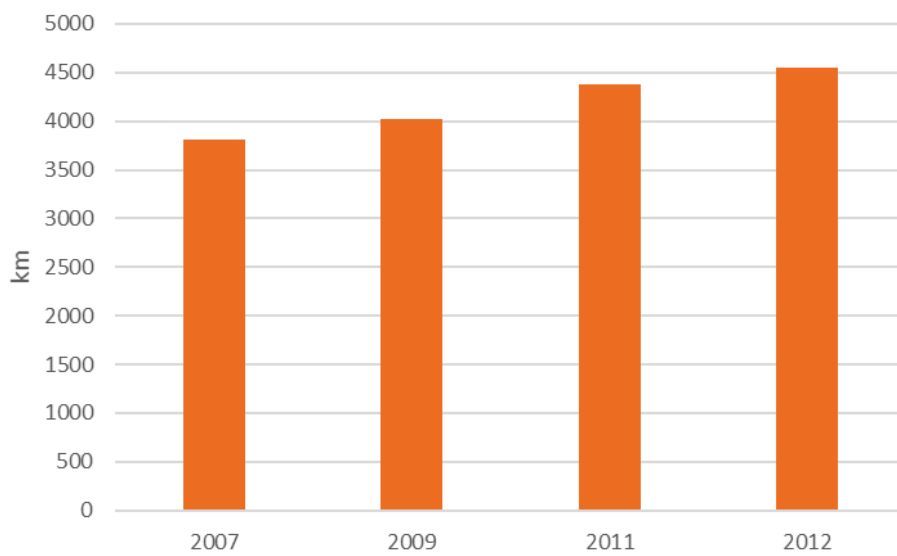


Figure 22 Length of district heating network in Austria
 Source: Euroheat and power

District heating has a quite competitive price compared to other energy sources, although the main competitor, natural gas has a lower price. The information about prices is quite heterogeneous, as there are sometimes big differences among cities/regions. The average price we used was calculated from the data of Statistik Austria, from the total spent money on district heating, and the total used district heat.

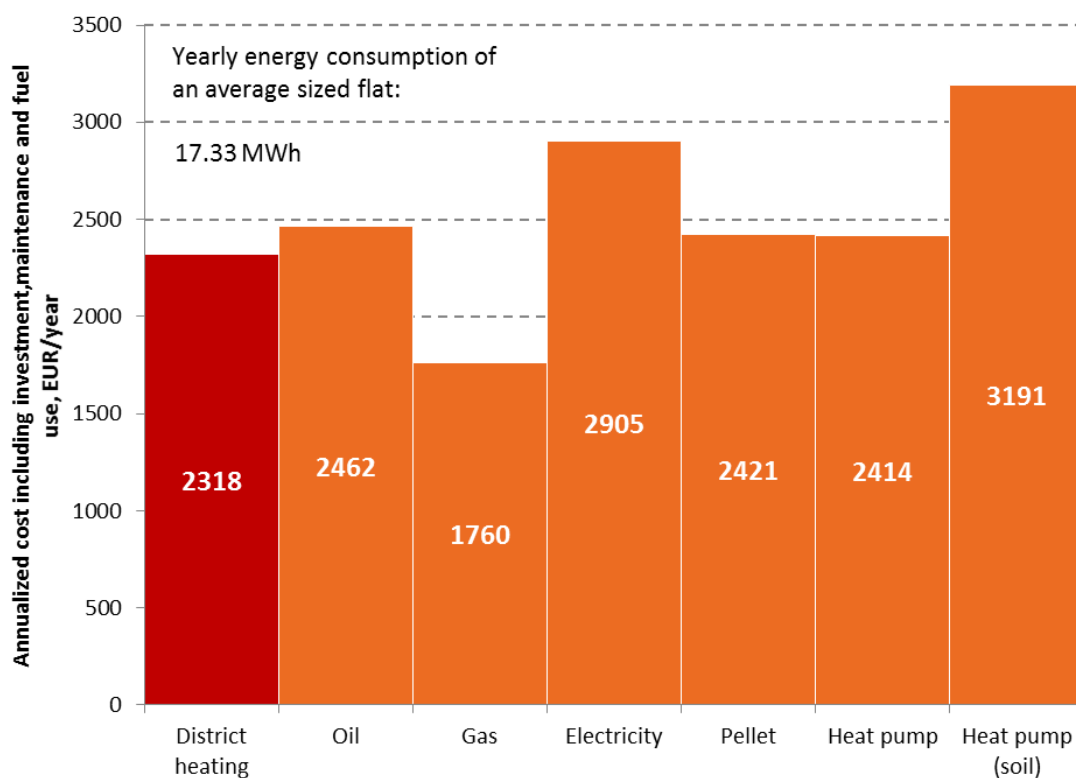


Figure 23 Annualized cost of different sources of heat for an average sized flat, 2012 in Austria
 Source: Statistik Austria, REKK calculation

7.1.3 Future vision of DH in national planning

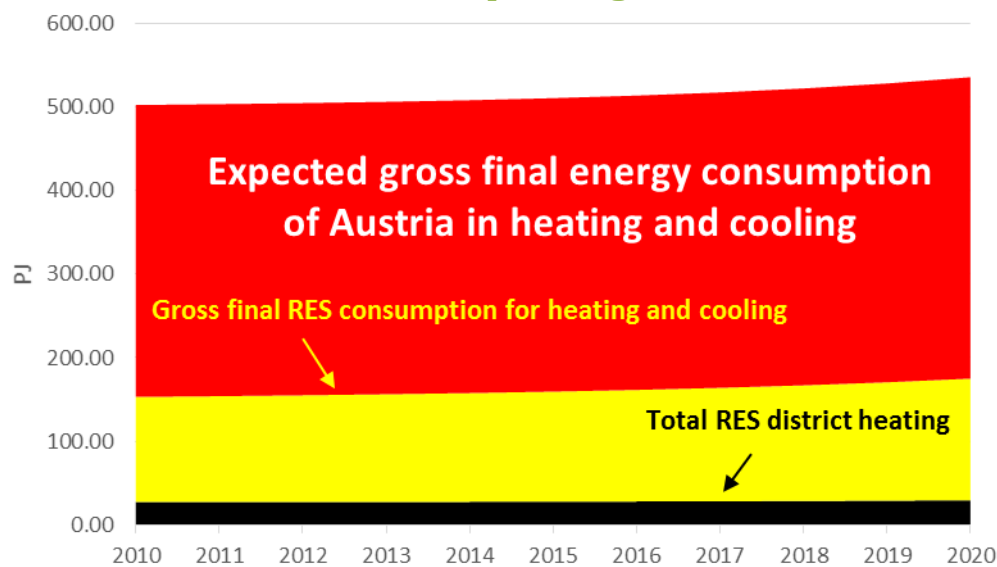


Figure 24 Renewable district heating consumption and total heat consumption to 2020, PJ in Austria
source: NREAP Austria

For RES-based district heating a slight increase was targeted from 2010 to 2020 in Austria's National Renewable Energy Action Plan (NREAP). This 2020 target, 702 PJ renewable DH consumption was already exceeded in 2010, showing that the NREAP of Austria was not sufficiently ambitious in this respect.

7.1.4 Regulation of District heating services

7.1.4.1 General regulatory setting

In Austria majority of the regulation is managed on "länder" (federal state) level, while there is also national regulation. There are different measures in the federal state level that promote the operation and extension of district heating systems, in some cases including compulsory connections.⁹ The national level mainly offers subsidies and other financial incentives, also through the creation of the Austrian Energy Strategy in 2010 that fell within the competence of the Federal Ministry of Agriculture, Forestry, Environment and Water Management. The plan set targets for GHG emission reduction of space heating, and provided the framework for several support schemes, such as Green Electricity Act, and the support of renewable heat as part of the Climate and Energy Fund. The National Renewable Action Plan (NREAP), and the Energy Efficiency Action Plan (EEAP) was developed on a national level. The CHP support system is set by the CHP Law that also applies nation-wide. Details of support schemes are given in section 7.1.4.4 and 7.1.5.

DH networks are managed at local level by individual supply companies. A very high share, 90% of district heating plants - both CHP-plants and heat-only plants - are publicly owned, by municipalities.¹⁰

7.1.4.2 Methods of regulation

In Austria no national price regulation is in force, usually the municipalities are responsible for price setting.¹¹ Some cases DH companies set prices freely and competition authority monitors excessive profits based on

⁹ European Commission's Progress Report on the application of Directive 2006/32/EC on energy end-use efficiency and energy services and on the application of Directive 2004/8/EC on the promotion of cogeneration based on a useful heat demand in the internal energy market, http://ec.europa.eu/energy/efficiency/doc/end_use/swd-2013-541.pdf

¹⁰ Svensk Fjärrvärme: An international comparison of district heating markets - 2009

¹¹ many cases they are the owners of the DH company

competition law,¹² other cases the municipality sets the prices. The 2013 Competition Report of Arbeiterkammer¹³ states that as district heating consumers have no chance to switch suppliers, they are vulnerable, and that the district heating market should be subject to deep examination. Prices are quite different among various parts of the country, and the price setting methodology is not always published. The most commonly used methodology is the cost-plus price regulation.¹⁴

In Wien for example, energy prices charged for space heating are subject to official price decision, issued by the Governor of Vienna.¹⁵

In Linz, the city with the highest share of district heating, the prices did not change from 1990 until 2004, and the little bit higher 2011 price level was the same as the one in 1983.¹⁶ In 2011 and 2012 Linz AG raised the prices referring to increasing fuel prices and consumer price index, but still this price is the lowest across Austria.

7.1.4.3 Specific rules of RES based DH regulation

There are special support schemes for RES based district heating, both in national and federal state level. Both cases the four supported types of plants are biomass, solar thermal, heat pump and geothermal installations. The national support is regulated through the Environmental Aid Act (UFG).¹⁷ More details are given in section 7.1.5.

7.1.4.4 Specific rules for CHP regulation

CHP plants are supported through two laws: one of them is the Green Electricity Act, in force since 2007,¹⁸ and the other is the Combined Heat and Power Law, that took effect in 2009.¹⁹

In the first one, there are three categories for plants. The first one, “existing plant” includes CHP plants with issued construction permits before 2003. These plants could be supported through this act until 2008. The second category is the “modernised plant”, where the cost of modernisation should be at least 50% of a new plant’s cost, and the date of plant commissioning cannot be before 2001 October. These plants were supported until 2010. One support criteria for these plants is to provide public DH services, while also energy efficiency standards should be met. The support is based on the costs and revenues, taking into account the cost of capital.

The third category is the “new plant”, where the work should began at latest in 2006, all construction permits should be obtained until 2012, and operation should begin in 2014. These plants could be supported until 2012. Only plants larger than 2 MW can be supported, again with the public DH supply and the energy efficiency criteria. The support here consists of two parts: one is the maximum 10% of the total investment cost, and the other part is a capacity based support.

The yearly available funds were the following:

¹²http://www.epha.ee/File/Overview%20of%20DH%20pricing%20and%20regulation%20in%20Europe_HP%20Korhonen.pdf

¹³ Wettbewerbsbericht der Arbeiterkammer 2013 (Competition Report of Arbeiterkammer 2013), http://media.arbeiterkammer.at/PDF/AK-Wettbewerbsbericht_2013.pdf

¹⁴ IEA: Coming in from the cold - Improving District Heating Policy in Transition Economies, 2004

¹⁵<https://www.wienenergie.at/eportal/ep/programView.do/pageTypeld/11889/programId/15491/channelId/-22264>

¹⁶http://www.linz.at/images/LL_207_43_43_Fernwaerme.pdf

¹⁷ Gesamte Rechtsvorschrift für Umweltförderungsgesetz <https://www.ris.bka.gv.at/GeltendeFassung/Bundesnormen/10010755/UFG%2c%20Fassung%20vom%2003.04.2012.pdf>

¹⁸<http://www.e-control.at/en/businesses/electricity/combined-heat-and-power%20%28CHP%29/CHP-support>

¹⁹<http://www.iea.org/policiesandmeasures/renewableenergy/?country=Austria>

Table 6 Yearly funds available for CHP plants, 2007-2012 in Austria

Year	Amount of support
2007	max € 54.5 million (incl. €10 million for new CHP plants*)
2008	max € 54.5 million (incl. € 10 million for new CHP plants*)
2009	max € 28.0 million (incl. € 10 million for new CHP plants*)
2010	max € 28.0 million (incl. € 10 million for new CHP plants*)
2011	max € 10 million (only for new CHP stations*)
2012	max. € 10 million (only for new CHP stations*)

*2006–2012: Total support available for new CHP stations max € 62.5 million

The CHP law provides support for the same plant categories, but excludes plants already being supported by the Green Electricity Act. The criteria are similar, although here only plants saving energy and CO₂ emission compared to separate heat and electricity production can be supported. The amount of support was 55 million euros, from 2006 to 2012, from which 30% was allocated to cogeneration plants for industrial use. The responsible bodies are federal states/federal authorities. There is no information available if these support mechanism were renewed or extended.

7.1.5 DH policy tools

7.1.5.1 For DH systems

For DH plants, that are not 100% renewable the following support system is established in the General legislation for heating and cooling Grid Expansion Act²⁰:

The supported elements are the following:

- Infrastructure pipelines
- Hot and cool water storage tank
- Pump stations
- Re-cooling system
- Transfer stations
- Chiller with refrigerating capacity more than 0.75 MW

The maximum support is 35% of the investment costs (excluding land costs) and not more than 50% of the environment-related investment costs.

Annual federal funding of up to € 60 million is foreseen until 2013.

7.1.5.2 For RES based DH²¹

There are two types of support for RES DH systems in Austria. One is on the individual federal state level, and the other is part of the national support scheme. The first one is mainly promoting small-scale-RES heating and cooling, and the eligibility criteria and the amount of support do not differ widely among provinces. Also the criteria and the support is similar on the national level. The four supported types of installations are biomass, solar thermal, heat pump and geothermal installations.

²⁰ https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2014_I_72/BGBLA_2014_I_72.pdf,

https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2008_I_113/BGBLA_2008_I_113.pdf

²¹ This section is based on information from res-legal.eu and on the funding guidelines for Vienna:

<http://www.wien.gv.at/amtshelfer/bauen-wohnen/wohnbaufoerderung/wohnungsverbesserung/heizungsinstallationen.html>

The national support is regulated through the Environmental Aid Act (UFG).²² In that case the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water is responsible for the entire support scheme. There is also an organisation entrusted as a settlement agency, The Kommunalkredit Public Consulting GmbH (KPC), who is responsible for the practical development of support programmes. Also the application is submitted to KPC.

There are two ways of support: one is a flat rate of “de minimis” support, if the amount of subsidy does not exceed a maximum of €200,000 public support over three years. The other option is the ‘standard reimbursement rate’. It usually amounts to 25% of the investment costs but can be increased to 30% through awards (sustainability and gas-cleaning awards, etc.). In some cases a minimum of €10,000 of environmental-related investment cost is a necessary condition for the support over the “de minimis” limit.

Table 7 Supports for RES-based district heating plants/other investments in Austria²³

Plant type (or other investment)	Sub-type	Support under de minimis limit	Support above de minimis limit	Note
biomass units	0-50 kW	120 €/kW		support can not exceed 30% of investment cost
	51-400 kW	60 €/kW		
	above 400 kW	20-30%* of investment cost	40% of investment cost (with a minimum of € 10,000 environment-related investment cost)	
biomass CHP		10-20%* of investment cost	40% of investment cost	a minimum of € 10,000 environment-related investment cost is required
biomass microgrids		25-30%* of investment cost		a minimum of € 10,000 environment-related investment cost is required
solar thermal	standard collector under 100 m ²	100 €/m ²		support can not exceed 30% of investment cost
	vacuum collector under 100 m ²	150 €/m ²		
	above 100 m ²	20% of investment cost	40% of investment cost (with a minimum of € 10,000 environment-related investment cost)	
heat pump	water heat pump under 400 kW	85 €/kWth (0-80 kWth) 45 €/kWth for every additional kWth (81-400 kWth)		support can not exceed 30% of investment cost
	air heat pump under 400 kW	70 €/kWth (0-80 kWth) 35 €/kWth for every additional kWth (81-400 kWth)		
	above 400 kW	15% of investment cost	40% of investment cost (with a minimum of € 10,000 environment-related investment cost)	
geothermal		30% of investment cost	40% of investment cost	

*the lower limit can be increased until the upper limit with awards

²² Gesamte Rechtsvorschrift für Umweltförderungsgesetz
<https://www.ris.bka.gv.at/GeltendeFassung/Bundesnormen/10010755/UFG%2c%20Fassung%20vom%2003.04.2012.pdf>

²³ source: res-legal.eu

7.2 Situation of DH in Denmark in general

7.2.1 General overview of the market

Denmark is the leading country in DH supply in Europe with high share of RES deployment. As the regulation of the sector also unique and the DH system is still growing, the Danish case is assessed in details. Regulation requires newly built houses and flats to connect to the district heating network, prohibits the installation of electric heating and individual gas heating. Although home owners are allowed to utilize other kinds of central heating (e.g. heat pumps or renewable heating), the installation cost of the new system needs to be paid. Due to the monopoly setting, district heating suppliers are heavily regulated. Suppliers are required to be non-profit, this is ensured by the regulator DERA. All district heating suppliers are required to submit their cost structure, and prices are set to cover their average costs to allow for maintenance and further investment.

On the heat production side of the market, power plants providing heat to the DH market are not regulated at all, so some kind of competition can occur between the heat producing plants.

Denmark is a heavily regulated heat market: both consumers are constrained in their heating choices and suppliers by the price setting and zero profit obligation. This strong regulatory approach is prone to errors in price setting, such as the case of heat produced in waste incinerating units (see Chapter 7.2.4.4 Other, non-fossil based DH).

7.2.2 District heating market characteristics

District heating has a considerable share in Danish households' heat supply – in 2013, 63% of households were using district heating as primary heating (Figure 17). This high ratio has been the result of regulation: since the 1980's new buildings and existing buildings in residential area have been required to connect to the district heating network. Although households were allowed to install any kind of additional heating, once the DH infrastructure was in place, a new system would require additional investment and DH prices tended to be competitive with other fuels (due to heavy taxation of competing fuels and regulation of DH end-user prices). Long-term tendencies show that oil heating dominant in the 1980's has been crowded out by district heating and natural gas heating in the 1990's.

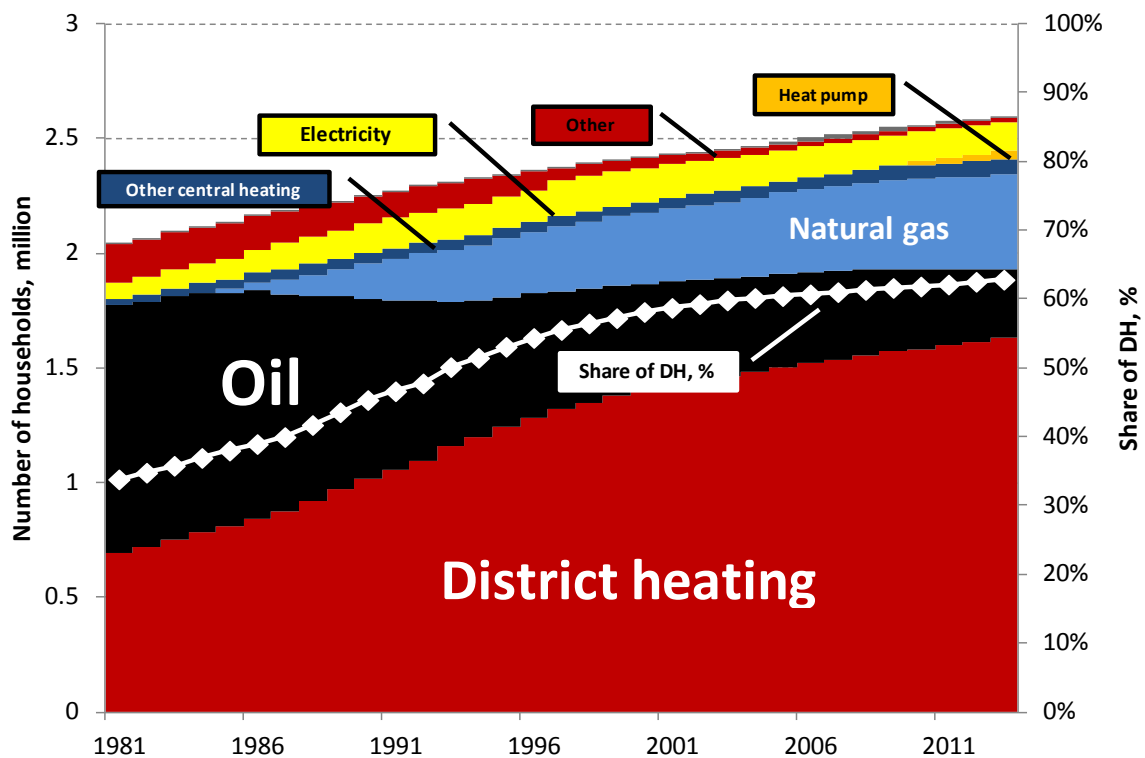


Figure 25 Share of district heating by number of flats connected in Denmark
Source: Statbank.dk

Household heating energy consumption closely follows the connection ratios. In 2013, 44% of heating energy consumption originated from district heating, followed by 27% renewable heat, and 17% natural gas. Oil, coal and electricity accounted for the remaining 12%. It is apparent that the 67% share of oil in 1980 was replaced with a more environment-friendly combination of district heating and renewable energies (mainly heat pumps and biofuels) and natural gas.

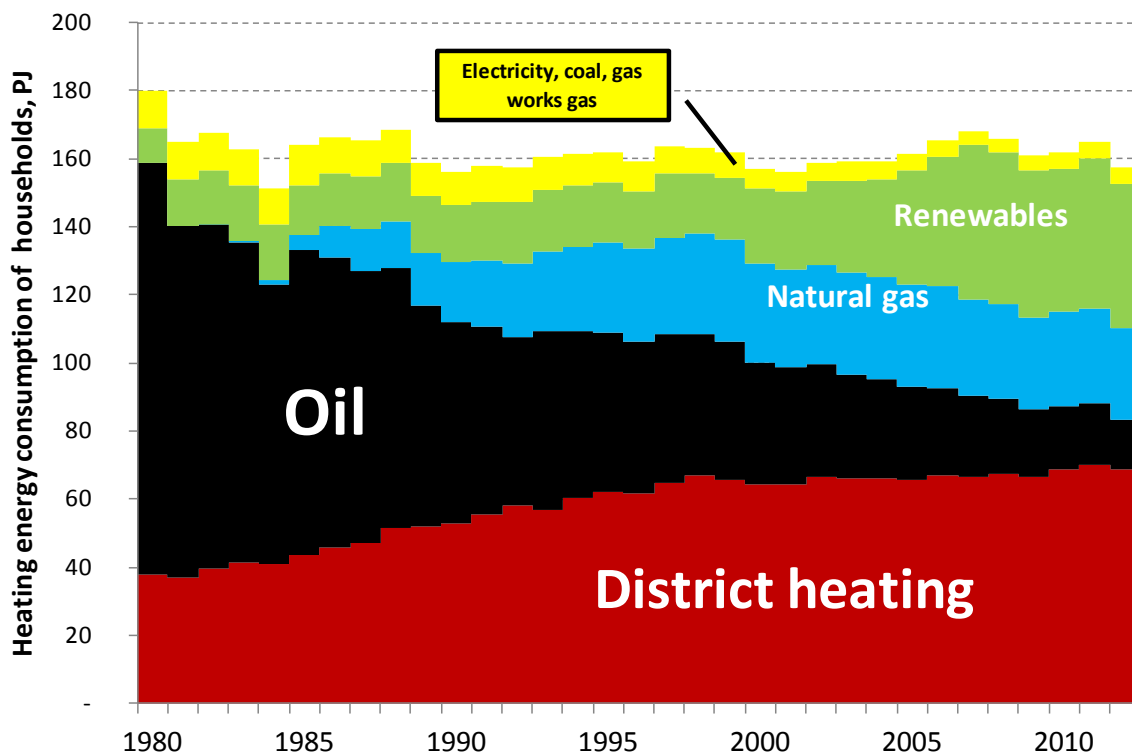


Figure 26 Heating energy consumption of households (temperature adjusted) in Denmark
 Source: Ens.dk and Statbank.dk. The year 2010 was exceptionally cold in Europe, yearly total heating degree days in Denmark, the Netherlands and Belgium were 16% over the 15 year average in 2010.

Structure of district heating consumption has not changed in the past 10 years. About 20% of production is lost while transporting to consumers, the industry and services sector uses 30% while half of the total production is consumed in households. Demand ranges between 120-130 PJ per year, in a cold year may surpass even 140 PJ.

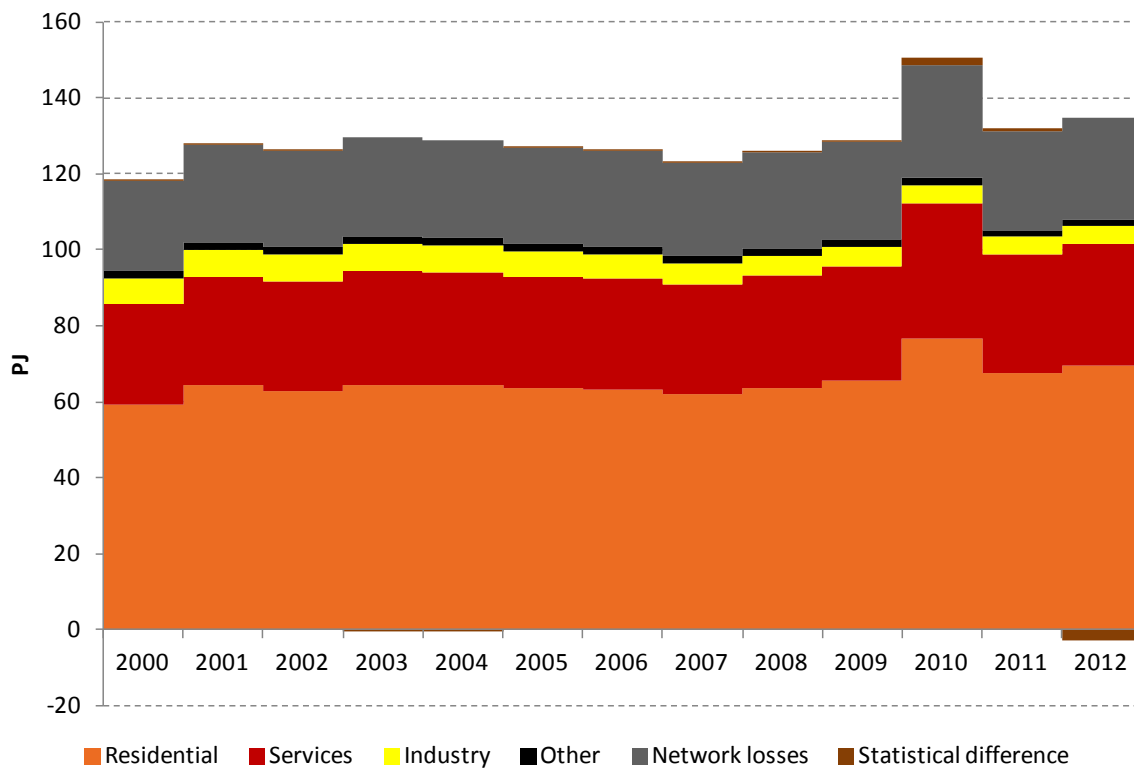


Figure 27 Network losses and main consuming sectors of district heating in Denmark
 Source: Eurostat. Not adjusted for temperature.

In 2012, fuels used for district heating production were mainly renewables (31%), natural gas (24%) and coal (24%). In the first half of the 1980's, oil dominated the fuel mix. From the second half of the decade throughout the 1990's, the district heating industry switched to coal as primary fuel and introduces gas and renewables to the mix. From 2000 on, renewables and natural gas started to crowd out coal. The background of the fuel switch is the gradual decentralisation of Denmark's heat supply and the policy of using biomass in district heating production.

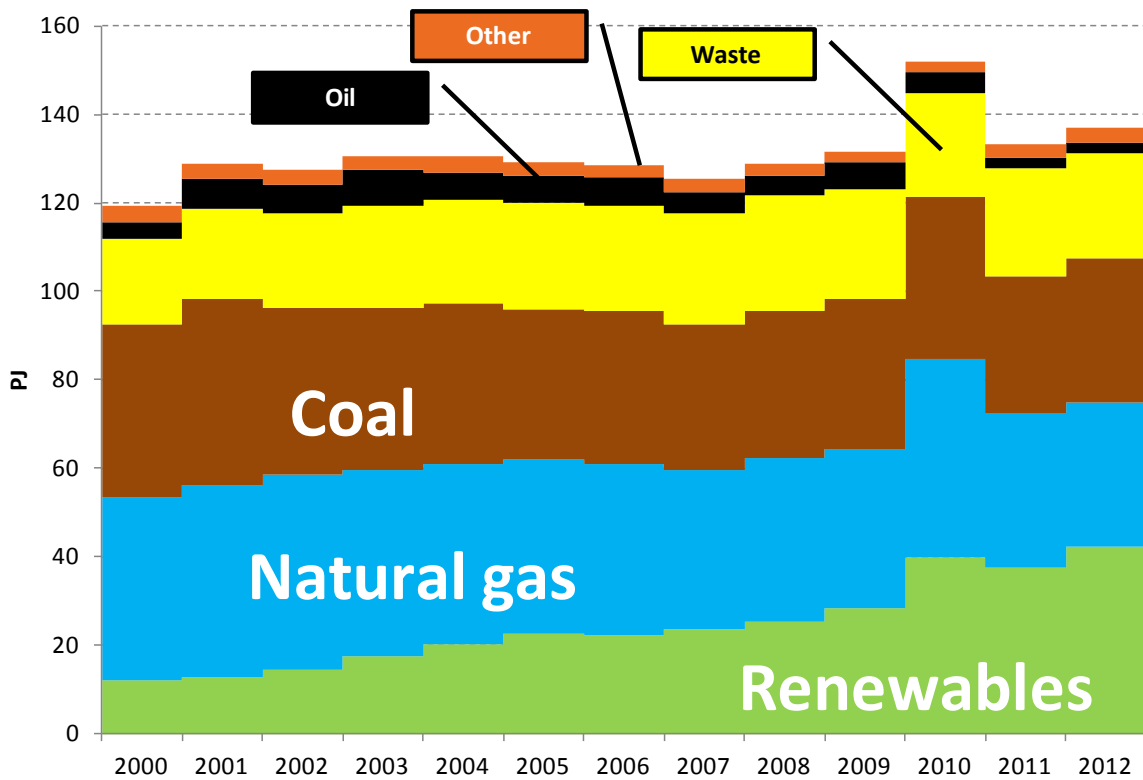


Figure 28 Main fuels used for DH production in Denmark
Source: Eurostat. Not adjusted for temperature.

In 2012/2013, 428 companies were engaged in DH supply. The number of firms has ranged between 413 and 459 in the 2008-2014 period, and has been around 430 since 2012.

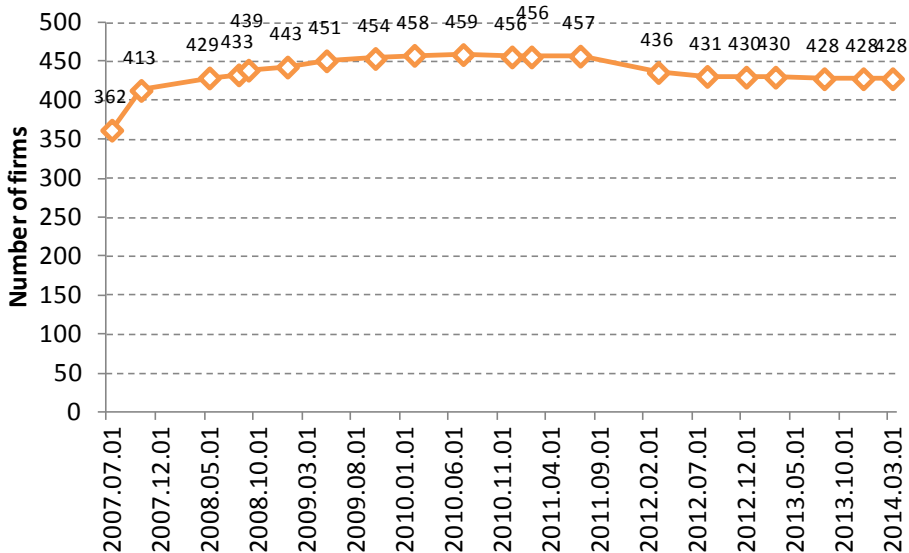


Figure 29 Number of DH supplier companies in Denmark
Source: DERA (<http://energitilsynet.dk>)

More than 82% of these companies were consumer-owned, 12% owned by municipalities, 4% by private companies and 1% by housing associations. When considering district heating supply, the share of municipality owned district heating sales makes up nearly 2/3 of heat sales (61%), due to the fact that the major consuming

urban areas of Copenhagen, Aarhus, Odense and Aalborg are supplied by municipality-owned companies. 36% of heat sales is supplied by consumer-owned companies.

Table 8 Ownership structure by number of firms and heat sold (2012) in Denmark

	Number of firms	Share of heat sold
Consumer-owned	354	36%
Municipality-owned	53	61%
Private company	19	4%
Homeowners association	3	0,10%

Source: DERA District Heating Statistics 2012 (<http://energitilsynet.dk>)

Share of CHP generation had been over 80% in 2000-2006, then started to decrease reaching 72% in 2012. Although it is a non-negligible drop, CHP share may still be considered high. CHP plants are usually natural gas fired units, which have been displaced by renewable biomass or biogas heat only capacities.

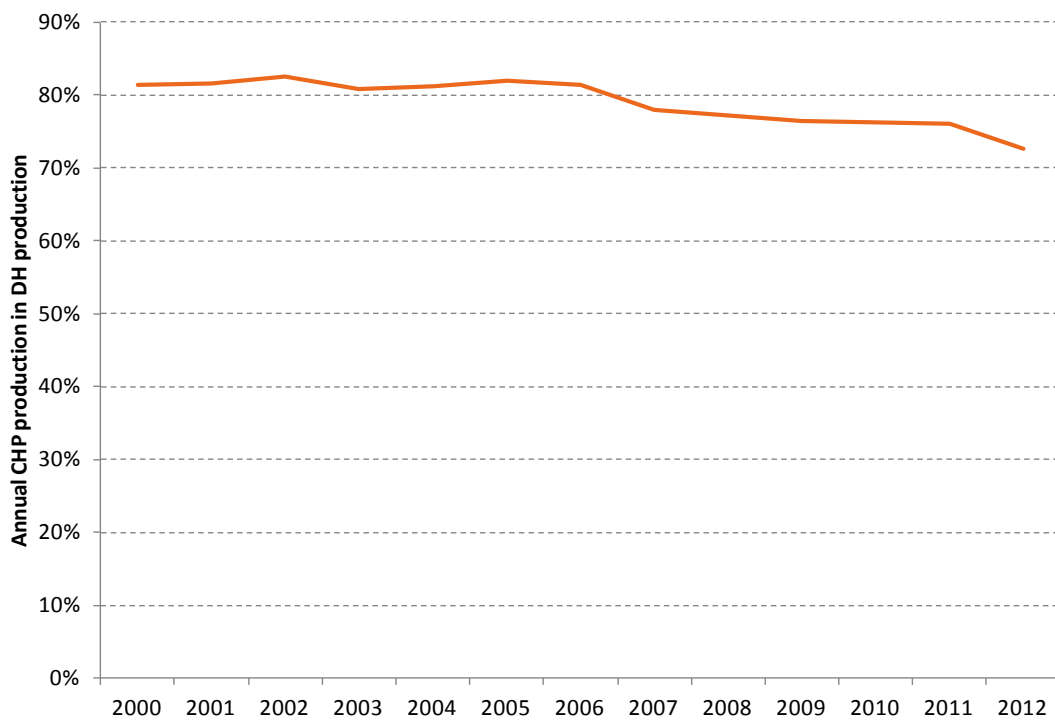


Figure 30 Share of CHP production in total DH generation in Denmark

Source: Eurostat

7.2.3 Future vision of district heating in national planning

No target exists for district heating production in 2020. Renewable district heating however is set out in the NREAP. The share of 13% renewable DH in 2010 is to be raised above 17% by 2020. The target is not too ambitious, but will be met by Denmark for sure.

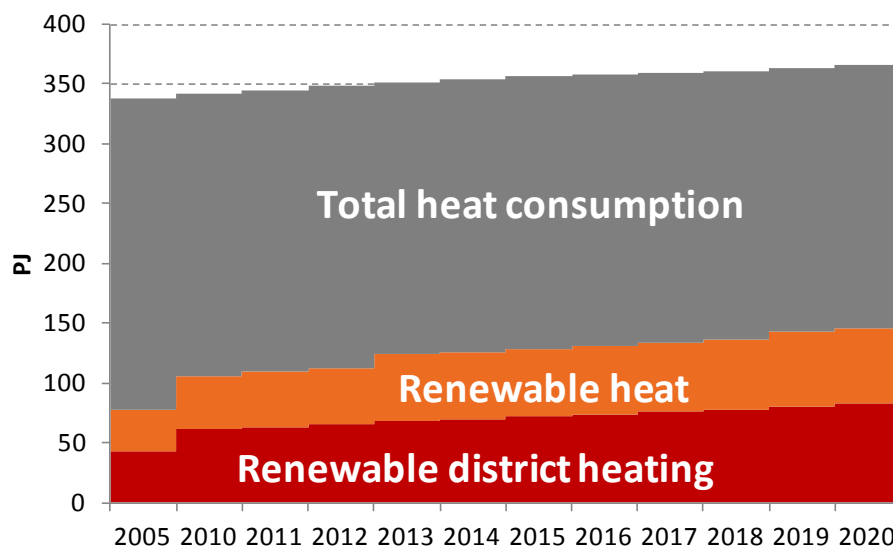


Figure 31 Renewable district heating consumption and total heat consumption to 2020, ktoe in Denmark
Source: NREAP Denmark

7.2.4 Regulation of District heating services

7.2.4.1 General regulatory setting

The district heating sector is regulated by the Danish Energy Agency (Energy Styrelsen). The majority of district heating plants are owned by consumers or by local authorities, municipalities and are expected to conduct a non-profit operation, resulting in the most cost-effective heat supply. Prices are set to allow for normal operation and long-term investment and maintenance as well.

Long-term policy goals are set by the Danish Energy Agreement of 2012. The Agreement is a strategic document accepted by a nearly unanimous majority (171 of 179) of the Danish Parliament, setting energy efficiency targets and actions to 2020, amounting to a 34% reduction in GHG emissions compared to 1990. Some of the actions targeted the building sector, such as: banning the installation of oil and gas fired boilers in newly built residential heating from 2013 and ban oil fired central heating in existing buildings with gas or district heating infrastructure from 2016. To finance the replacement of heating systems, government will introduce a tax on fuels used for space heating (even on non-fossil fuels, such as biomass).

Strategic Documents

- Danish Energy Agreement for 2012-2020 (2012)
- Ban on oil and gas boilers in new buildings
- Energy Strategy 2050 (2011)
- Ban on oil boilers
- National Renewable Energy Action Plan (NREAP 2010)
- 40% of heating to be supplied with renewable energies by 2020

Regulatory bodies

- Ministry of Climate, Energy and Buildings
 - Formulating policies to prevent climate change, manage energy and building policies
- Danish Energy Regulatory Agency
 - Regulation of the power, gas and heat sector, price setting and price cap regulation
- Danish Energy Agency
 - Providing database and statistics for Ministry and DERA

DH price setting allows for non-profit operation of heat suppliers. Annual heat revenues and costs are calculated by DERA and any difference is corrected in next year's price. A positive profit for instance would result in

lower heat prices next year while costs higher than revenues would mean higher regulated prices. The following costs may be justified when calculating the price of heat:

- Energy costs
- Salaries and other operating costs
- Investments
- External financing costs
- Losses from previous years
- Administration costs
- Additional costs due to taxes

7.2.4.2 Specific rules of RES based DH regulation

A carbon tax is introduced for fossil fuel based heat generation. Renewable energies are exempted from paying this tax. However, the Energy Agreement set out a new tax (Security of Supply tax) for space heating which would be paid by any kind of technology, to finance the renewable support. The base of the tax is the energy consumed.

Renewable district heating investment replacing fossil fuel capacities may receive support from the state. The subsidy is financed from a 500 million DKK (~67 Mn EUR) fund, set up to support the fuel change of 2013-2020. The fund provides 45-65% of the investment costs.²⁴

7.2.4.3 Specific rules for CHP regulation

CHP production had been subsidized in the 1980's and 1990's, but receives no support currently. Probably this contributes to the continuous reduction of CHP share to DH in Denmark in addition to other factors (stagnating electricity consumption coupled with increasing RES-E share, taxation of heating energy consumption, and increasing gas prices). While RES based DH shows continuous increase, fossil fuel based CHP heat production shows a steady fall in the last 5 years.

7.2.4.4 Other, non-fossil based DH

Waste incinerating plants have a unique price cap regulation. Waste processing CHPs face a complex problem: when producing power, heat and disposing of waste, revenues are generated in three different markets, and it is a question how costs should be allocated between these loosely interconnected (power and heat) or non-connected markets (waste and others).

Regulation so far allowed for a heat price equal to the cheapest substituting heat price in the region. So if the waste incinerator was working in the same area as a gas-fired CHP, it would receive a price cap equal to the price paid for the gas-fired production. However, in some cases this price would not cover the costs of production, in which case the waste incinerator would increase its prices for electricity or waste uptake. This would create a vicious circle, since in some cases, waste incinerators do compete for fuel. Higher waste fees would result in less waste sold to the specific plant, lower heat production and consequently the plant would supply fewer consumers. To alleviate this problem, a price cap regulation was introduced for waste incinerators. Furthermore, a substitution price approach would result in a price increase if the substituting fuel price hiked: a high gas price in a natural gas based area would result in higher waste-based heat prices, without cost-based fundamentals. In most cases, this created a perverse incentive of locating waste incinerating plants where the heat price would be highest (i.e. natural gas areas), but not coal heated areas, which emitted more GHG.

The new price cap model is setting a uniform price for all waste incineration plants. This cap is equal to the weighted average hot water price produced in central power stations (which is a quite low price, due to economies of scale).²⁵ The price cap will be updated annually, based on the previous year's production data and set

²⁴ <http://www.kpmg.com/global/en/issuesandinsights/articlespublications/taxes-and-incentives-for-renewable-energy/pages/denmark.aspx>

²⁵ The price of the two most expensive central power stations is disregarded

for the next year. So the 2015 price is announced in 2014, based on 2013 production and price data.²⁶ To allow time for the waste incineration plants to adjust, the older system of differentiated prices will remain in force until 2016 and will be phased out gradually. Price caps will be equal to the 2013 price caps indexed with inflation. Price caps are differentiated between gas-fired and non-gas fired power plants and central and decentralised units.

7.2.5 District heating policy tools

7.2.5.1 For district heating systems

Since the 1973 oil crisis, Denmark started to switch its oil-based residential heating to district heating in several waves. First, heating networks were built in urban areas, supplied by huge coal-fired power stations (so-called central power stations). In the 1990's a gradual decentralisation of heat production to smaller units and fuel switching to gas started. Decentralisation meant the installation of new, small heating capacities in rural Denmark, using gas, and renewable energy – mostly biomass – as a fuel.

On the demand side, various regulatory acts tried to set appropriate demand for district heating. Homeowners of existing and newbuild flats and houses are required to connect to an already existing district heating network. Moreover, electric heating and central gas heating is banned in newly build homes according to the 2010 building code. Existing houses are not allowed to use electric heating and will not be allowed to install oil boilers from 2016. The government offers financial assistance for building owners to replace their oil boilers.

Recent amendments (June 2014) of the Building Code made the individual heat and hot water metering a requirement in both existing and new buildings, if it is technically and economically feasible.²⁷

7.2.5.2 For RES based district heating

Investment support for RES-based DH:

Tax support

High tax levels are set for fossil fuels used for heating. Renewable fuels such as biomass are exempted from these taxes, thus receiving an 'implicit support'.

Feed-in

Furthermore, biogas used for heating receives direct support of 26 DKK/GJ from 2013 to 2016 and 10 DKK/GJ from 2016 to 2019. (RES-Legal)

7.3 Situation of DH in Estonia

7.3.1 General overview of the market

In Estonia, the dominant heating solution is district heating with around 70% of all heat sales coming from it.²⁸ In 2012, 51.8% of households heated their homes with district heating. This means that Estonia is one of the countries with the highest share of DH in heat supply. Also, the share of RES in DH is outstanding amongst the new Member States, making the country worth to assess in details. (Other heating options are: 28.3% stove or fireplace heating, 15.5% local central heating, 4.2% electrical heating.) Currently there are some 200 companies – producers, distributors and traders – supplying district heating in the country.

²⁶ <https://www.retsinformation.dk/Forms/R0710.aspx?id=144617>

²⁷ BEK nr. 563 af 2. juni 2014. Gældende, §6-7

²⁸ Estonian Competition Authority:

http://www.konkurentsiamet.ee/public/Baltic_Electricity_Market_2011/Regulation_of_utilities_in_Estonia_ots.pdf

7.3.2 District heating market characteristics

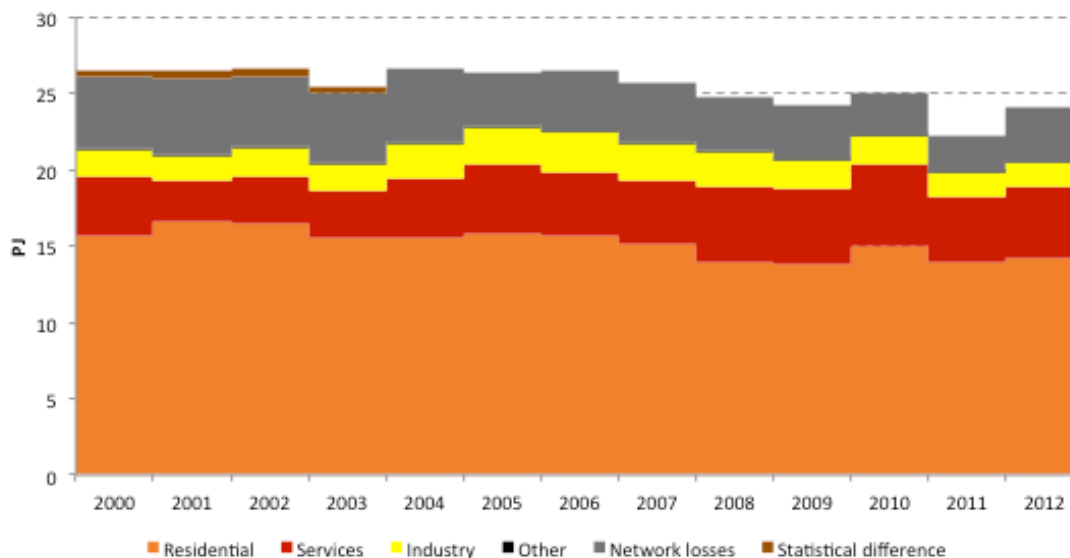


Figure 32 Network losses and main consuming sectors of district heating in Estonia
Source: Eurostat

The structure of district heating use was largely stable in Estonia since 2000: households remain the largest district heat consuming sector with a share of about 60% of the total consumption, while services showed an increasing share, growing to 20% by 2012. In network losses we see a slightly decreasing trend: while in 2000 close to 20% of all district heat supply was lost, this ratio was between 10-15% during 2007-2012. Estonia’s district heating pipeline system is 1450 km long.²⁹

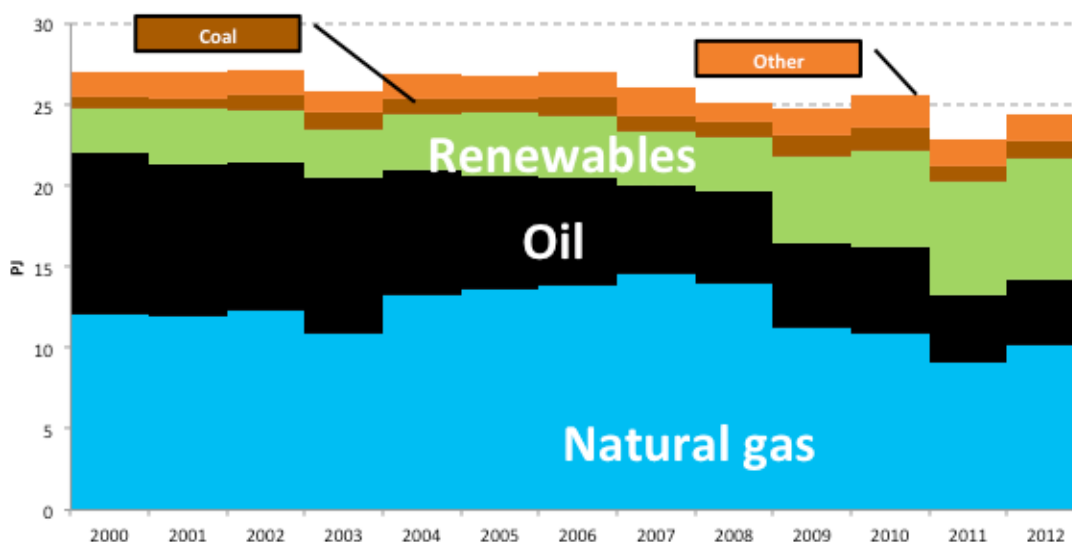


Figure 33 Main fuels used for DH production in Estonia
Source: Eurostat

In 2012 natural gas was still the most important fuel used for district heating production with 41%, but throughout the last five years renewables were catching up, and by 2012 they provided almost one-third of all fuels used. Oil has, on the other hand, lost most of its importance since the early 2000s, with its share falling below 10% by 2012.

²⁹ www.euroheat.org/Estonia-75.aspx



Figure 34 Share of CHP production in total DH generation in Estonia
Source: Eurostat

The share of CHP in district heating generation was mostly in the 30-40% range since 2000, with a decreasing trend until 2008 and a sharp increase in 2009, and remaining at around 40% since then. The 2009 increase may be at least partly explained by the Fortum Tartu CHP plant, which started operation in that year with a heat production capacity of 52 MW.³⁰

7.3.3 Future vision of DH in national planning

In Estonia's national renewable energy action plan (NREAP) the RES target in all district heating production was 33% for 2013, compared to the 21% value in 2005 stated in the NREAP. (Eurostat data, however, indicate 14% RES share in district heating for 2005). Based on Eurostat data, RES-based district heating production was 31% in 2012 (see

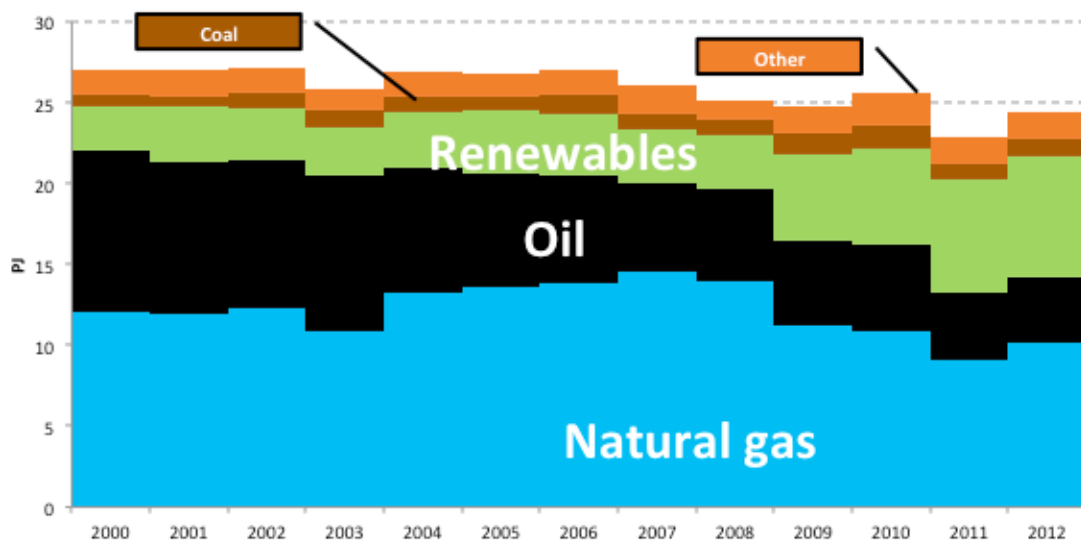


Figure 33), which was close to meeting the 2013 target stated in the NREAP.

³⁰ [http://metso.com/Automation/magazinebank.nsf/Resource/309_results_automation_p24-25/\\$File/309_results_automation_p24-25.pdf](http://metso.com/Automation/magazinebank.nsf/Resource/309_results_automation_p24-25/$File/309_results_automation_p24-25.pdf)

Figure 35 shows the share of RES-based district heating in Estonia's total energy consumption for heating and cooling.³¹

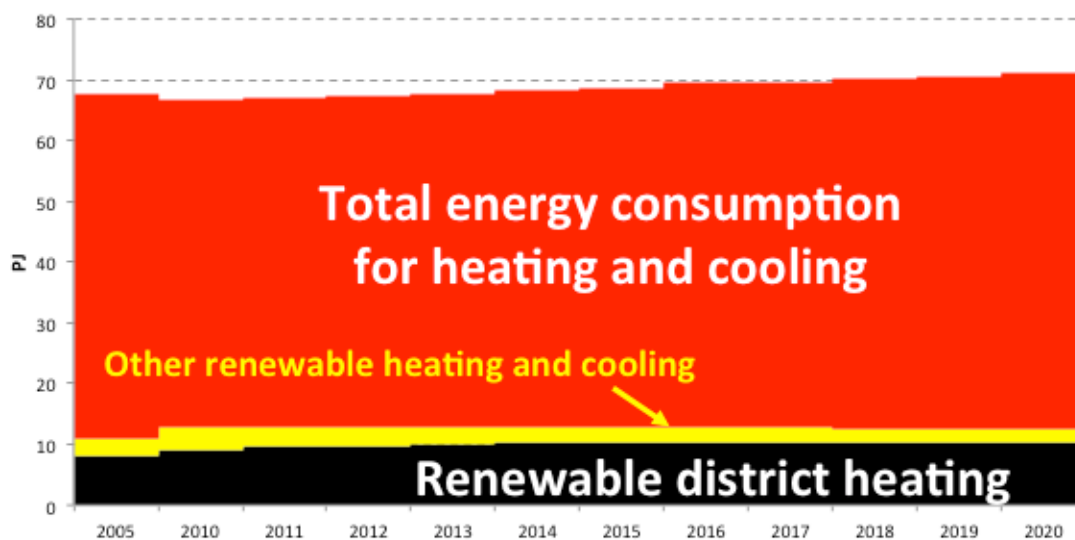


Figure 35 Renewable district heating consumption and total heat consumption to 2020, ktoe in Estonia
Source: NREAP Estonia

Meanwhile, in gross final consumption of total heating and cooling Estonia's NREAP indicate a RES share of 16.3% for 2005 with a 2020 target of 17.6%.

7.3.4 Regulation of DH services

7.3.4.1 General regulatory setting

In Estonia the responsible body for district heating regulation is the Estonian Competition Authority (ECA), which oversees the activities of about 200 entities – producers, distributors and sellers – involved in the supply of district heating. The current market structure is a result of a privatization process which started in 1998, and district heating providers are mostly private companies, with only a handful of them remaining in the ownership of municipalities. The Estonian district heating market is based on a zoning model, where a zone represents a geographical area where district heating is the preferred option over other kinds of heating systems, and in each such zone one or more enterprises are given rights for heat supply following an application procedure. Applications are evaluated by the ECA, and the ECA is also responsible for the approval of maximum prices for heat, which prices are first submitted by the undertakings involved in heat sales for approval. These price caps are set separately for heat produced and for heat sales for final consumers (enterprises can sell heat directly to end consumers or via distributors). In the District Heating Act, there is no differentiation between household and industrial consumers regarding the maximum applicable prices, or any other differentiation between different consumer groups. The regulation of Estonia's district heating sector is based on so-called district heating regions which are established by municipalities and mean that if a geographical area has an existing district heating region then in that area the use of district heating is compulsory – only customers using renewable sources for heating can be exempted from the compulsory connection.³² As in the case of maximum prices, the legislation does not differentiate between industrial and household groups in this obligation.

³¹ National Renewable Energy Action Plan of Estonia (NREAP)

³² IEA Energy Policies Beyond IEA Countries, Estonia 2013

7.3.4.2 Methods of regulation³³

Since Estonia's District Heating Act entered into force in 2003, district heating suppliers operate with regulated prices (price caps) which are applied on a zone-specific basis. Each supplier – producers, distributors and sellers – must submit maximum prices to the ECA for approval: these prices should be submitted separately for each zone (district heating region) in which the enterprise is involved in the sales of heat. Maximum prices are applicable for all end consumers, whether they be households or industrial consumers, and sales at lower prices than the price cap is possible. All price caps are applicable for up to three years.

According to the District Heating Act, maximum prices should be set in a way that ensures that:

- the necessary operating expenditures, including expenses incurred in relation to the production, distribution and sale of heat are covered,
- any investments necessary in order to perform the operational and development obligations can be made,
- environmental requirements are met,
- quality and safety requirements are met,
- and that justifiable profitability is ensured.

The district heating undertakings are obliged to monitor factors which are independent from their operations but can affect the price of heat: in case an enterprise observes a development in these factors which could lead to a reduction in the end-user price of more than 5% then the enterprise should notify the ECA and submit a new maximum price for approval.

The current zoning system allows sizeable regional differences in district heating prices. In general, small district heating regions are the ones where heat prices are higher, which is due to several factors: in these smaller zones the fuels used for district heating are predominantly oil shale and natural gas, which are relatively expensive; low sales volumes and the aging production equipment results in low efficiency of heat sales in these regions, also driving up prices. In mid-2013 the weighted average price cap in 89 small regions (regions where annual heat sales are below 10,000 MWh) was 70.99 €/MWh, while the average of 33 larger areas was a considerably lower 57.96 €/MWh.³⁴

Competition between producers is ensured via a tendering process: if multiple producers intend to enter the market in a district heating region, or in case there is a necessity for new producing capacities, the network operator should organize a tender, where in principle the most cost-efficient offer should be selected. However, if it is possible, heat produced from renewable energies, renewables-based cogeneration, waste, peat or carbonization gas should be the preferred option. While there is no obligation that these technologies should be given priority access, due to various support schemes available for RES, renewables-based heat production or heat produced by CHP plants is usually the most cost-efficient option.³⁵

7.3.4.3 Specific rules of RES based district heating regulation

Estonia's District Heating Act states that in district heating regions producers shall be chosen by a procedure in which "if possible, preference shall be given to heat produced from predominantly renewable energy sources or heat produced predominantly in an efficient cogeneration regime from renewable energy sources, from waste within the meaning of the Waste Act, from peat or from carbonisation gas obtained as a result of the processing of oil shale, and to the best clean technologies currently available."³⁶

Apart from this, however, there is no specific treatment for renewables in Estonia's district heating legislation.

³³ Estonia's District Heating Act: <https://www.riigiteataja.ee/en/eli/ee/530102013083/consolide/current>

³⁴ Republic of Estonia Competition Authority Annual Report 2013

³⁵ Heating & Cooling in Estonia: Connection to the grid, <http://www.res-legal.eu/search-by-country/estonia/single/s-res-hc/t/gridaccess/aid/connection-to-the-grid-17/lastp/123/>

³⁶ District Heating Act, §14 (1)

7.3.4.4 Specific rules for CHP regulation

According to Estonia's Electricity Law,³⁷ every five years the Ministry of Economic Affairs and Communication shall prepare a development plan for the electricity sector included an analysis of the national potential for efficient cogeneration. Support for production exists in case electricity is generated from efficient CHP plants – the definition of efficient plants is set out in the Law –using biomass or waste, or in efficient small CHPs with a generation capacity not exceeding 10 MW. The support is based on the kWh of electricity produced.

Investment support exists for the construction of CHP plants, the reconstruction of boiler houses to accommodate RES-based operation and for the reconstruction of the district heating network to improve energy efficiency. These subsidies are allocated following an application process. Biomass, biogas and geothermal energy are the eligible technologies. Projects which are not eligible include:

- construction and reconstruction of CHP plants with a capacity more than 2 MW outside of Estonian islands,
- boiler houses with a capacity of more than 4 MW,
- projects with a total budget exceeding 50 million euros.

This support, similarly to some other supports for RES-based district heating (see section 7.3.5.2 below) are provided from the EU's Structural Funds.

Apart from these, efficient cogeneration is one of the technologies which the District Heating Act sees as a preferred option when choosing producers to supply to the district heating grid (see section 7.3.4.3 above).

7.3.4.5 Other, non-fossil based district heating

Currently a decreasing share of natural gas for use in district heating can be observed, which is being displaced by wood and peat as less expensive alternative energy sources.³⁸ The Estonian Competition Authority thinks that, along with CHP, peat and wood are sustainable options for district heating in areas where the district heating supply is based on the more expensive fossil fuels (natural gas and oil). The switch to use peat for heating is also important as Estonia has considerable resources of peat (and oil shale) domestically, while oil and natural gas is mostly imported. While prices of peat and wood are determined by the market, for both peat and wood there is the reduced 5% VAT rate applied instead of the standard 20% rate, and both are exempted from fuel excise duties.³⁹

7.3.5 District heating policy tools

As a result of Estonia's energy policy before the dissolution of the USSR, in most parts of the country district heating is accessible, meaning that even in sparsely populated areas district heating is usually the dominant heating option. In 2013 there were 230 district heating regions in Estonia, of which 122 were small zones, each with less than 10,000 MWh of annual heat sales; in 53 zones heat sales remain below an annual 3,000 MWh. This has led to a heating system with a lot of inefficiencies. Hence, the Estonian Competition Authority argues that the system of district heating regions should be discontinued to abandon district heating as a preferred option in areas where district heating is relatively costly and switching to other, local heating methods would be more cost-efficient. This at the same time could, as the ECA argues, lead to the discontinuation of price regulation in these areas, leading to lower heating costs for consumers in case they are able to switch to local heating options. However, for those customers who would continue to use district heating in these areas the end of price regulation would mean higher costs. Hence, the ECA emphasizes that detailed plans are necessary to decide where to maintain district heating regions. Nevertheless, the penetration of district heating in Estonia seems to be larger than it would be reasonable based on cost-efficiency.

³⁷ Accessed at www.legaltext.ee

³⁸ Estonian Competition Authority:
http://www.konkurentsiamet.ee/public/Baltic_Electricity_Market_2011/Regulation_of_utilities_in_Estonia_ots.pdf

³⁹ <http://www.oecd.org/site/tadffss/EST.pdf>

7.3.5.1 For district heating systems

Investment support exists for the reconstruction of the district heating network to improve energy efficiency (See section 7.3.4.4).

There is no binding obligation for connecting DH systems. As district heating is the dominant heating option in Estonia, policies prefer a more efficient district heating network with a growing use of renewables, but no further extension of its use is supported. Furthermore, as district heating is considered to be inefficient in many smaller, less densely populated region, the idea of switching away to local heating options is even endorsed by the regulator.⁴⁰

7.3.5.2 For RES based district heating

Currently there are multiple initiatives for supporting RES-based district heating, most importantly in the form of investment supports. The investment support is partly financed by the European Regional Development Fund (ERDF) under the “Extended use of renewable energy sources for the generation of energy” program, which had a single application round in 2009 and awarded grants for the reconstruction of boiler houses and district heating networks as well as the construction of CHP plants which are required to sell energy to district heating networks. The budget of this round was 150 million Estonian kroons (9.6 million euros in 2009) and supported 17 projects. Currently there are no plans for additional financing from the ERDF. Another source of funds is the Green Investment Scheme (GIS) which finances the reconstruction of district heating network from CO₂ quota sales under the so-called “Extended use of renewable energy sources for the generation of energy and reconstruction of district heating networks” program.⁴¹ This is handled through the Estonian Credit and Guarantee Fund (KredEx), and mainly provides grants and loans for apartment building reconstructions, including but not limited to the more efficient use of district heating. For example in 2011 KredEx operated with a total budget of 28 million euros to be spent on residential renovations.⁴²

Additionally, Estonia also intends to spend approximately 78 million euros on renovating its heat distribution networks between 2014-2020, which will be funded from the EU Structural Funds. The program coordinator for all investments is the Estonian Environmental Investment Centre (KIK).⁴³

7.4 Situation of DH in Germany

7.4.1 General overview of the market

In absolute terms, Germany is one of the largest markets for district heating in Europe. Due to pre-1990 policies district heating is more widely used in the Eastern than in the Western parts of Germany: in the territories of the former West-German state the market share of district heating in the heating market is only 9%, in the Eastern regions it is around 30%. In Germany as a whole, around 30% of heat is supplied by district heating in cities with over 100,000 inhabitants.⁴⁴

In 2013, approximately 13% of Germany’s total heating need was served by district heating.⁴⁵ The number of German citizens served by district heating was 9.7 million, or 12% of the country’s population. 47% of district heating is consumed by residential customers, 36% by public buildings and enterprises providing services, while

⁴⁰ Republic of Estonia Competition Authority Annual Report 2013

⁴¹ <http://www.kik.ee/en/energy/renewable-energy>

⁴² <http://www.promitheasnet.kepa.uoa.gr/Promitheas4/images/file/D.5%20Estonia.pdf>; www.kredex.ee

⁴³ <https://www.mkm.ee/en/objectives-activities/energy-sector/heating-sector>

⁴⁴ <http://ecoheat4.eu/en/Country-by-country-db/Germany/Overview-of-National-DHC-Market/>

⁴⁵ Euroheat&Power: “Country by Country 2013 – Germany”

the remaining 18% is consumed by the industry.⁴⁶ The total length of the district heating pipeline system is around 100,000 km,⁴⁷ while Germany's district heating production capacity is approximately 57,000 MWh. In 2011 there were 239 enterprises involved in the provision of district heating.⁴⁸

In Germany, district heating and cooling is considered a particularly important instrument in both reducing primary energy consumption and improving Germany's security of supply: according to the district heating association AGFW, until 2030 the combined use of district heating and combined heat and power production could reduce primary energy consumption by 4% and national energy imports by 15%.⁴⁹

7.4.2 District heating market characteristics

Though Germany introduced new, more favourable legislation in 2009 to support the dispersion of district heating as a more environmentally friendly heating option, a more rapid uptake has not yet started. District heating sales have been stagnating throughout the last decade, mostly due to the weak price competitiveness compared to alternative heating options like gas and oil boilers.⁵⁰

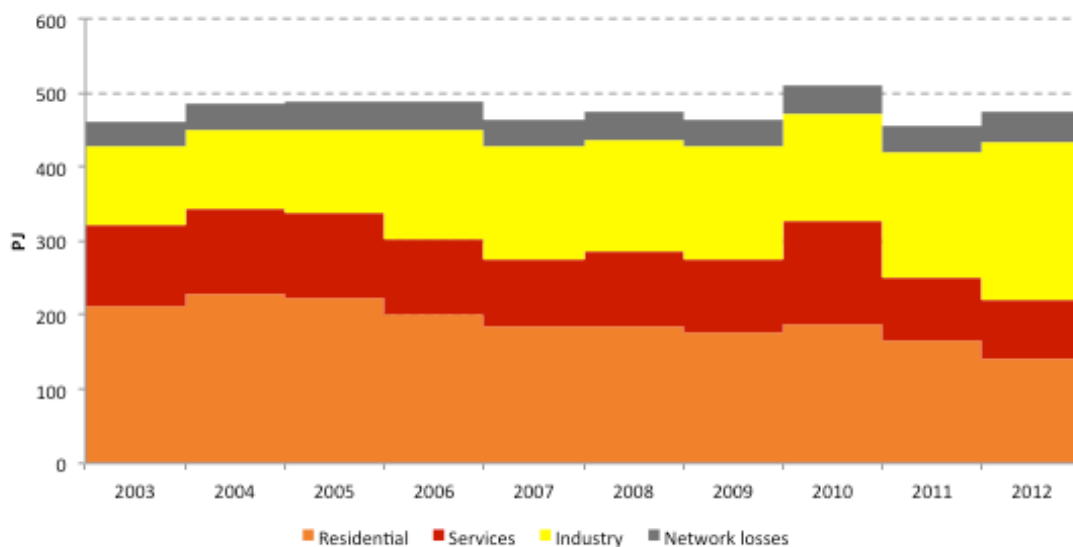


Figure 36 Network losses and main consuming sectors of district heating in Germany
Source: Eurostat

In the composition of district heat consumption we can see a significant shift towards a larger share of industrial use and a smaller share of households and the services industry. Network losses were stable, amounting to a moderate 7-9% in the observed time period.

⁴⁶ <http://www.cospp.com/articles/print/volume-10/issue-4/features/district-heating-in-germany-a-market-renaissance.html>

⁴⁷ http://www.districtenergy.org/assets/pdfs/2011Annual_Conf/Proceedings/P3LUTSCHRoadmapGermanyIuw.pdf

⁴⁸ <http://www.euroheat.org/Germany-78.aspx>

⁴⁹ http://ecoheat4.eu/en/upload/Documents/EcoHeat4EU_Country_pdf/Germany/DE%20WP6%20Roadmap%20report.pdf, p. 45.

⁵⁰ <http://ecoheat4.eu/en/Country-by-country-db/Germany/Overview-of-National-DHC-Market/>

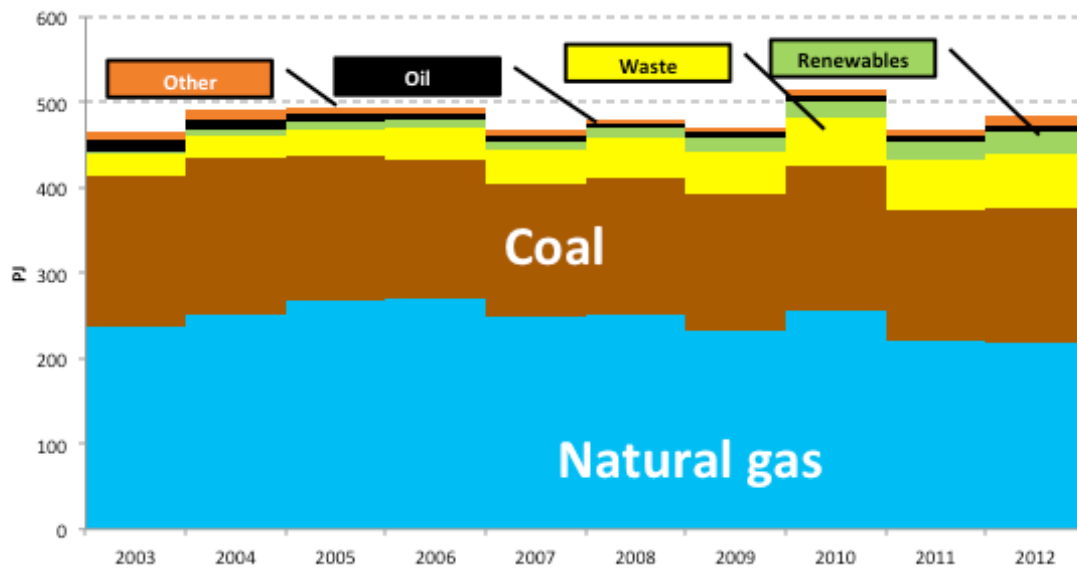


Figure 37 Main fuels used for DH production in Germany
Source: Eurostat

Based on 2012 Eurostat data, heat provided via district heating is predominantly produced using natural gas (45%) and coal (33%), the remainder is provided by waste (13%), renewable sources, mostly biomass (6%), oil (2%) and other fuels (2%).

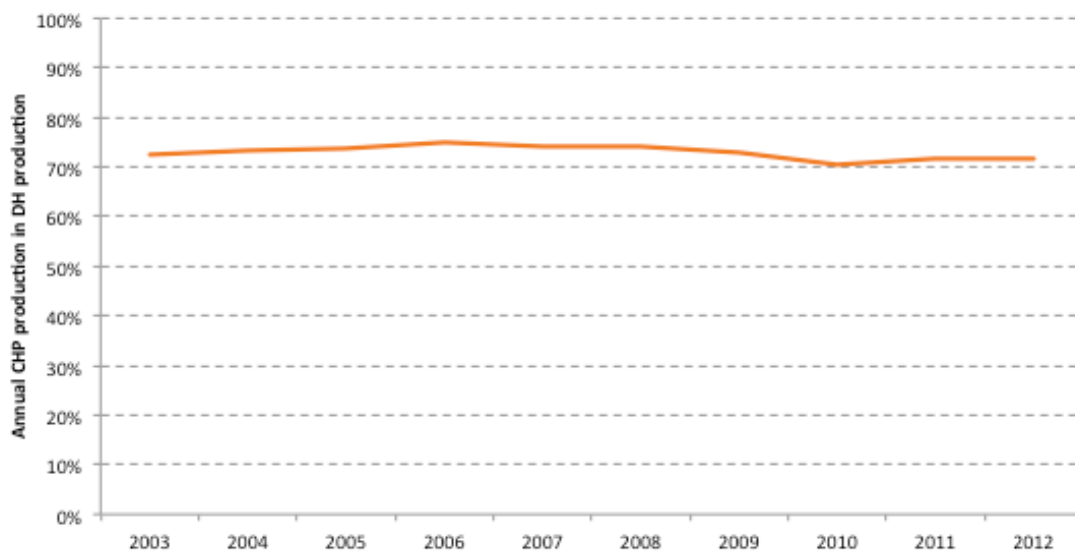


Figure 38 Share of CHP production in total DH generation in Germany
Source: Eurostat

Based on the same Eurostat data, the share of district heat generated by CHP plants was 72% in 2012, and has been stagnating at this level in the last ten years.

7.4.3 Future vision of DH in national planning

In line with Germany’s target of 25% CHP share in electricity production by 2020 – which was set by the “Energiewende” policy in 2011 –, the country’s district heating association, the AGFW expects the market share of district heating in all heat production to increase to 18-22% by 2020, a moderate expansion compared to the

13% share currently. German policy-makers also see a long-term target of 65% district heating by 2050.⁵¹ Present study by Fraunhofer IFAM indicates that the 25% CHP share is unlikely to reach due to the loss making character of gas fired plants under present conditions. In biomass CHP the government capped capacity expansion to 100 MW per year, but according to the previous assessment only half of it would be realized.⁵²

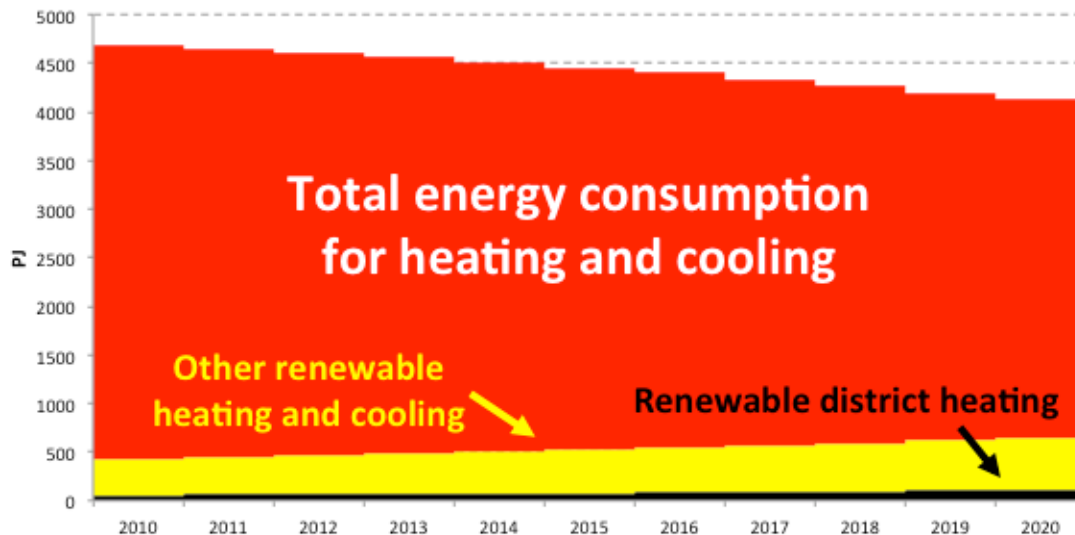


Figure 39 Renewable district heating consumption and total heat consumption to 2020, ktOE in Germany
Source: NREAP Germany

In Germany's national renewable action plan (NREAP) the expected size of RES-based district heating is 2560 ktOE in 2020, almost doubling from the 1370 ktOE in 2010. Nevertheless, this would only mean a renewable district heating share of about 2.5% in total heating and cooling consumption by 2020. This can be compared with a 14% target share of renewables (not only renewable district heating) in all heating and cooling by 2020.

7.4.4 Regulation of DH services

7.4.4.1 General regulatory setting

Germany's district heating market is a liberalized competitive market with approximately 400, mostly vertically integrated district heat suppliers.⁵³ District heating companies can set competitive prices, while the competition authority (Bundeskartellamt) monitors excessive profits based on Germany's competition law.⁵⁴ A comprehensive sector inquiry⁵⁵ was carried out by the Bundeskartellamt in August 2012, and found substantial differences in prices – considerably larger ones than what can be observed in the competitive electricity and gas sectors – but only a few cases of abusively excessive pricing were identified. The Bundeskartellamt concluded that these sizeable price differences may indicate a lower than desirable level of competition, but argued that unbundling and the introduction of price regulation would not be advisable.

There is no state-wide regulation of district heating in Germany. Instead, district heating supply is either regulated on the level of federal states or indirectly, through the CHP Law (Kraft- Wärme-Kopplungsgesetz, KWKG),

⁵¹ AGFW presentation: <http://dhc12.ttu.ee/presentations/1-3.pdf>, page 9.

⁵² Platts Power in Europe 2014 October

⁵³ <http://www.cospp.com/articles/print/volume-10/issue-4/features/district-heating-in-germany-a-market-renaissance.html>

⁵⁴ http://www.lsta.lt/files/events/121204_FORTUM/10_Overview%20of%20DH%20pricing%20and%20regulation%20in%20Europe_H-P%20Korhonen.pdf

⁵⁵ http://www.bundeskartellamt.de/SharedDocs/Publikation/EN/Sector%20Inquiries/Sector%20Inquiry%20District%20Heating%20-Final%20Report.pdf?__blob=publicationFile&v=2

which was last modified in 2012. A federal law which affects district heating supply more directly is the Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare-Energien-Wärmegesetz – EEWärmeG): this law also requires heat planning on the federal level in order to create legal certainty and to help global environmental protection.

The KWKG law was created and in 2009 modified (KWKmodG 2009) to help the growth of district heating and by this support primary energy savings and Germany's climate goals. The first review of its effects made it clear that the law that it was successful in helping to maintain Germany's existing district heating production but failed to induce further growth in the share of DH.

According to the German district heating association AGFW, one of the biggest hurdles for the spread of district heating is the EU ETS system, which only accounts for CO₂ emission reductions by power plants with installed capacities over 20 MW – thereby the small CHP installations which are responsible for much of district heating supply, are left out, resulting in a distorted market for their detriment. This reasoning however is turned to the opposite since 2013, as the power plants have to buy carbon credits and it is not allocated for free. However the 20 MW size differentiation in the ETS market still introduces distorting elements in both the electricity and heat markets. The current policy agenda of the AGFW also comprises the revision of the CHP act, including the abolition of the 20% support limit for DH investments (see section 7.4.5.1) and the reduction of administrative burden for district heating investment support. Furthermore, the AGFW is an advocate for better DH planning at the municipality level and for the inclusion of district heating in the national 2020 energy strategy, from which it is currently omitted. Another idea supported by the AGFW is a reduced VAT rate for district heating.

7.4.4.2 Methods of regulation

Most of the regulation of Germany's district heating sector is the responsibility of municipalities. Article 16 of the EEWärmeG law states that, in line with municipal codes, municipalities have the right to establish compulsory connection to and use of a district heat and cold supply network. The aim of this possibility is to create a more favourable investment climate for district heating by securing DH supply in an area which has not yet been connected to a district heating grid. According to the text of the law, "municipalities and municipal associations can make use of a national legislation which authorises them to justify the obligation to be connected to and use the public district heating network, for the purpose of climate and resource protection."⁵⁶ As of 2011, only 9% of all district heat was delivered to such mandatory connection zones. The rare use of such mandatory zones can be partially explained by the aversion of inhabitants as the heat market in Germany was a liberal market from the onset and they are accustomed to free choice among heating options.⁵⁷ In the sector inquiry mentioned above in Section 7.4.4.1, the competition authority Bundeskartellamt argued that a more intensive competition between different heating systems would be desirable to achieve lower DH prices, and thus "compulsory connection to the district heating system should remain the exception rather than the rule". Accordingly, the Bundeskartellamt states that district heating suppliers should be more exposed to the competition of small and highly efficient CHP than what is required by the CHP Act.

The technical and commercial terms of district heat supply are laid down in the AVBFernwärmeV ("Ordinance on the general conditions for the supply of district heating"). In this ordinance, §24 (4) also stipulates that when changing prices for district heat provision, suppliers must be transparent in their price calculation and also must adequately take into account generation costs and related heat market conditions.⁵⁸

Hamburg in the forefront of renewable district heating development^{59, 60}

⁵⁶ Germany's National Renewable Energy Action Plan

⁵⁷ http://ecoheat4.eu/en/upload/Documents/EcoHeat4EU_Country_pdf/Germany/DE%20WP6%20Roadmap%20report.pdf

⁵⁸ http://www.gesetze-im-internet.de/bundesrecht/avbfernw_rmev/gesamt.pdf

⁵⁹ http://www.iba-hamburg.de/uploads/tx_cal/media/120308_Praesentation_Jan_Gerbitz_BE12.pdf

⁶⁰ <http://www.iba-hamburg.de/en/projects/energiebunker/projekt/energy-bunker.html>

The city of Hamburg, Germany's second largest city, holds an important position in the country's district heating landscape not only as a forerunner – Hamburg utilized CHP-based district heating as early as in 1893 – but also as a centre for district heating innovation.

The market share of district heating in Hamburg is around 19% in all heat consumption. There are four DH providers in the city: the dominant supplier is Vattenfall with a market share of over 80%. District heating is mostly used by private households and commercial consumers, with a smaller role of industrial usage.

While the largest player, Vattenfall produces district heat predominantly (60%) from coal, while the smaller providers like E.ON and RWE mostly produce using natural gas with a smaller role biomass and solid waste. This resulted in high CO₂ emissions comparable to the level of emissions by oil-firing boilers, a problem which the city decided to tackle by partly by supporting the construction of “regenerative” heating networks in the framework of the so-called “Renewable Wilhelmsburg” Climate Protection Concept.

One element of this concept is the establishment of a so-called Energy Bunker – a former air raid bunker transformed into a power plant with a mixed use of a biogas CHP, a wood chips boiler, solar thermal and photovoltaic power as well as waste heat, coupled with hot water storage. This demonstration project plant is able to supply 3000 households with heat and 1000 households with electricity, intended to show the possibilities in the balancing the fluctuations in energy production from intermittent renewable sources. The bunker was established by local energy utility Hamburg Energie using two sources of financial support: EUR 2.08 million from the EU's regional development fund (ERDF) representing 27% of total investment costs, and an additional EUR 1.35 million from Hamburg's climate protection funds. Hamburg Energie currently seeks to extend the district heating grid supplied by the bunker with new users. Construction of the bunker was completed in March 2013, while the heat grid expansion is expected to be completed in 2015.

Another part of the concept – an ongoing project also partly financed by Hamburg Energie – aims to create an integrated energy network in the Wilhelmsburg Central area, a district heating network aggregating decentralized supply of several producers into a virtual power plant. The grid would be supplied by waste heat from various renewable producers (using either solar thermal, biogas CHP or wood pellets), complemented with two central CHP plants and two biogas boilers. An interesting aspect of this project is that the project developers build on the idea of establishing a district heating zone for the area supplied by this virtual plant. In the case of Hamburg, the municipality is empowered by the local Climate Protection Law to create a district heating zone where connection is compulsory to a district heating grid supplied by either CHP, industrial waste heat or renewables. This would not be unprecedented: district heating zones have been established in Hamburg in more than 50 cases so far. This project is supported by EUR 1.1 million from Hamburg's climate protection funds.

7.4.4.3 Specific rules of RES based DH regulation

The German act on the use of renewable energy sources in the heating sector (EEWärmeG), introduced in 2008, set the target of increasing the share of renewables in heat production 6% to 14% by 2020. This law also suggested using district heating in conjunction with cogeneration. The act introduced obligations about the renewable energy use for heating and cooling that owners of newly constructed buildings and the public sector must meet. The EEWärmeG states that the use of district heating and cooling can be an alternative measure for the direct use of renewables in case:

- a “substantial share” of the heat and cold comes from renewable energies,
- or in case at least 50% of it comes from installations that use waste heat,
- or at least 50% comes from CHP,
- or at least 50% comes from the combination of the above measures.

According to the law, obligated parties need to prove that they are meeting their renewable energy obligation by acquiring a certificate from the network operator.

7.4.4.4 Specific rules for CHP regulation

CHP is regulated by the modified CHP Act (KWKmodG), the latest version of which came into effect in July 2012. A key objective of this legislation is the increased use of CHP plants for electricity production; however, this Act does not regulate the use of renewables or district heating selectively.

According to the latest CHP law, only highly efficient plants are supported by a surcharge, currently amounting to 15–51.1 EUR/MWh. According to the AGFW, the total spending on district heating investment support and on the modernization and development of CHP is over EUR 10 billion.⁶¹ To be eligible for the surcharge, an important criterion is that they do not displace existing, CHP-supplied district heating capacities. Plants in this law are regarded highly-efficient based on the efficiency criteria of Directive 2004/8/EC of the European Parliament and the Council. The surcharge is paid by the grid operators as a fixed premium for CHP electricity on top of the market price for a limited time (30.000 operating hours). The surcharge is differentiated based on the capacity of CHP plants. The costs of these subsidies are shared among all electricity consumers, who currently pay 0.02 to 0.5 EUR/MWh in their energy bills.⁶² This means that in Germany there is a significant level of cross-subsidization between electricity and district heating consumers.

The new 2012 law set 2020 as the target year of the earlier 25% CHP aim in electricity production, and also raised the per-kWh premium given to CHP plants.

7.4.4.5 Other, non-fossil based DH

The required share of 50% waste heat in district heating supply is one of the possible prerequisites for district heating to be considered as an alternative measure for direct renewable energy use requirements. (See section 7.4.4.3 for more details.)

7.4.5 District heating policy tools

7.4.5.1 For district heating systems

Apart from local support schemes which have been in place for some time, federal level support also exists for newly built heating pipes: the 2009 modification of the CHP law (KWKmodG 2009) introduced an incentive investment grant for the expansion and extension of district heating networks. To receive this grant, the DH network must be supplied with at least 60% heat from CHP plants and must begin operation at the latest by the end of 2020. Originally, investment grants supported network expansion projects by up to 20% of the costs with a cap of EUR 5 million per project, and were granted on a basis of EUR 1 per millimetre diameter and meter length of a DH pipe.⁶³

The newest modification of the CHP law, introduced in 2012, extended the support for district heating and cooling grid investments, which is now at most 40% of construction costs for pipelines with a diameter of up to 100 mm, and up to 30% in case of a diameter above 100 mm in case of new installations, and also raised the maximum support level to EUR 10 million per project. The aggregate annual budget of investment grants for network extensions (including heat and cold storage investments) shall not exceed EUR 150 million.⁶⁴

⁶¹ Dr. Heiko Huther: District Heating and District Heating Research in Germany, AGFW presentation, Seoul, November 2011

⁶² German CHP law as of 2012: http://www.energieagentur.nrw.de/_database/_data/datainfopool/KWK-G%202012_07_12.pdf

⁶³ <http://www.cospp.com/articles/print/volume-10/issue-4/features/district-heating-in-germany-a-market-renaissance.html>

⁶⁴ German CHP law as of 2012: http://www.energieagentur.nrw.de/_database/_data/datainfopool/KWK-G%202012_07_12.pdf

According to a study carried out by the AGFW in 2009, of the available funds of EUR 150 million the district heating sector were able to use up only EUR 30 million.⁶⁵ The low utilization of available grants remains a problem.

7.4.5.2 For RES based district heating

There are a number of options for the support of district heating supply and investments. The German Renewable Energy Act (EEG) also offers bonus payments for CHP plants that use renewable energies provided their heat production is fed into district heating networks.

There are other funding options available that indirectly support the development of local heating systems, for example low-interest loans provided by the state-owned development bank KfW for various renewable technologies of heat production, including biogas, biomass, geothermal energy and solar thermal energy.

Furthermore, the BAFA (Federal Office of Economics and Export Control) provides investment support (in the framework of the Market Incentive Programme, or MAP) for heat produced in existing buildings, and eligible technologies are biomass, geothermal energy and solar heat energy. The support is divided into three parts: basic, bonus and innovation support, which are differentiated according to the three supported technologies.⁶⁶ District heating networks are eligible for this type of funding if:

- they utilize at least 20% solar energy provided that the remaining heat is produced “almost exclusively” by high efficiency CHP plants or heat pumps, or
- in case at least 50% of heat is supplied from renewable energy⁶⁷

Regarding the overall support for the use of renewables in heating and cooling networks, the EEWärmeG law originally assigned an annual EUR 500 million as support from the federal government’s budget.

7.5 Situation of DH in Hungary in general, role of RES based DH

7.5.1 The Hungarian DH market

Hungary gives an interesting example of a New Member State which is characterised by a shrinking DH market, in spite of the many policy tools introduced to support the DH market, e.g. tax advantages, CHP heat subsidisation. In addition, Hungary has changed its DH regulatory regime several times in the last decade, which makes it an interesting case study from regulatory point of view. The examination of regulatory environment is also interesting as although there is significant potential of renewable heat production in Hungary (mainly from biomass and geothermal sources) the regulatory and policy tools do not facilitate investments in this field.

7.5.2 District heating market characteristics in Hungary

Concerning the share of district heating in households Hungary is middle-ranked in Europe – about 650,000 flats (15% of households) in 97 cities are connected into a district heating system.

⁶⁵ http://ecoheat4.eu/en/upload/Documents/EcoHeat4EU_Country_pdf/Germany/DE%20WP6%20Roadmap%20report.pdf

⁶⁶ Support schemes for heating and cooling in Germany, www.res-legal.eu

⁶⁷ Germany’s National Renewable Energy Action Plan, pp. 59-61.

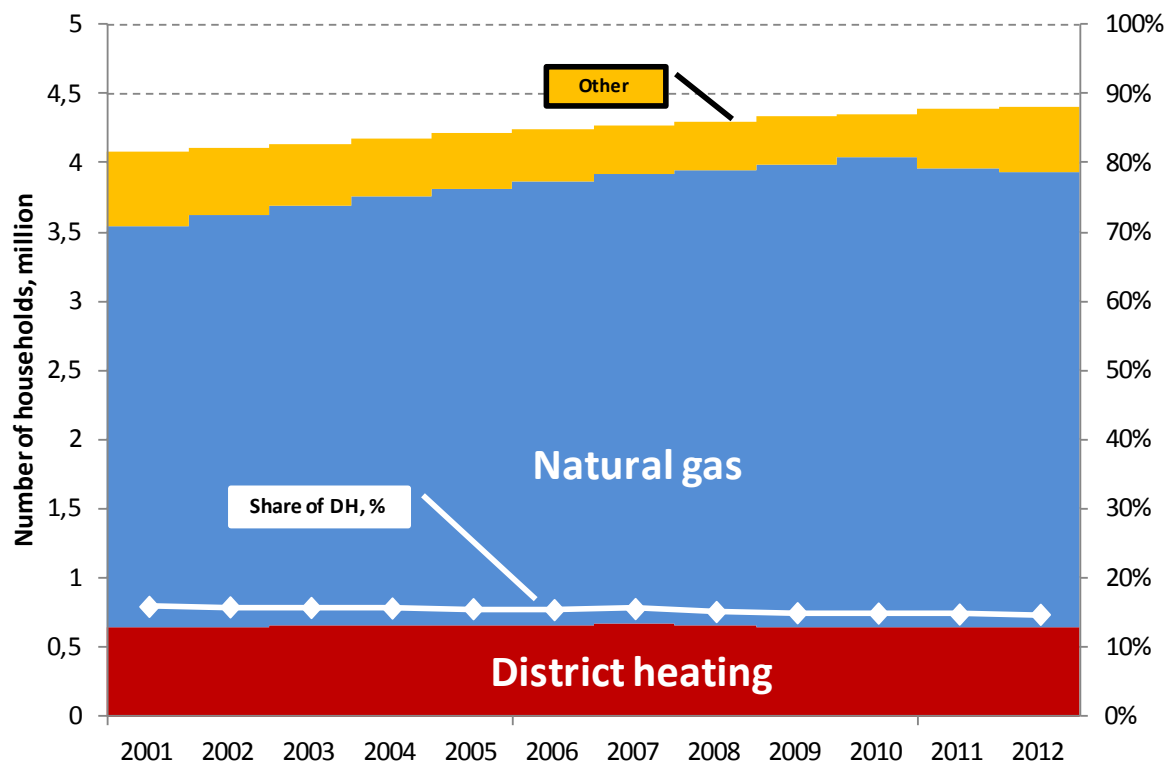


Figure 40 Share of different heating methods in households in Hungary
Source: KSH, MEKH

The main heating solutions in Hungarian households are district heating and individual gas heating. Natural gas heating amounts to more than 60% of the residential heating market. 93% of the localities are connected to the gas market.⁶⁸ In general all cities and the majority of villages are connected. In urban areas natural gas competes with district heating. Electricity and oil products are rarely used for heating. In rural areas, coal and wood-fired boilers are also used.

Hungarian district heating consumption is dominated by households; residential market share is around 60% which is among the highest in Europe.

District heating consumption continually decreases in all sectors. The most significant decrease is observable in the case of industrial customers, but households have also tended to switch away from district heating networks. The main reason of the disconnections in the residential sector is that more than 75% of district heated buildings were constructed as prefabricated building with high heat losses, which do not offer the possibility for individual regulation of heating and results in high heat costs. Several energy retrofits programs were targeted on these buildings, improving their energy performance in the last ten years.

⁶⁸ Source: KSH

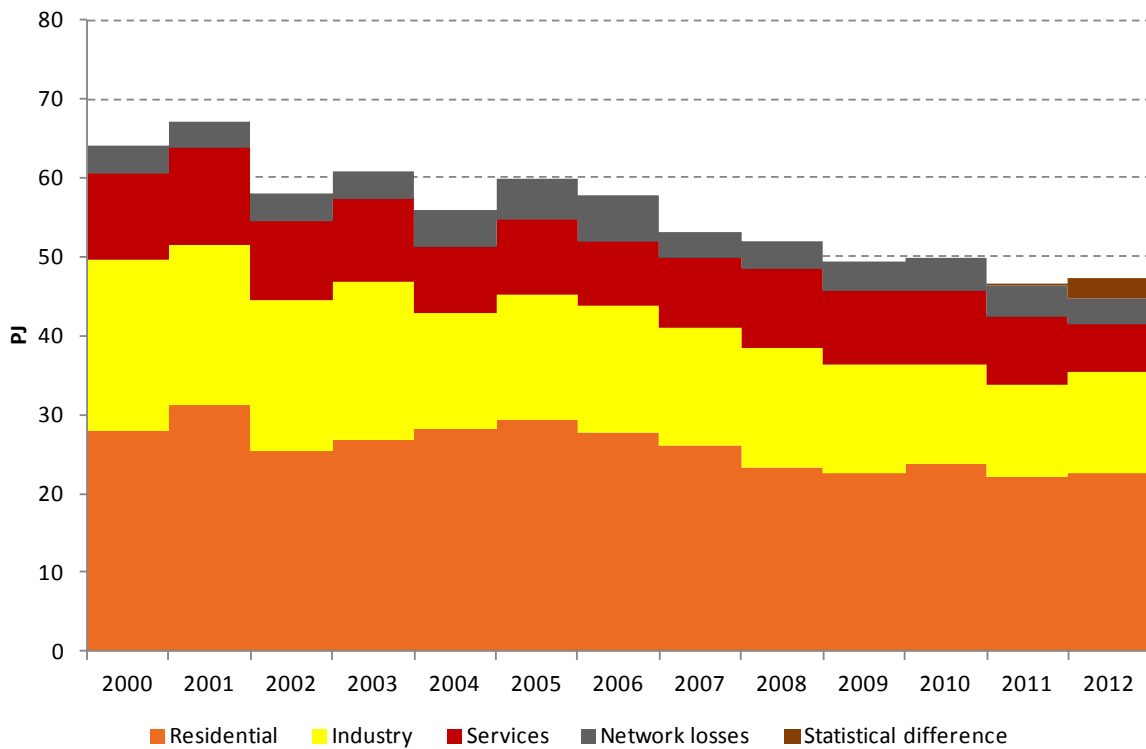


Figure 41 Distribution of district heating consumption in Hungary
 Source: Eurostat

Natural gas with its almost 80 percent share is the main fuel for district heating in Hungary. This share is outstanding in European relation as well. The share of renewables in district heating production is below 8% from which biomass (5.1%), waste (1.6%) and geothermal energy (0.8%) are the most significant. Currently biomass is used for district heating production in 15 cities with a total 270 MW heat capacities, while geothermal district heating capacity in 2012 was around 138 MW in 10 cities. Photovoltaic energy and biogas based heat is injected into the district heating system in a single area.⁶⁹

⁶⁹ Source: MEKH

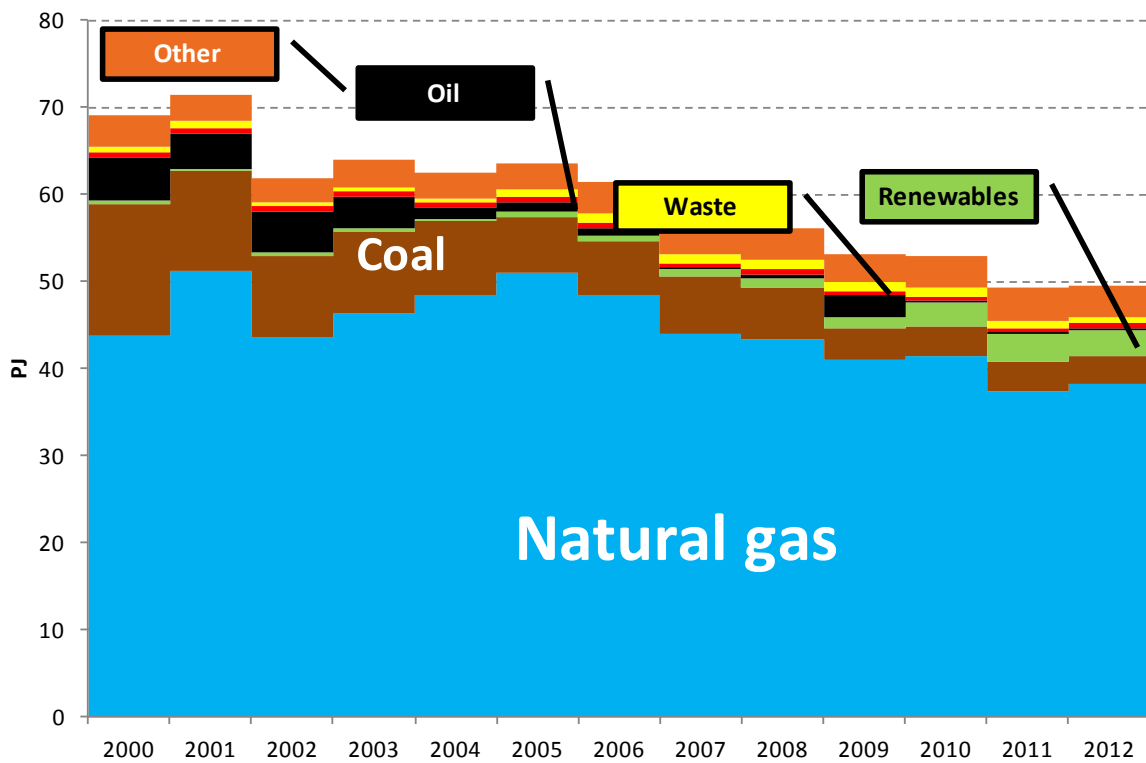


Figure 42 Main fuels of district heating in Hungary
 Source: Eurostat

Similar to other countries in Europe the share of CHPs in the district heating production is considerably high (in 2012 this was about 50 percent). In the case of more than 60 cities at least a part of district heating energy derives of CHPs. However the share of CHPs has dropped significantly since 2011 when the feed-in tariff for CHPs was terminated.

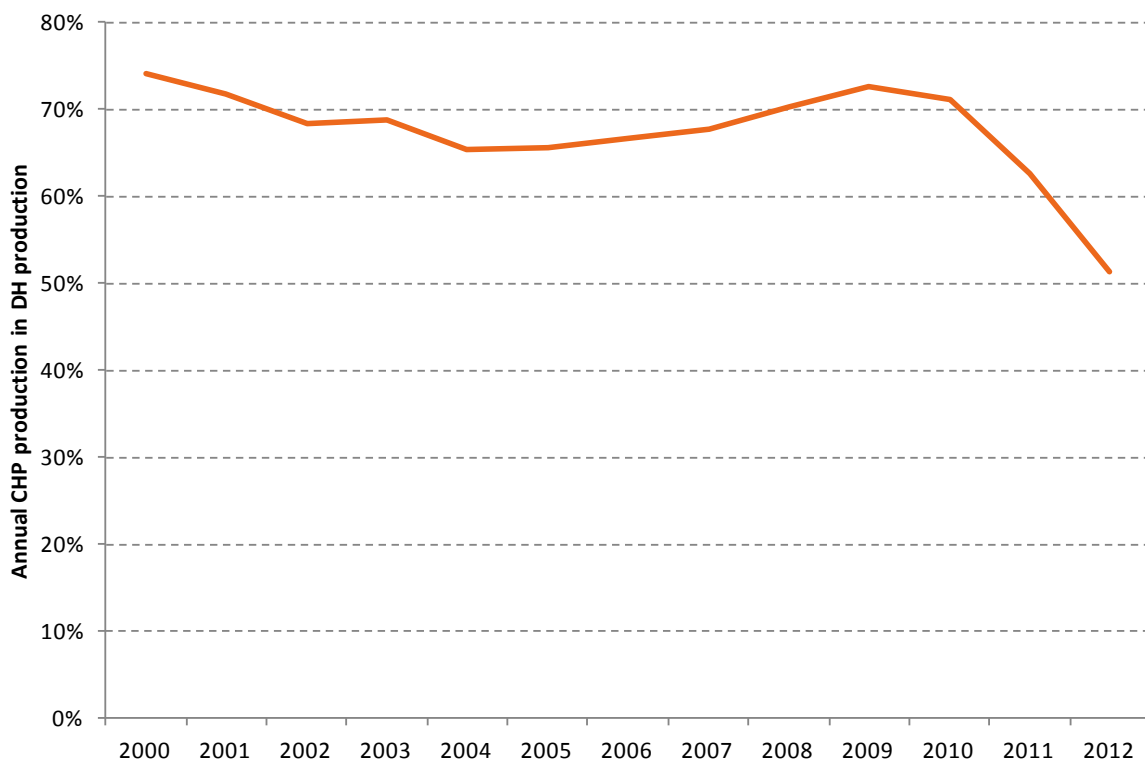


Figure 43 Share of CHPs in district heating production in Hungary
Source: Eurostat

Table 9 Number of district heating systems and length of district heating pipeline in Hungary

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of district heating systems	260	257	250	242	238	232	214	202	202	207	196	211	193
Length of district heating pipeline, km								3500				4110	4304

Source: VEZESTÉK, Euroheat

Currently 105 district heating utilities serve the consumers via about 200 district heating system⁷⁰ using the heat produced by 106 producers.⁷¹

The price of residential district heating applied in various district heating networks differs significantly in Hungary: the district heating costs of an average-size flat (52 m²) in 2013 moved in the interval between 450 and 775 euro. As it is noticeable in Figure 44 gas heating can be a competitive alternative of district heating in some area. Disconnection from district heating networks is also allowed by law.

⁷⁰ Some of the utilities operate more systems

⁷¹ Source: MEKH

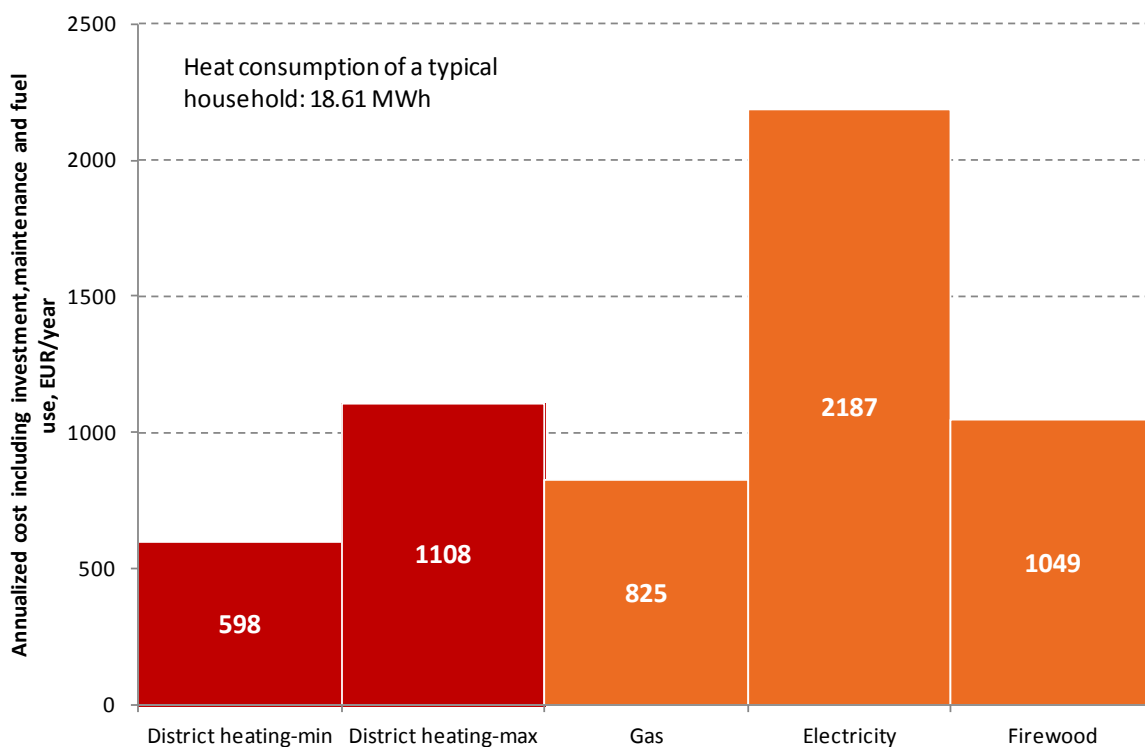


Figure 44 Heating costs of a representative household in Hungary
 Source: MATÁSZSZ, MEKH, KSH

Hungarian renewable based heat potential is relatively favourable in European perspectives; mainly the geothermal potential is outstanding. The biomass and geothermal potential which gives 80 percent of total renewable heat production would be able to supply the whole Hungarian district heating demand presently. According to EGE⁷² the number of geothermal district heating systems will be more than doubled until 2016.

7.5.3 Future vision of district heating in national planning

Figure 45 shows the share of RES-based district heating in Hungary’s total energy consumption for heating and cooling based on Hungarian NREAP.

⁷² European Geothermal Energy Council

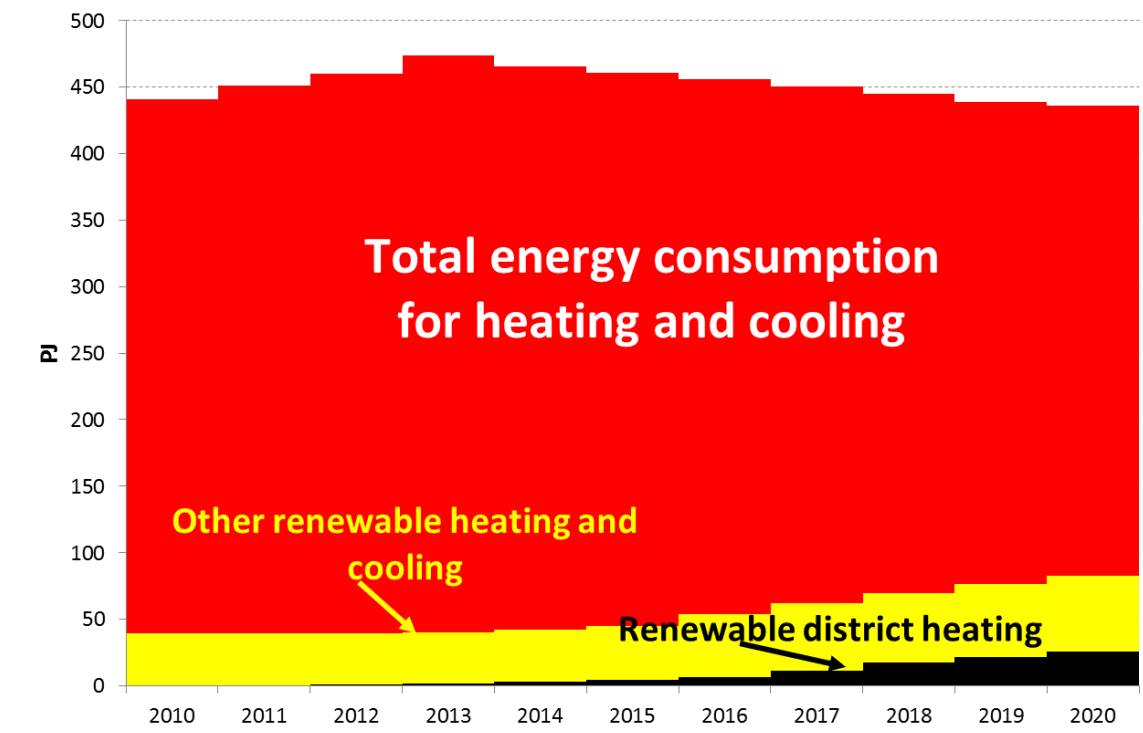


Figure 45 Renewable district heating consumption and total heat consumption to 2020, PJ in Hungary
Source: NREAP, Hungary

According to the Hungarian NREAP the share of renewable energy sources in the total heating consumption should be doubled (up to 19 percent) between 2010 and 2020. Hungarian Energy Strategy aims to increase this share up to 25% until 2030.

7.5.4 Regulation of District heating services

District heating service providers have monopoly power on their district heating system. In the case of heat producers competition is possible, however half of the districts heated cities are supplied by a single producer and the other half by 2 or three suppliers, so opportunities to introduce competition is restricted in these later cases as well.

With a few exceptions, most district heating utilities are owned by the local municipalities. In the case of district heat producers the ownership structure is mixed: about the half of these companies are owned at least partly by private companies.

7.5.4.1 Price regulation of district heating

Since 1998 district heating has been regulated by law. Between 1998 and 2005 the energy minister set the price for those producers which had licence for also electricity production, otherwise these prices were set by municipalities. The prices of residential district heating were also set by local authorities.

The current law dating back to 2005, which regulates the legal relationship between the district heating supplier (utility) and the customer and also between the heat producer and the district heating utility has been modified many times. Between 2005 and 2008 those producers which had licence also for electricity generation and sold steam and hot water for residential purposes directly or indirectly were able to sell the district heat at regulated prices if heat capacity bought for this aim at the given city was more than 50 MW. In other cases there was no price regulation for district heating producers not supplying residential customers directly or indirectly, so they sold heat at freely negotiated prices. The price of the heat sold to households by the service

providers was set by local authorities. Between 2008 and 2011 the prices of district heating producers were not regulated either if their heat was sold directly or indirectly to the households, but prices of DH service providers remained regulated by municipalities.

According to the Act No XXIX of 2011 amending Acts on energy and power with effect from 15 April 2011 both the price of district heat sold by producers to the district heating service provider and the price of district heating sold by the utilities to the residential customers and the public institutions are regulated. Prices in both relations are set by the minister in charge for energy policy taking into account the suggestions of the Hungarian Energy and Public Utility Regulatory Authority while the connection fee of district heating is still set by the local authorities. The prices of district heat sold to other market participants (e.g. industrial or agricultural consumers) by producers or service providers are not regulated.

The Minister published district heat seller and service provider tariffs to be applied from 1 October 2011 in Decree No 50/2011 (Pricing Decree). The district heating producers can get two types of fee: heat fee (paid in Ft/GJ based on the used heat quantity) and capacity fee (paid in Ft/MW/year based on the booked capacity). The decree sets different fees for each producer according to their adjusted cost based on benchmarking with the help of Energy Office. The detailed methodology of the calculation is not included in the decree, only the principles of the calculation. If the district heat derives from CHPs certain criteria are required⁷³, otherwise the producer does not get efficiency fee and the heat fee equals 3408 Ft/GJ (39.7 €/MWh). Producer prices are set every year which leads to high uncertainty in investment decisions.

The decree froze the end-user tariff rates at the level in place on 31 March 2011 which determined previously by local governments. It must be noted that these fees did not really reflect the real cost of the service, consequently these frozen prices are still distorted.

According to the decree the profit rates of district heating producers and service providers are capped. The profit factor which equals the earnings before taxes divided by the gross asset value is maximised at 4.5% in the case of certain CHP producers (in the case the investment has not paid back yet) and at 2% otherwise. However since 2013 if their profit factor exceeds this limit the concerned companies have the possibility to ask not to pay back this amount if they realize an efficiency-increasing investment.

7.5.4.2 Subsidies for CHP producers

Between 2000 and 2011 medium scaled CHP power plants⁷⁴ fell under purchase obligation. They could sell the produced electricity at a regulated price (much higher than the market price) to the Hungarian Transmission System Operator (MAVIR) which allocated this generation among market participants delivering electricity to the final consumers. They got quotas in MWh during the obligatory take over period which lasted until the return of the investment. As the CHP's share in district heating production was about 70 percent this support mechanism resulted in significant cross-financing between electricity and district heat consumers. Since July 2011 CHP production has not fallen under the purchase obligation.

However in parallel a combined production structure transformation fee was introduced which is paid by all electricity customers to the Hungarian TSO (MAVIR).⁷⁵ This amount is spent to support the district heating services, thus heavy cross-financing between electricity and district heating customers still stays up. The detailed rules of this support are included in NFM Decree No 51/2011 (Subsidy Decree). Subsidy can be required by those service providers and public institutions which buy district heat from CHP producers. Unit support is set separately for each market participant.

⁷³ the minimal share of CHP production in the overall heat sales and the minimal efficiency of CHP production is determined – primary energy saving deriving from the combined heat and electricity production should be at least 10 percent

⁷⁴ gas engines, gas turbines, CCGTs with less than 50MWe capacities

⁷⁵ This fee is about 0.35 €/MWh (1.2 Ft/kWh)

There have been some significant changes in NFM Decrees during the last three years. One of the most important changes is that since 2013 January the profit factor is maximised at 4.5% in the case of all district heating suppliers which sell heat produced from renewables or CHPs with high efficiency.

The end-user prices have changed two times since they were frozen in March 2011. In the autumn of 2012 residential prices decreased by 6.5% while the prices of public institutions increased by 4.2%. In 2013 residential prices decreased by an additional 11% as part of the government regulation to reduce energy carrier prices for HH. These price reductions were not based on reduced cost for energy providers, but rather to adjust prices for HH income. So the price setting principle in Hungary presently is to adjust prices according to the ability of HHs to pay their energy bills.

The new waste Act (CLXXXV of 2012) can support district heating production from waste, since from January 2013 has increased the cost of laying waste with the introduction of a new waste laying fee which will increase continuously in the following years. This measure can incentivize the usage of waste in district heating production. However the present share of DH from waste is minimal, so slow improvement could be expected in this field.

7.5.5 District heating policy tools

7.5.5.1 For district heating systems

In 2010 the VAT imposed on district heating was reduced from 20% to 5% by comparison with 27% for natural gas, which gives a high competitive advantage to DH.

In the Hungarian support system a possible subsidy available for the residential sector in order to modernize the district heating system is the “Panel Programme” for blockhouses managed by the Ministry of Local Government and Regional Development.

7.5.5.2 For RES based district heating

In general support for the use of renewable energy sources for generating heat is provided by subsidy programmes under the Environmental and Energy Operative Programmes (EEOP) financed through European Union funds, by national support schemes under the Green Investment Scheme (Zöld Beruházási Rendszer – ZBR) and by the EEA (European Economic Area) grants. Under the Environment and Energy Operational Programme for the period 2007-2013 about 21 million € was used under the tender scheme ‘satisfying local heating and cooling needs through renewable energy sources’. However, currently no calls for projects are open. EU funds will be allocated in Hungary in the 2014-2020 period in the framework of the Széchenyi 2020 program on the basis of 7 operation programs (OPs)– aligning to the EU 2020 Strategy - approved by the European Commission. Renewable and energy efficiency investments will be funded dominantly from the operation program called KEHOP. Expectedly 300 billion HUF will be available for non-refundable grants and 60 billion HUF for other financial instruments (favourable bank loans and state guarantee).⁷⁶

At the end of 2013 Renewable Energy Program of EGT Fund has been opened which subsidizes the setup of geothermal based district heating systems.

⁷⁶ Source: Ministry of National Development (2014-20-as tervezés: A Környezeti és Energiahatékonysági Operatív Program fejlesztési irányai, Nemzeti Fejlesztési Minisztérium, Fejlesztés- és Klímapolitikáért, valamint Kiemelt Közzolgáltatásokért felelős Államtitkárság, előadás: Budapest, 9 Dec. 2013)

7.6 Situation of DH in Poland in general, role of RES based DH

7.6.1 General overview of the market

Poland is one of the largest markets for district heating in Europe: 42% of the 38.1 million inhabitants are served by district heating, reaching 60% on average in urban areas.⁷⁷ The district heating market is made up of local monopolies due to the economic nature of the service; however, competitive behaviour of heating companies is also observable in relation to alternative heating sources: individual heating, small local generating units and other heat producers connected to the same network.⁷⁸

7.6.2 District heating market characteristics

As Figure 46 illustrates, 180 PJ (72%) of supplied district heat was consumed by the residential sector in 2012, followed by the services sector with 39.4 PJ (16%) and the industry using 29.3 PJ (16%). Increasing consumption can be observed only in the services sector, district heat utilization of the industry and households has been falling, mainly as a result of improvements in energy efficiency. On the other hand, the number of new households connected to the system increased during the last years. According to the latest survey of Euroheat and Power, in 2011 the number of new connections reached 6160, more than double of newly integrated households in 2009. A study commissioned by the Ministry of Economics forecasts a 15% increase in DH consumption up to 2030, expected to be achieved mainly in the service sector, while a moderate uplift is projected in the industrial, agricultural and residential sectors.⁷⁹ Please note that network losses associated with the transportation of heat are not depicted in the figure, because of missing data for years 2000-2010. (Data on network losses are shown later in this chapter.)

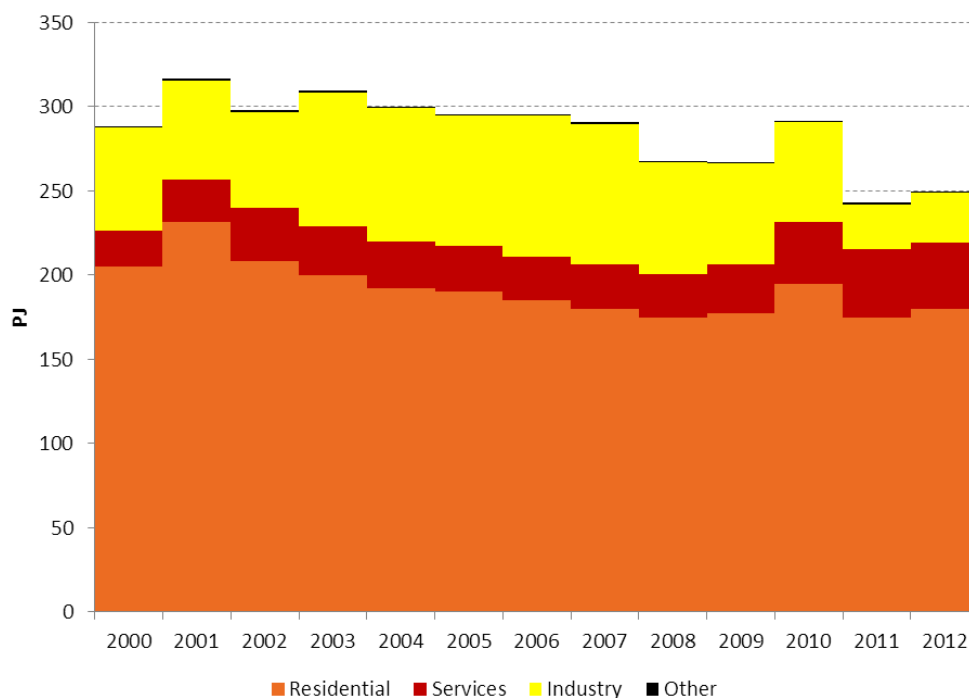


Figure 46 District heating consumption by sectors in Poland

Source: Eurostat; Note: Network losses are not included because of missing Eurostat data for years 2000-2010

⁷⁷ Energy Consumption in Households in 2012, Polish Central Statistical Office, p. 58.

⁷⁸ PWC:), Rynek Ciepła w Polsce, 2012, http://www.pwc.pl/pl_PL/pl/publikacje/assets/raport_rynek_ciepła_w_polsce_2012.pdf

⁷⁹ Aktualizacja Prognozy zapotrzebowania na paliwa i energię do roku 2030, http://www.mg.gov.pl/files/upload/11099/ARE%20MG_2011_Raport_koncowy_01_09_2011.pdf

The majority of Polish households uses solid fuels (46%) and district heating (41%) for space heating, as Figure 47 shows. Solid fuels include fire wood and coal, which are used interchangeably in stoves or heating boilers, depending on the relative prices of fuels and on the temperature in winter. Gas heating represents a relatively small share (9%), however its popularity is moderately increasing in family houses due to its convenience.⁸⁰ Electricity and oil heating have minor roles, and usually serve as secondary heating sources, while other renewable heating methods (heat pumps and solar heat collectors) are yet rarely used.

Shares of dwellings using different types of heating sources in years 2002, 2009 and 2012 can be seen on Figure 48. Please note that the shares of dwellings using the different heating sources do not add up to 100%, as some households use multiple fuels for heating. This chart indicates again the major roles of coal and fuel wood besides district heating, and the fact that coal and fuel wood are usually consumed together. Based on the figure no clear trends can be observed in the use of different heating methods.

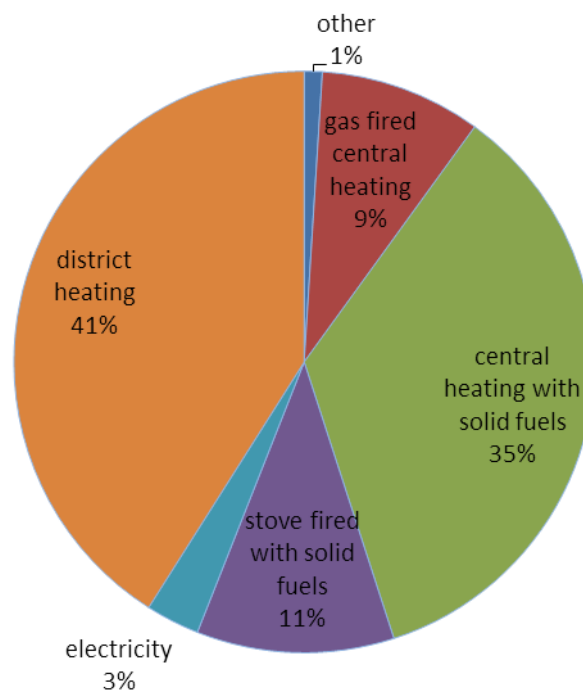


Figure 47 Composition of households by main heating technology in Poland
Source: CSO, Energy consumption of households, 2012

⁸⁰ CSO, Energy Consumption of Households, 2012

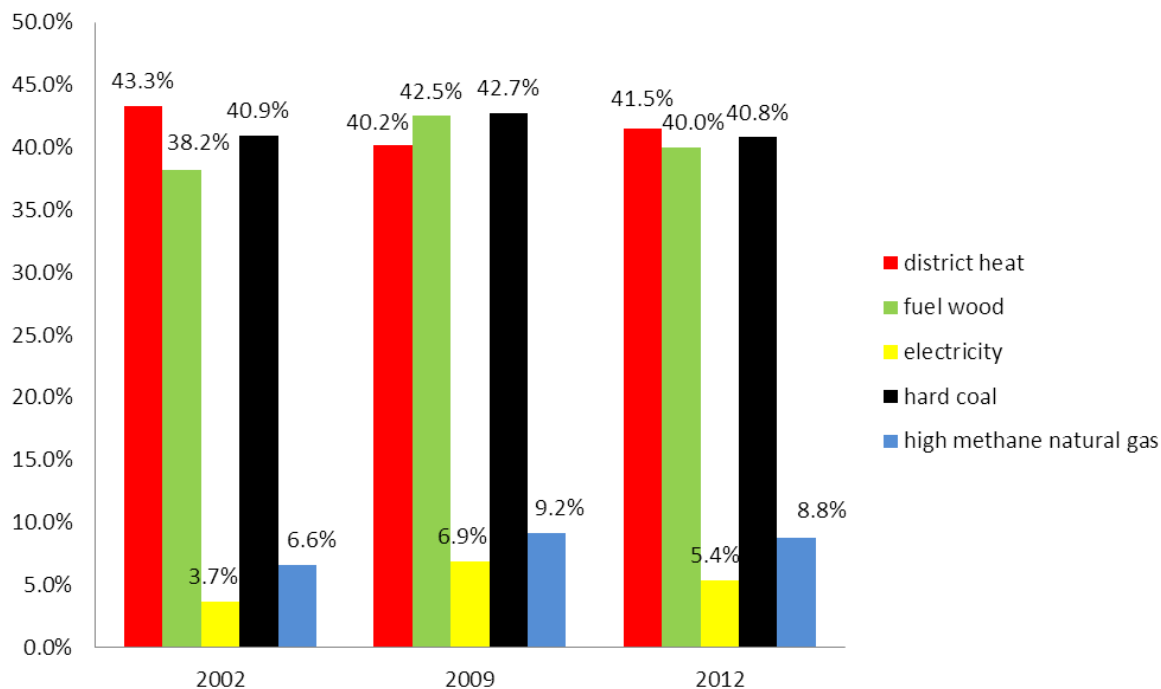


Figure 48 Share of households using different types of heating sources in Poland
 Source: CSO; Energy consumption of households, 2012 Note: Shares do not add up to 100% as households might use different heating sources interchangeably and/or simultaneously.

The composition of Polish district heat generation by fuel type is shown in Figure 49. DH production is traditionally dominated by coal, due to its high domestic availability and relatively low price. Although its share has been decreasing, in 2012 still 80% of heat was generated by burning coal. Renewables account only for 6% of the fuel mix, although their contribution increased at a faster pace than that of natural gas during the last 10 years, mainly as a result of the partial replacement of coal with biomass in large, coal-fired CHP plants (co-firing), encouraged by the renewable electricity support system of the country. Other types of fuels, such as oil and waste represent smaller shares.

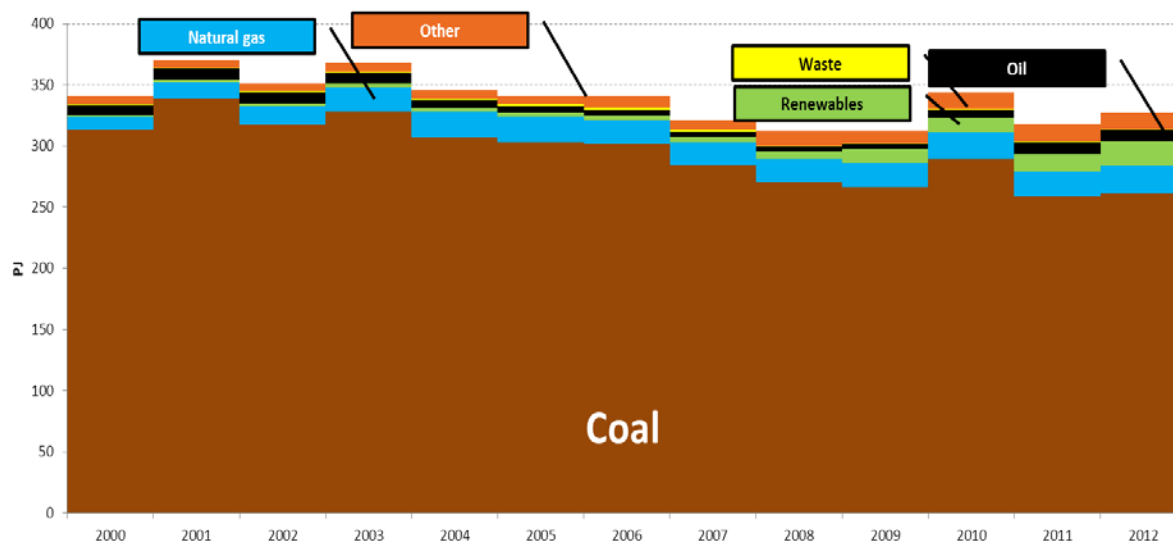


Figure 49 Fuel mix of district heat generation in Poland, 2000-2012 in Poland
 Source: Eurostat

Heating companies are typically vertically integrated and have licenses for several types of DH related activities. The number of companies having licenses for different activities has fallen from 894 in 2002 to 463 in 2012, partly due to a regulatory change that decreased the MW limit of license obligation from 1 to 5 MW_{th} in 2005, and partly due to a consolidation process that has been taken place in the industry. The share of firms active in transmission, distribution and trading increased, while a higher proportion of companies previously only engaged in production expanded their business into distribution and trade.

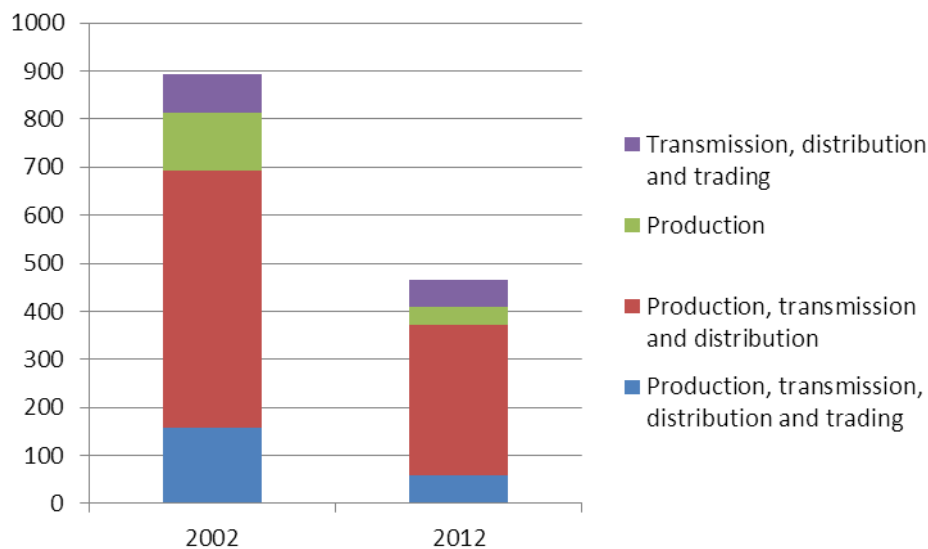


Figure 50 Number of DH companies by licensed activities in Poland
 Source: Energetyka ciepła w liczbach, Polish Energy Office, 2012

As can be seen in Table 10, municipalities own almost half of the companies in the DH sector. 59.8% of DH firms are controlled by the state or municipalities, while 40.2% have dominant private ownership. Publicly owned companies mainly operate heating systems in smaller cities, while the systems of largest Polish agglomerations providing the majority of heat are controlled by private companies, often operating in more than one city and even in several provinces.⁸¹ The largest private owner, Dalkia, is active in nearly forty cities throughout Poland, including Warsaw, Lodz and Poznan. Fortum is another large player owning networks and generating plants in several large cities.⁸²

⁸¹ <http://www.ure.gov.pl/en/communication/news/6,Activity-Report-2005-of-the-President-of-the-ERO.html?search=863>

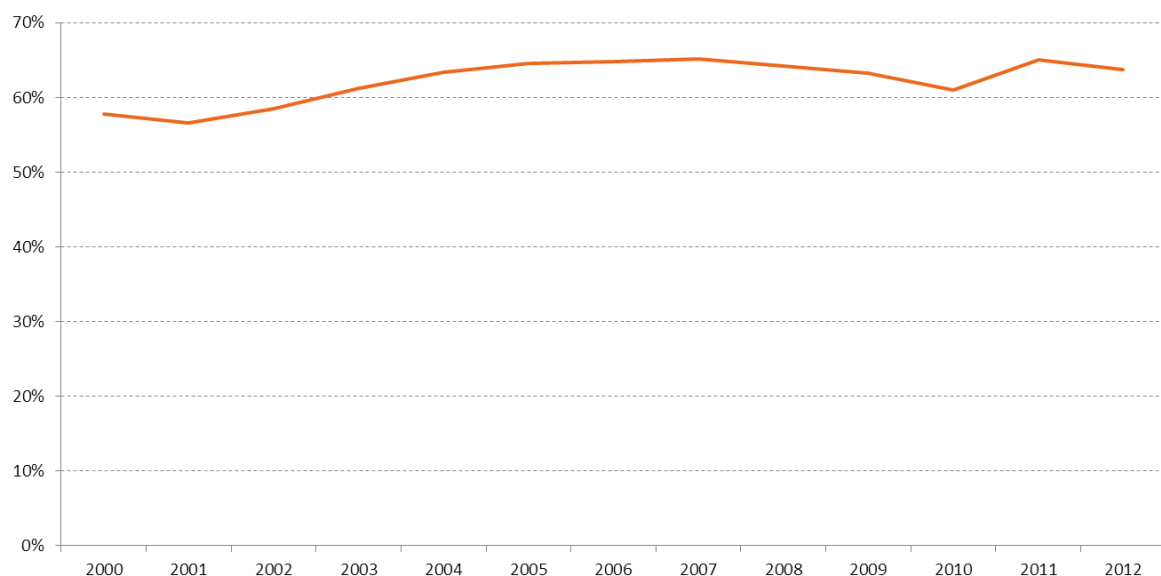
⁸² Rynek ciepła w Polsce, PWC, 2012, http://www.pwc.pl/pl_PL/pl/publikacje/assets/raport_rynek_ciepła_w_polsce_2012.pdf

Table 10 Composition of firms in the district heating sector by ownership in 2012 in Poland

Type of ownership	Number of firms	Percentage of firms
state ownership	15	3.2%
owned by municipalities	207	44.7%
domestic private	93	20.1%
foreign private	18	3.9%
mixed ownership with public dominance	55	11.9%
mixed ownership with private dominance	75	16.2%
total	463	100.0%

Source: Energetyka ciepła w liczbach, Polish Energy Office, 2012

More than 60 % of generated heat comes from combined heat and power installations. One of the policy goals of Poland is to double the 2006 level of cogeneration by 2020, leading to lower primary energy consumption and lower DH price, as envisaged by the Energy Policy of Poland, 2030. According to sector representatives, there is still high potential for heat generation in CHP plants, as a large share of heat is still produced in heat-only plants.⁸³

**Figure 51** Share of CHP production in total DH generation in Poland

Source: Eurostat

⁸³ Energy Policy of Poland until 2030, Ministry of Economy,
http://www.mg.gov.pl/files/upload/8134/Polityka%20energetyczna%20ost_en.pdf

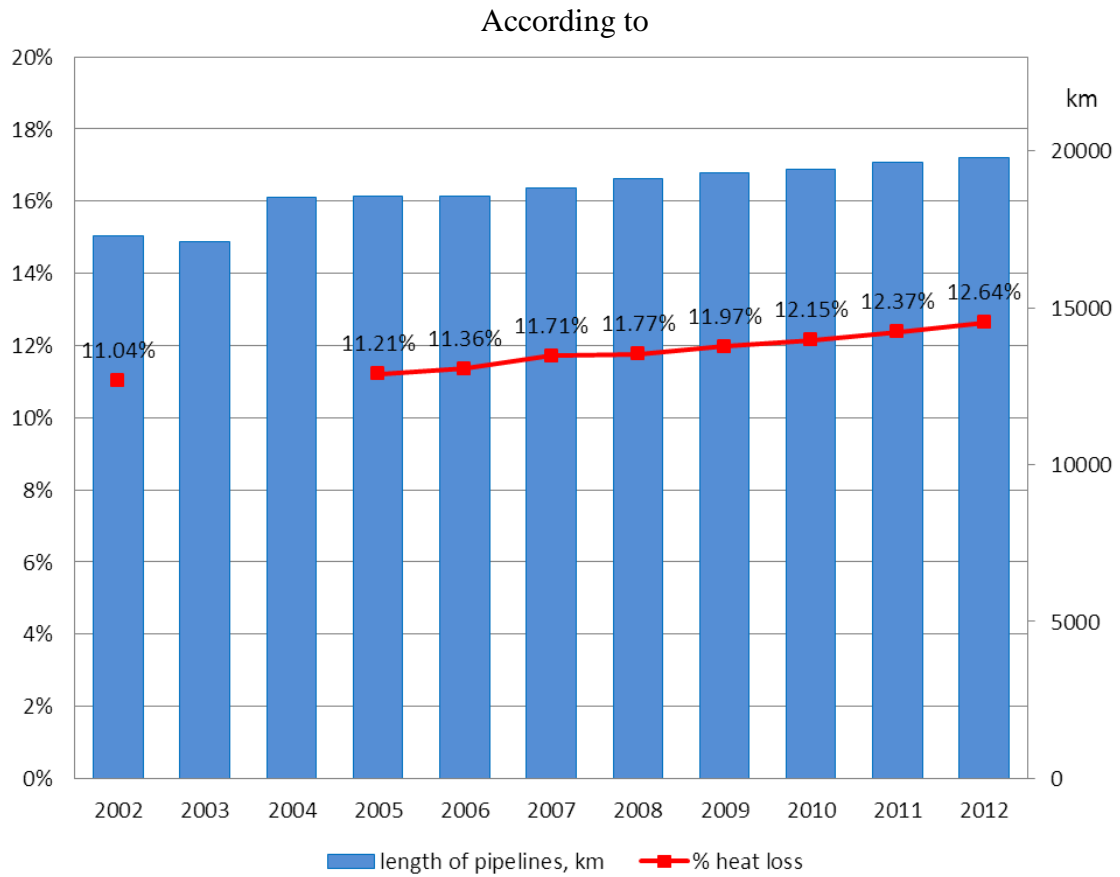


Figure 52 the length of pipelines has been increasing continuously from year to year. Almost 50 % of the oversized heating system is older than 20 years; therefore the losses of heat transportation are high in spite of the continuous renovation activities, although there is a large variation in the state of different network sections. As the figure illustrates, the heat loss amounted to more than 12.6% in 2012.⁸⁴

⁸⁴ http://innoheat.eu/wp-content/uploads/2012/04/Polish-district-heating_ENG.pdf

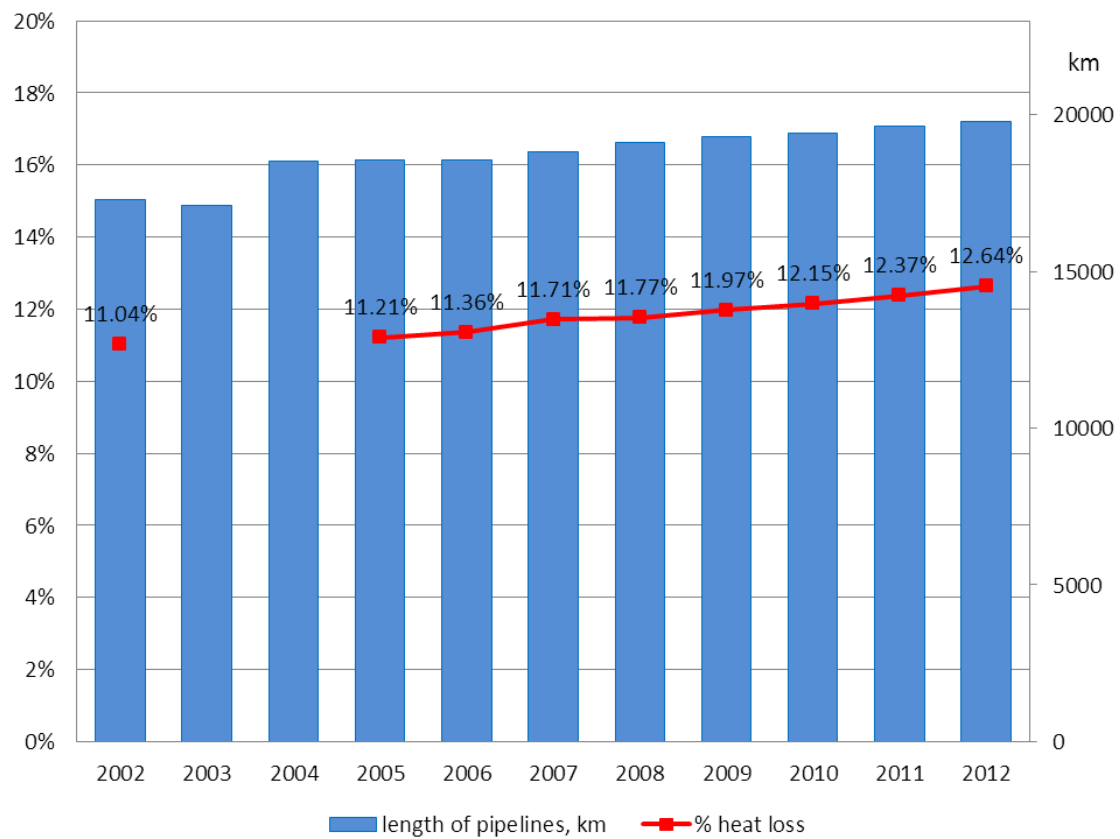


Figure 52 Length of DH network and the share of heat loss (%) in Poland
 Source: Energetyka ciepła w liczbach, Polish Energy Office, 2012

Figure 53 depicts 2012 statistics on heating costs for Polish households, based on the energy consumption survey carried out by the Polish Central Statistical Office (CSO). The presented values do not include investment costs needed to install the heating devices, only fuel costs are indicated. Cost ranges published by the CSO extend from the 1st to the 9th deciles instead of minimum and maximum values, in order to exclude outliers from the statistics. It is obvious from the graph that fuel wood is by far the cheapest option followed by coal, explaining the fact that the majority of Polish dwellings are heated with these two sources. In cities, however, where individual heating might be difficult to implement, district heating can be the most competitive option. According to the CSO, there is a considerable variability in district heat prices according to the location of dwellings, due to the differences in the level of heat production, costs of transmission and distribution, the fuel source (coal being the cheapest) and the size of heating network. Heat prices are particularly low in large cities served by modern heating systems, and might be much higher in smaller cities with less modern installations.⁸⁵

⁸⁵ CSO, Energy Consumption of Households, 2012, <http://stat.gov.pl/en/topics/environment-energy/energy/energy-consumption-in-households-in-2012,2,2.html>

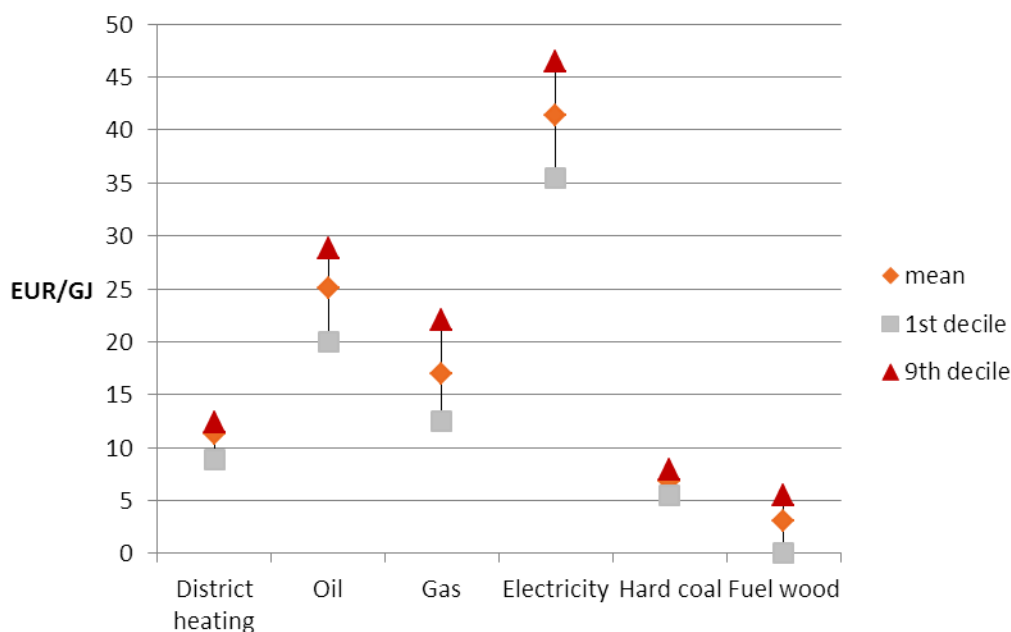


Figure 53 Range of fuel costs for households, 2012 in Poland

Source: CSO, Energy consumption of households, 2012

Although the share of households reached by gas networks is 56.2% in Poland, there is a large difference between urban (73.2%) and rural areas (20.8%).⁸⁶ Probably due to the higher price of gas relative to the other heating options, the use of gas heating is not widespread in Polish dwellings.

As we have shown earlier in this section, the majority of heat injected into the DH system by large CHP plants, industrial enterprises and heat-only plants is also produced from coal. Coal-based sources with plant size over 20 MW fall under the scope of the EU Emissions Trading Scheme, but received their allowances free of charge until 2013. The allowance purchase obligation that will increase gradually until the entire phase out of free allocation by 2027 will probably raise the price of heat from DH networks, depending on the market price of CO₂. Producers will also have to comply with the emission standards set by the Industrial Emissions Directive (2010/75/EU), which will also require investments in cleaner and more efficient generation units in Poland.⁸⁷ These changes might challenge the future competitiveness of district heating companies.

7.6.3 Future vision of district heating in national planning

The Energy Policy of Poland until 2030 projects the trajectory included in Table 11 for final energy demand in the district heating sector.⁸⁸ There are no forecasts available separately on the contribution of renewable sources to district heating consumption, the NREAP of Poland only envisages the contribution of RES to gross final consumption in the entire heating and cooling sector, including both DH and non-DH heating. If we look at the forecasts published in the two documents we can suppose that district heating and cooling will contribute with 20-26% to total final energy consumption of the sector in 2020 (Table 11).

⁸⁶ Polish Statistical Office, Statistical Yearbook of Poland, 2013, p. 333

⁸⁷ Rynek ciepła w Polsce, PWC, 2012, http://www.pwc.pl/pl_PL/pl/publikacje/assets/raport_rynek_ciepła_w_polsce_2012.pdf

⁸⁸ Energy Policy of Poland until 2030, Ministry of Economy, 2009, Appendix 2, p. 12

Table 11 Demand for final energy in the district heating sector, TJ in Poland

	2010	2015	2020	2025	2030
Demand for final energy in the district heat sector (EPP)	309.82	343.32	381.00	418.68	439.61
Expected gross final energy consumption in the heating and cooling sector (DH and non-DH) (NREAP)					
- reference scenario	1 323.03	1 624.48	1 934.30		
- with additional efficiency measures	1 356.52	1 385.83	1 452.82		

Sources: Energy Policy of Poland until 2030, Ministry of Economy, 2009 (EPP) and NREAP of Poland, 2010

The projected composition of RES-based heat consumption is available only for the entire heating sector. Based on the NREAP we can conclude that Poland wishes to rely mainly on biomass in harnessing renewable sources for heat production, as shown in Figure 54.

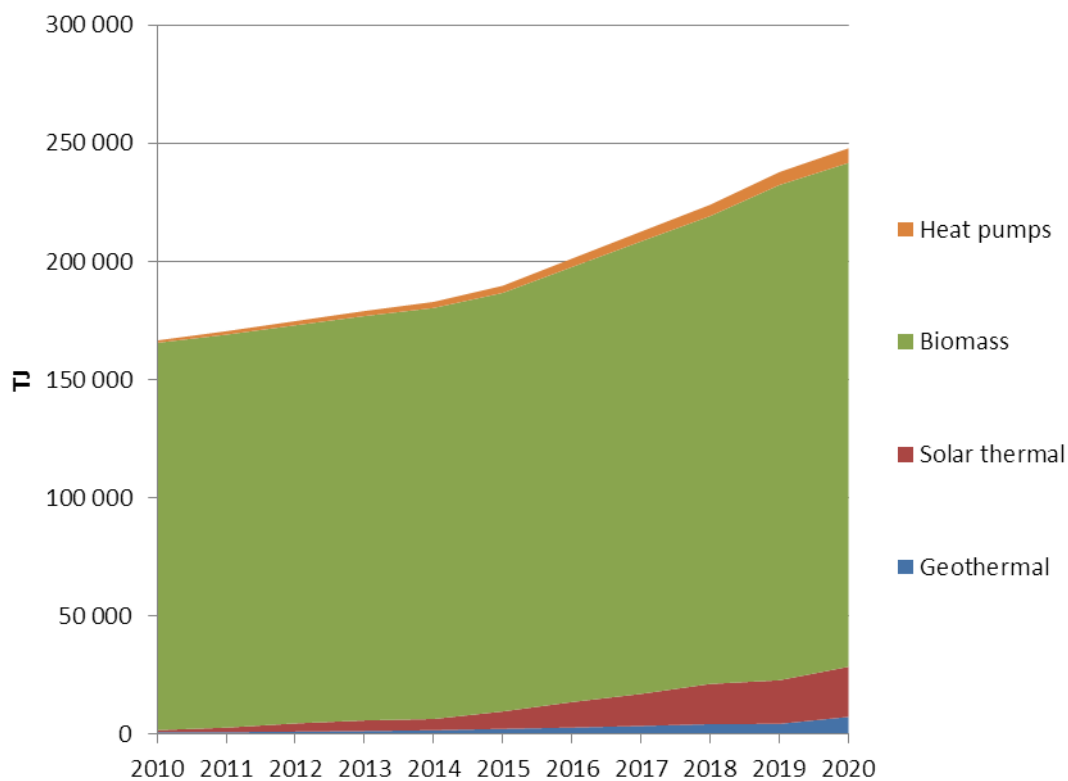


Figure 54 Estimated contribution of renewable energy technologies to meet 2020 RES targets, TJ in Poland
Source: NREAP of Poland, 2010, p. 136

7.6.4 Regulation of District heating services

7.6.4.1 General regulatory setting

Production, transmission and distribution companies with at least 5 MW capacity have to apply for license to the Energy Regulatory Office (ERO) and are subject to price regulation. Firms below this threshold are regulated by the municipalities.⁸⁹ In the process of cost-plus price regulation companies have to calculate their tariffs according to the provisions laid down in the Energy Law and the relevant secondary legislation, and submit them for approval to the regional office of the regulatory agency (the ERO has 8 regional offices). Tariff setting

⁸⁹ Regulatory Implications of District Heating, Inogate Textbook, ERRA, 2011, http://www.leka.lt/sites/default/files/dokumentai/regulatory_implications_of_district_heating_lukosevicius_werring_2011.pdf

is based on the justified costs of heat production and distribution and includes justified costs of modernization, development and environmental protection, as well as the return on capital.⁹⁰

At present introduction of changes in the Energy Act are under way concerning heat price regulation. According to a proposal, the current cost-based approach would be simplified and altered to a kind of ex-post tariff control. The draft amendment of the legislation would not require companies to submit their calculated tariffs for approval to the President of ERO.⁹¹

In Poland third party access in district heating is ensured, meaning that the recipients are theoretically able to choose the heat source from which to purchase the heat supplied to the heating network. However, the opportunity is limited by the technical conditions and the capacity of the district heating systems in the relevant sections of the grid.⁹²

7.6.4.2 Specific rules of RES based DH regulation

Renewable energy regulation is based on a green certificate system in Poland, introduced in 2005 with the amendment of the Energy Act of 10 April 1997, and the relevant secondary legislation. RES based heat generation is supported only indirectly by the legislation, as only renewable electricity is entitled to receive green certificates. Therefore, CHP plants harnessing renewable sources can benefit from the support system. No time limit for eligibility exists, and the system does not differentiate among technologies, i.e. all sources receive one certificate for 1 MWh from renewable energy. Companies selling electricity to final consumers have to buy a certain amount of green certificates each year and submit them until 31 March to the ERO. The penalty for non-compliance (substitute fee) is determined by the energy agency, which basically sets a maximum price for the certificates.

According to the draft of the new version of the Polish RES Act (approved in April 2014 by Polish government) the certificate system will be replaced by a support system based on an auction mechanism. A given amount of money available for support will be granted to winning projects, and will be received by operators in the form of feed-in tariffs (FIT) in case of installations with rated capacity below 1 MW and feed-in-premiums (FIP) above 1 MW. Existing projects will continue receiving green certificates, however a time limit of 15 years will be set counted from the time of commissioning of the eligible installations. The level of support given to units co-firing biomass and coal will be reduced: they will receive only 0.5 certificate per 1 MWh electricity.⁹³ It is a question whether these changes will set back the development of renewable generation or will be successful in changing the orientation of RES-E investments towards other technologies.

RES heat is not supported by the green certificate system and no guaranteed price or tax exemption applies to heat production from renewable sources, only heat produced in cogeneration units is supported indirectly through the effective renewable and CHP certificate systems (described in the next section). The Energy Law obliges heat traders to purchase the offered RES based heat in the territory of their activities, but only up to the maximum quantity demanded by customers connected to the same grid, and ensuring that the resulting price increase does not exceed the average price index of consumer goods and services published by the Polish Central Statistical Office.⁹⁴

⁹⁰ <http://www.ure.gov.pl/download/1/4342/DHbenchmarkingpilotstudyJune2011ERRAFortumfinal.pdf>

⁹¹ <http://www.ure.gov.pl/en/communication/news/193,Development-of-electricity-and-gas-markets-2012-summary.html?search=880211077>

⁹² ERO, 2007, <http://www.ure.gov.pl/pl/rynki-energii/cieplo/charakterystyka-rynku/1810,2007.html>

⁹³ <http://www.nortonrosefulbright.com/knowledge/publications/115453/the-final-draft-renewable-energy-sources-act-approved-by-the-polish-government>

⁹⁴ http://www.keepontrack.eu/contents/keeptrackcountryfactsheet/analysis-of-deviations-and-barriers_poland.pdf

7.6.4.3 Specific rules for CHP regulation

In Poland a certification system is in place for supporting cogeneration as well. CHP electricity producers benefit from the purchase obligation imposed on distribution companies if the efficiency of their unit reaches at least 70%. The type of support depends on the rated capacity of the installation and the type of fuel applied:⁹⁵

- Yellow certificates can be granted to cogeneration units firing gaseous fuel, or to installations with a rated capacity below 1 MW, regardless of the type of fuel used.
- Purple certificates are used in case of firing methane captured from coal mines and biogas, regardless of the capacity installed. In case of biogas obtained from biomass processing the entitled operators might choose between a purple and a yellow certificate.
- Red certificates are available for those generators who do not fall into the two former categories. In case of firing different types of fuels at the same generation unit the operator might apply for different types of certificates, based on the energy input from different sources.

The president of ERO issues the certificates of origin for all kinds of CHP generation. Renewable electricity generated in a unit which meets the conditions of highly efficient cogeneration is entitled to two kinds of certificates at the same time. For example, an agricultural biogas plant might receive both green and purple certificates for all the MWhs produced. The value of the CHP certificates is also set indirectly by the Polish energy regulator by determining the penalty levels on a yearly basis.

The central register of the certificates is kept by the Polish Power Exchange, where they can be traded in the so called „Property Rights Market”. The actual prices of the different types of certificates are presented in Table 12.

Table 12 Monthly weighted average prices of certificates of origin at the Polish Power Exchange, August, 2014

Monthly Weighted Average Price	Green	Purple (or Violet)	Yellow	Red
PLN/MWh	192.56	60.42	103.33	8.11
EUR/MWh	46.01	14.44	24.69	1.94

Source: Polish Power Exchange (POLPX) Monthly Report, August 2014, p. 15, using exchange rate 4,1853 PLN/EUR (average exchange rate for April 2014, ECB)

7.6.5 District heating policy tools

7.6.5.1 For district heating systems

From July 2012 a new rule concerning the connection of new customers to heating networks entered into force. The Act on Energy Efficiency imposes an obligation on DH companies to connect customers free of charge if the following conditions are met: 1) the heating of the building requires at least 50 kW thermal capacity, 2) technical conditions of delivery from the DH network are met, 3) at least 75% of the heat provided from the network comes from RES, CHP or waste industrial heat. The energy company is required to ensure the implementation and financing of the necessary expansion of the network and the connection of the entities.

7.6.5.2 For RES-based heating systems

RES heat in Poland is supported through low interest loans granted to enterprises aiming at purchasing and installing heat generating units based on biogas, biomass and geothermal sources. Subsidies and low interest loans are also available for local government units and private persons or housing associations to support the establishment of small and micro-RES installations, such as heat pumps harnessing aerothermal and hydro-

⁹⁵ Polish Energy Agency (ERO), <http://www.ure.gov.pl/en/information-for-invest/support-systems/141,Support-Systems.html>

thermal energy, biomass installations and solar thermal units, up to 300 kW_{th} capacity. In addition, solar collector installations are also subsidized with preferential loan opportunities.⁹⁶

7.7 Situation of DH in Sweden in general, role of RES based DH

7.7.1 General overview of the market

In Sweden, almost totally oil-based district heating systems have been transferred into mainly RES-based ones, operating in all Swedish cities and serving the heat demand of more than 50% of the Swedes. The country example of Sweden proves that:

- Economies of scale in district heating might ensure more economic heat supply for the residents. As part of the municipal housing program of the 60s, the new buildings were automatically connected to the DH network, which helped to reach the necessary economy of scale for DH.
- RES fuels might be used in district heating systems that would have been expensive, difficult and troublesome at individual level (municipal solid waste, biomass, industrial surplus heat, deep geothermal etc). Biomass, waste and waste heat adds more than 60% of the total district heating fuel mix.
- Overall CO₂ emission of a country could be reduced by high percentage of heat served by environment friendly district heating.
- Input fuels structure of DH systems might be radically changed as a result of determined government incentives and regulations. Administrative rules, such as the prohibition of landfilling combustible waste played an important role in the expansion of RES DH systems.
- Introduction of third party access rules poses challenges to the regulation.
- Private ownership increases RoR expectations in Sweden compared to municipal ownership.

7.7.2 District heating market characteristics

Starting already in the 1950's, district heating systems play a significant role in Sweden currently. Thanks to incentive policy actions, the number of inhabitants served by district heating increased constantly during the 1960's and 1970's and since then. The DH systems were mainly oil-based that time, but after the oil crisis, high energy taxes for fuel oil have been introduced, and DH systems were switched to use other, mainly RES energy sources.

Today, *in multi-dwellings buildings* district heating is the most common form of heating, serving around 90% of dwellings and amounting to a total of 75,600 TWh in 2011. Less common types are electric heating and oil, only around a small 5-5% respectively.

In contrary, *in single- and two-dwelling buildings* the most common method of heating is electric heating. A total of 518,000 dwellings, 27% of this category were heated this way in 2010. Second most common type is combined biofuel and electric heating, in 382,000 houses (20%). District heating is also popular, ensuring heating for 230,000 single- or two-dwelling buildings (12%). In the 1990s and since then the number of heat pumps has been increasing constantly. Nowadays there is heat pump in 923,000 single-family or two-family houses, 46% of total in this category (but it is only supplementary heating method in a small number of the cases). Oil heating is used only in 1% of single- and two-dwelling houses.

⁹⁶ RES-Legal

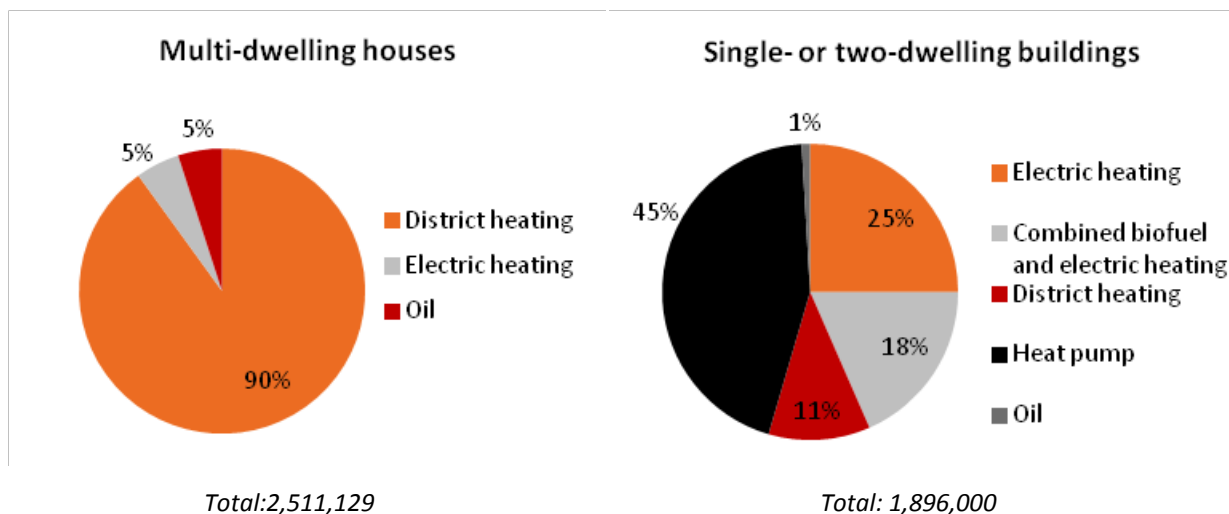


Figure 55 Share of different heating methods in households, 2010-12 in Sweden
Source: Statistics Sweden

Besides residential dwellings, district heating is also popular in commercial premises: 83% of these are served by DH.

Total deliveries of district heat in all premise in Sweden in 2012 was 52,324 GWh,⁹⁷ and is distributed among the different costumers as Figure 57 shows. Most district heating heat quantities are used in multi-dwelling houses, but deliveries to one- and two-dwellings houses and public administration are also significant (public administration comprises public administration, defence, research, medical and other health services and welfare institutions).

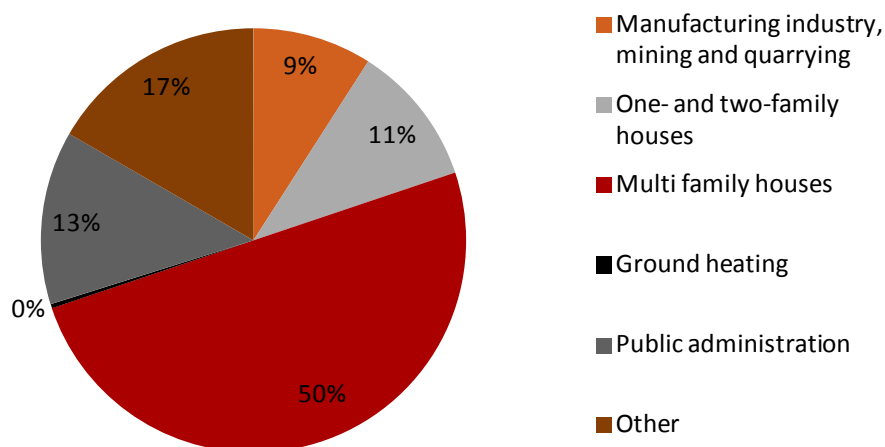


Figure 56 Main consuming sectors of DH in Sweden, 2012⁹⁸
Source: Sveriges Officiela Statistic

Number of DH networks can be estimated between 440 (Euroheat) and 540 (Werner). These networks are operated by 140 companies in 220 municipalities.⁹⁹ Ericsson (2009) stated that virtually all Swedish towns have

⁹⁷ Sveriges Officiela Statistic: Electricity supply, district heating and supply of natural and gasworks gas 2012, Table 10

⁹⁸ Sveriges Officiela Statistic: Electricity supply, district heating and supply of natural and gasworks gas 2012, Table 10

⁹⁹ Sven Werner: District Heating in Sweden – Achievements and challenges, 2010

DH system. Total length of DH networks in 2011 was estimated 22,800 km all over the country (Euroheat, 2013).¹⁰⁰ The prefabricated steel pipe with polyethylene casings (third generation DH network) is the dominant type. According to the statistics of the Swedish Energy Agency, the heat losses in the DH systems were 11-12% in 2013.¹⁰¹

Initially, DH utilities were managed by municipal administrators. Later they were transferred into municipally owned companies. During the 1990s some of these were sold to national or international energy companies, for example Vattenfall, E.on and Fortum, which accounted for 39% of the district heat supply in 2004 and the municipal energy companies supplied the other half, 58% (Ericsson 2009). Some utilities remained under municipal administration, but add altogether 2% of district heat supply (Ericsson 2009). Production and distribution often have the same owner.

District heating accounts for one-third of the total energy use in the residential and service sector in Sweden (see Figure 57).

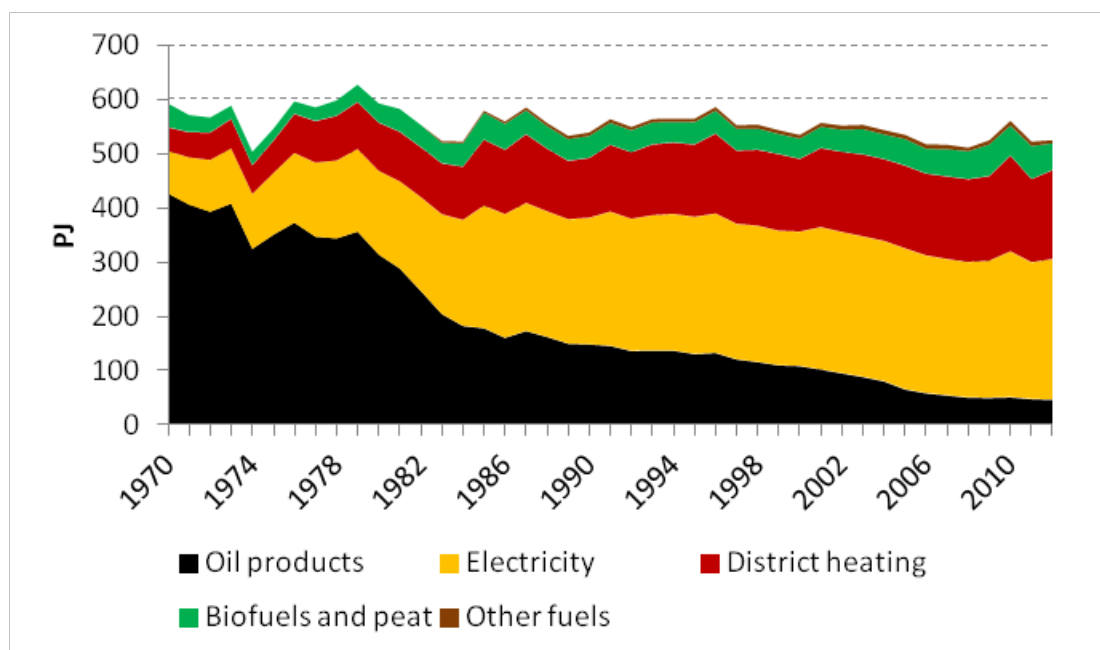


Figure 57 Energy use in the residential and services sector in Sweden, between 1970-2012, TJ in Sweden
Source: Energy in Sweden 2013- Facts and figures

District heating is produced from a basket of different sources. Most dominant inputs are *municipal solid waste*, *biomass* and *industrial surplus heat*, which altogether add up to 60% of fuels used (see Figure 58).¹⁰²

¹⁰⁰ Euroheat: 2013 Survey

¹⁰¹ Danil Frieberg: The Swedish policy case for Cogeneration and District Heating, 2013

¹⁰² Sveriges Officiella Statistik: Electricity supply, district heating and supply of natural and gasworks gas 2012

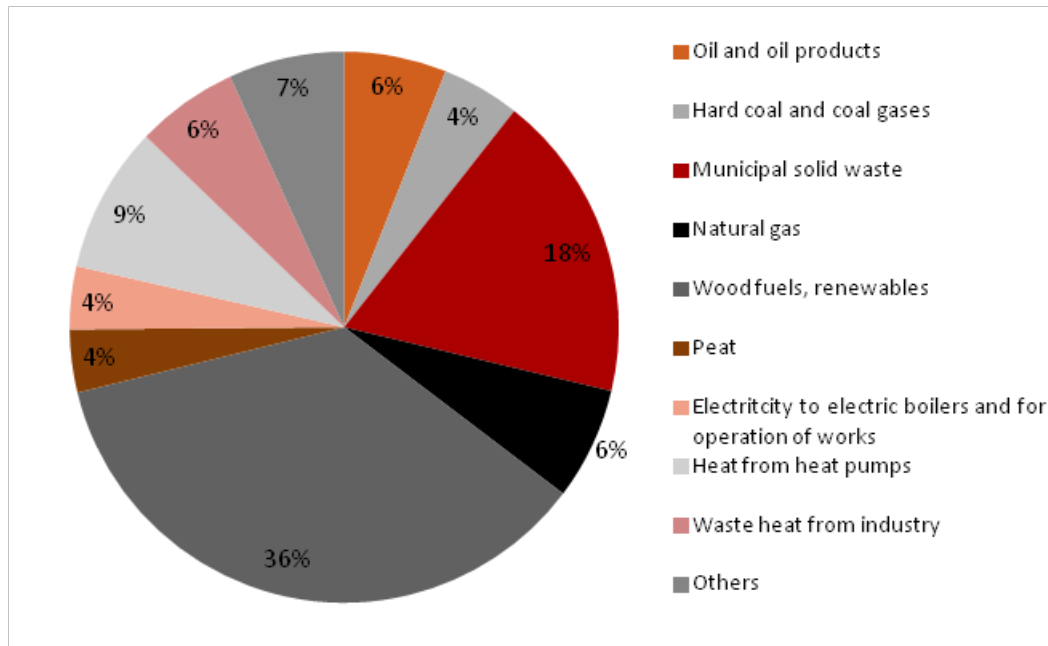


Figure 58 Fuels used in district heating in Sweden, 2012

Source: Sveriges Officiella Statistik

The main characteristics of input fuels used in DH in Sweden as follows:¹⁰³

- Municipal solid waste: is the base load in 30 DH systems.
- Industrial surplus heat: is recycled in about 50 DH systems, comes mainly from oil refineries, paper mills, steel mills and chemical industries. The 2 longest pipes for recycling industrial surplus heat are both 18 km long, and are in Varberg and Lindesberg.
- Wood fuels and peat: About 120 companies use this fuel, this is the dominant form. The most common base fuel in small DH systems. Used in both CHP plants and heat-only boilers. Partly imported from neighbouring countries.
- Natural gas, LPG, biogas and blast furnace gas: usage depends on availability. Natural gas is only available since 1985 in Southwest Sweden between Malmö and Göteborg.
- Heat pumps: large heat pumps are used in about 40 systems.
- Electric boilers: less used because higher electricity prices and taxes
- Coal: was used by many systems in early 1980's as the first oil substitution, but most of these systems were converted to biomass (see carbon dioxide tax in 1991).
- Oil: only used in peak and stand-by boilers.
- Other: bio-oil, dangerous waste, rubber tires, straw, refinery gas, animal waste, demolition wood waste, imported olive stones etc.

Important condition that natural gas is only available since 1985 in Southwest Sweden between Malmö and Göteborg (Werner 2012, Ericsson 2009), thus % of households reached by gas networks is very low.

As a result of the above basket of DH inputs, *CO₂ emission/MWh decreased significantly*: from 350 kg CO₂/MWh heat during the 70s and 80s to 50 kg CO₂/MWh in 2010. This is relatively low compared to other European cities using natural gas and fuel oil to heat buildings.

CHPs did not play a significant role in DH systems for a long period, their share in DH production remained below 50% before 2000. From that time this ratio rose considerably: from 55% in 2000 to 70% in 2012.

¹⁰³ Sven Werner: District Heating in Sweden – Achievements and challenges 2010

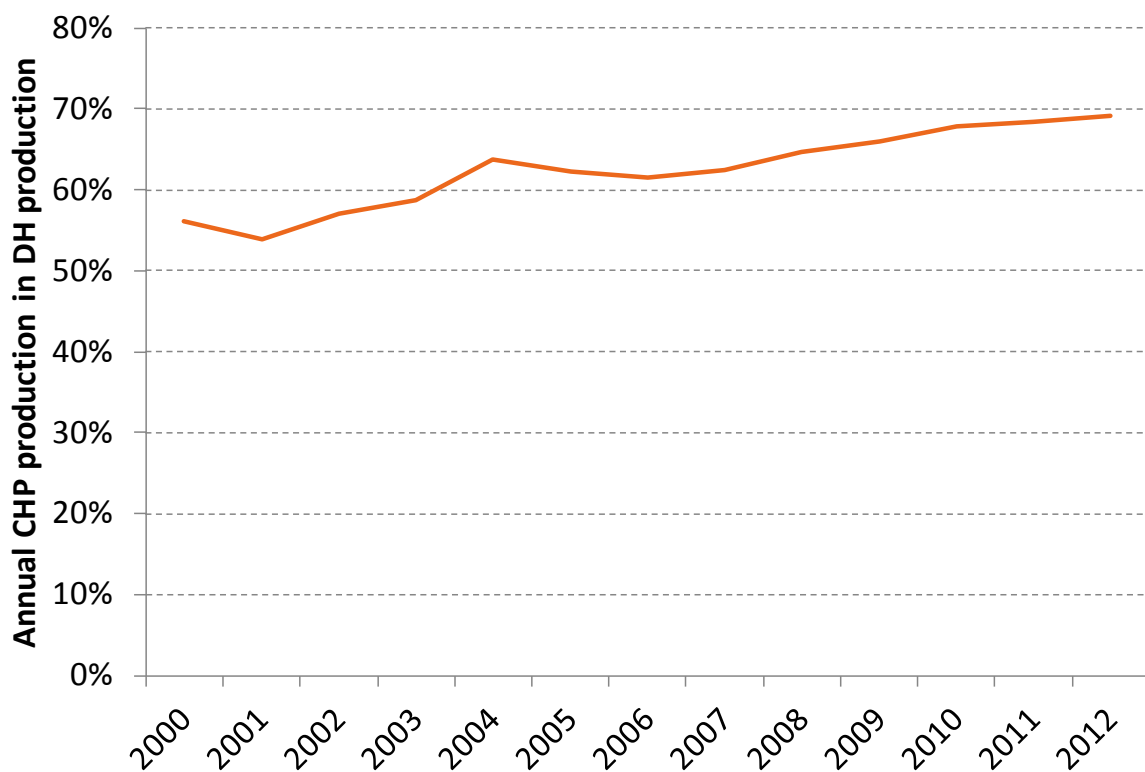


Figure 59 CHP production in DH production, 2000-2012 in Sweden
Source: Eurostat

There are traditional reasons why CHPs didn't play a higher role in Swedish district heating. According to *Werner* (2012) the most important factors were the following:

- New nuclear plants in the 1970s offered relatively cheap electricity (besides the already existing hydro power plants) and the oil crises turned oil-based CHPs too expensive.
- Until 2004, the heat side of the CHP plants was taxed as if the fuel had been used in heat-only boilers, fossil fuels used in CHP plants were proportionally allocated to electricity and heat. This was later modified in 2004.

In the last 15 years, investment and operational conditions for Swedish CHPs became more favourable, and ensures more than 60% of DH heat nowadays (69% in 2012¹⁰⁴). Main policy measures supporting CHP investments are the following (*Werner*, 2012):

- With the introduction of the Nordic electricity market, conditions for CHPs in Sweden became more harmonized in Europe (Swedish electricity balance is no longer a restriction of the amount of electricity generated).
- Higher investment grants for new biomass CHP plants (1991 and 1997, see details under section 7.7.5.2)
- New green certificate system, introduced in 2003, ensures long-term support for biomass CHPs.

As a consequence of the more favourable regulatory conditions, the role of CHP plants in district heating heat production is expected to strengthen.

Regarding *DH prices* in Sweden, we must emphasize that i) no alternative gas supply was available ii) fuel oil prices were increased by the fuel oil and CO₂ emission taxes. That's why the average price of district heating was below the typical prices of alternative heating solutions. The VAT for district heating is 25% in Sweden.¹⁰⁵

¹⁰⁴ Eurostat 2014

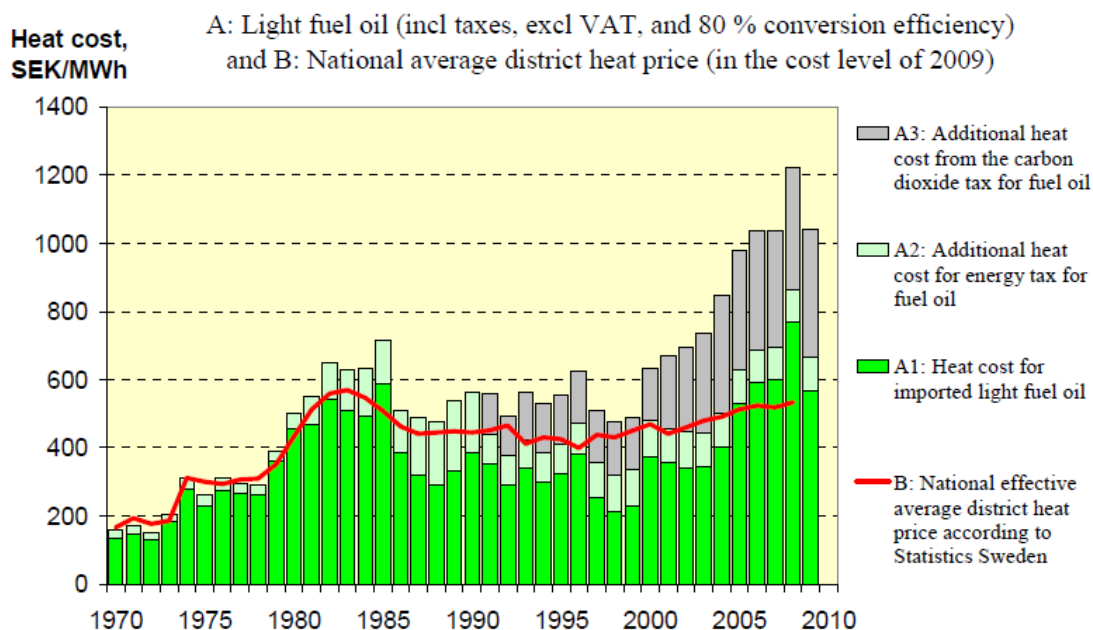


Figure 60 Comparison of heat prices, different technologies in Sweden¹⁰⁶

Source: Werner: *District Heating in Sweden – Achievements and challenges*.

7.7.3 Future vision of district heating in national planning

Overall, district heating is already the dominant form of heating multi-dwellings buildings and commercial premises. As a consequence, possible future developments in DH sector are investments in more efficient networks and enlargement of district heating systems towards rural, single family houses areas.

In National Renewable Energy Source Industry Roadmap¹⁰⁷ Sweden has indicated 10TWh additional increase in bioenergy used in district heating until 2020, however ratio of RES is already high compared to other EU member states.

¹⁰⁵ Vatlive, <http://www.vatlive.com/country-guides/sweden/swedish-vat-compliance-and-rates/>

¹⁰⁶ Werner, 2010

¹⁰⁷ http://www.repap2020.eu/fileadmin/user_upload/Roadmaps/REPAP_Sweden_Roadmap_FinalVersion.pdf

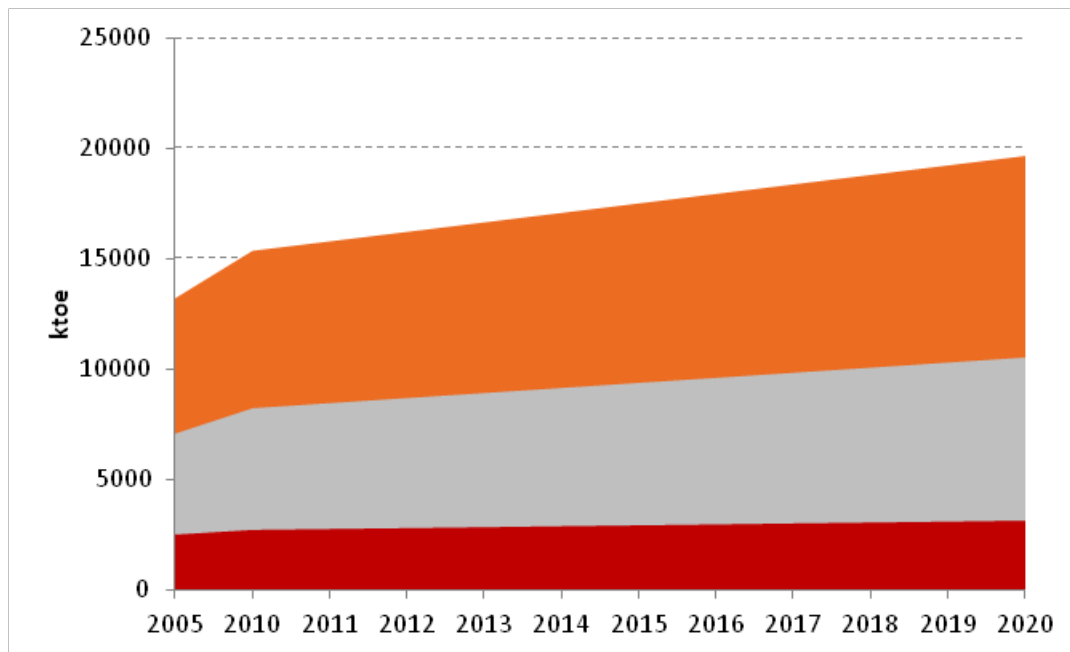


Figure 61 Renewable district heating consumption and total heat consumption to 2020, ktoe in Sweden
Source: NREAP Sweden

7.7.4 Regulation of DH services

7.7.4.1 General regulatory setting

7.7.4.2 Main regulation

The district heating market in Sweden is governed by the *District Heating Act (2008:263)*.¹⁰⁸ The regulation – in accordance with the 1996 deregulation of the energy market – does not contain rules for price level or obligations for fuel mix etc. However, the Act orders district heating companies to prepare regulatory financials report on their district heating operations to Energy Market Inspectorate every year, no later than 31 July.

The report shall consist of annual reports and accounting for operations and business conditions. If the same company is also involved in the production and trade of district heating, the regulatory financial accounts shall also encompass production and trade (accounting separation).

7.7.4.3 Price regulation

Prices are set free since the liberalization of district heating market in 1996. Before that time municipalities were ordered to set DH prices under cost based pricing. Since privatization and liberalization of the sector, big energy companies set DH prices as an element of their energy portfolio, and DH prices vary between different distribution companies, between 0.4 to 0.9 SEK/kWh in 2008,¹⁰⁹ 0.6 SEK in 2013¹¹⁰ (20.63 euros). Some companies still apply cost-based pricing. The profit level of a municipal DH company is about 3%, but for some national/international energy companies this can be higher, for example Fortum's corresponding annual return was 12% (Ericsson 2009).

The cost structure of a typical DH production and distribution company is summarized in Table 13.

¹⁰⁸ http://ei.se/Documents/Publikationer/lagar_pa_engelska/District_Heating_Act.pdf

¹⁰⁹ Ericsson 2009

¹¹⁰ Euroheat

Table 13 Energy company costs associated with DH production and distribution¹¹¹

	Production	Distribution	Others	Total	
	SEK/MWh			SEK/MWh	%
Fuel	160	20	0	180	45
Capital	80	50	5	135	33
Operation and maintenance	40	10	0	50	13
Staff	20	5	10	35	9
Total	300	85	15	400	100
Total (%)	75	25	21	4	100

Source: Karin Ericsson: Introduction and development of the Swedish district heating systems

The free price setting has been under debate, as mentioned above in EMI's 2012 investigation. Besides, the Swedish Competition Authority also has on several occasions argued for the regulation of DH companies.

7.7.4.4 Regulatory bodies and their roles

The district heating sector is supervised by the **Energy Market Inspectorate (EMI)**. EMI also supervises the electricity and natural gas markets. Regarding district heating market, EMI's main role is to ensure that district heating companies comply with the District Heating Act. In case of breaches, EMI submits report to Government Commissions.

However EMI inspects reasonability of network fees for electricity and gas and connection fees for electricity, EMI currently does not directly inspects the reasonability of prices charged by district heating companies to the private customer.

Yet, in 2013 EMI had a general investigation on the price changes and a principle for equal treatment for customers in the same customer category in the DH sector. The concluding/closing proposal of the investigation is a matter of limiting companies' permitted price increases with the use of a special sector index (Trial price changes and equal treatment principles for district heating) (Ei R2013:07).¹¹²

The building of DH systems has been supported and incentivized by **municipalities** from the beginning. Till 1996 district heating was regulated by the Local Authority Act and municipalities were responsible for ensuring heat services for residents. Since the ownership structure of DH firms changed and the deregulation happened in 1996, municipalities play a less important role in DH sector. Yet, they have to prepare municipal energy plans (since 1977).

¹¹¹ Karin Ericsson: Introduction and development of the Swedish district heating systems, RES-H paper

¹¹² Ei Annual Report 2013

Box 1 Role of Municipality in Östersund in Ensuring Favorable Public Attitude Towards DH

In June 2005 a questionnaire survey has been carried out of about 700 homeowners who lived in the city of Östersund in houses with resistance heaters. About 84% of the respondents did not intend to install a new heating system. Since then these homeowners were influenced by (a) an investment subsidy by the Swedish government to replace resistance heaters with district heating, a brine/water-based heat pump, or a biomass-based heating system and (b) a marketing campaign by the municipality-owned district heating company. These two measures influenced about 78% of the homeowners to adopt the district heating system. The follow-up survey of the same homeowners in December 2006 showed that the investment subsidy and the marketing campaign created a need among the homeowners to adopt a new heating system. The marketing campaign was successful in motivating them to adopt the district heating system.

Source: Survey by Krushna Mahapatra and Leif Gustavsson

The **District Heating Board** is an independent organizational unit within the Energy Agency, established by the 2008 Act. The main roles of the Board are the following:¹¹³

- District heating companies are, for example, required to negotiate with individual district heating customers concerning certain terms and conditions for the supply of district heating. If they cannot reach agreement, they can apply to the District Heating Board for arbitration.
- The Board shall also arbitrate negotiations between district heating companies and other parties wishing to obtain access to the distribution networks

The **Swedish District Heating Association** has an important role in ensuring technical standards within the sector.

7.7.4.5 Ownership of district heating companies

7.7.4.6 Methods to increase competition in the DH sector

As it is often difficult for heat producers to obtain access to the distribution network, some argue for the compulsory third party access. Current developments regarding TPA in Sweden are as follows¹¹⁴:

- A commission was set up to look into the conditions for obligatory third party access in order to open up the district heating market for access by suppliers of industrial waste heat.
- The Third Party Access investigation in 2011 (SOU 2011:44) proposed dividing up the market in order to make networks accessible to competing production and trading companies.
- However, uncertainties regarding the effects and costs of introducing obligatory third party access resulted in the Energy Markets Inspectorate being instructed to investigate the matter in more detail.
- In 2013, EMI has submitted its final report to Government Commissions in this area ('Model for regulated access to the district heating networks'). In brief, EMI's proposal is that no district heating company should be able to deny a heat producer access to the networks unless there are special reasons to do so. According to the proposal, the heat producer must cover the entire cost of connecting their facility to the district heating network. (Regulated access to district heating networks) (Ei R2013:04)¹¹⁵

¹¹³ Energy in Sweden 2012

¹¹⁴ Energy in Sweden 2012, EMI Annual Report 2013

¹¹⁵ Swedish Energy Market Inspectorate: Annual Report 2013

7.7.5 DH policy tools

7.7.5.1 For district heating systems

7.7.5.1.1 Financial, economic policy tools

Several incentives were implied in order to increase the market share of district heating during its more than 50 years in Sweden, for example:

1. Municipal electricity departments started district heating systems in order to obtain heat sinks for future municipal CHP plants. The domination hydropower supply was to be supported by new thermal power in the electricity balance (1948-70)¹¹⁶
2. To improve poor housing conditions, national housing programme was launched to build one million new dwellings during 10 years (1965-74) and most of them were connected to the growing district heating systems.
3. State grants for heat distribution pipes and connection of new customers.

7.7.5.1.2 Administrative policy tools

Significant part of multi-dwelling buildings was in municipal ownership in 1960s and 1970s and thus provided with district heating system as a result of the municipal decision.

7.7.5.2 For RES based district heating

7.7.5.2.1 Financial, economic policy tools

In order to increase the usage of renewable fuel sources in district heating systems, several substantial investment support programs have been launched.¹¹⁷

- In the 1990s, biomass CHPs were eligible for subsidies in two phases:
 - In 1991-96 a program aimed at increasing biomass-based electricity production by 0.75 TWh/y and had a budget of 1 million SEK. 16 new biomass-fired CHP plants were subsidized, 12 of which in the DH systems.
 - In 1997-2002, the next program ensured maximum amount of 3000 SEK/kW and was awarded to other nine biomass CHP plants.
- In 1998 Local Investment Programmes (LIP)¹¹⁸ have been launched. These programs had a board scope between 1998 and 2002, but DH played an important part. The related results of the programme were as follows:
 - About 1 billion SEK were allocated to district heating projects: establishment of new small-scale district heating, expansion of existing DH systems, retrofitting and extension of production capacity and construction of new DH production capacity, including the recovery and utilization of industrial waste heat.
 - Recovery of industrial surplus heat was in focus. 240 million SEK were granted to the recovery of industrial waste heat in DH systems and involved 370 GWh of heat.
 - Besides, subsidies were granted to connect one- and two-dwelling buildings to DH systems and for the establishing of small-scale DH systems.
- In 2003, Climate Investment Programmes (KLIMP)¹¹⁹ have been introduced. Klimp replaces Lip, as having a board scope but DH important part as well. Different forms of local energy projects could be subsidized.

¹¹⁶ Werner (2012)

¹¹⁷ Details of these policy tools are summarized based on Ericsson 2009

¹¹⁸ Local Investment Programmes - The way to a sustainable society

¹¹⁹ <http://www.governancereport.org/home/governance-innovations/featured-innovations-2014/climate-investment-programmes-sweden/>

- In 2006 subsidies were introduced for the replacement of oil heating in one- and two-dwelling buildings and of direct electric heating in all residential buildings. The supported replacement options were district heating, ground-source heat pumps and biofuel boilers.
 - Out of the 450 million SEK available, 20% was used for introducing district heating instead of oil heating.
 - Out of the 1-5 billion SEK 480 million had been granted for replacement of direct electric heating until 2008 and 80% of the amount had been granted for shift to district heating.

7.7.5.2.2 Administrative policy tools

The regulation of municipal waste plays an important role in the RES fuel structure in Sweden. In 2002, a ban on landfilling combustible waste has been introduced, and in 2005 a ban on landfilling organic waste also came into force.¹²⁰

¹²⁰ European Environment Agency: Municipal waste management in Sweden, 2013

8 District Heating Case Studies

8.1 RES District Heating Case Study in Germany: Geothermal district heating in the city of Poing

8.1.1 Introduction

In 2010, the share of housing stock connected to district heating networks in Germany was around 13%.¹²¹ The share of renewable energy sources (RES) in district heating networks is currently around 9%.¹²² Space heating, process heating and hot water account for around 56% of total energy consumption in Germany.¹²³ As the German Government aims to reduce greenhouse gas emissions by 80% in 2050, compared to 1990 levels, RES play an ever increasing role in heat supply.

The following case study presents the example of a **geothermal plant connected to an old district heating network in the community of Poing**¹²⁴, which is in the Upper Bavarian district of Ebersberg, located ca. 20 km east of Munich (see Figure 1). The city of Poing exhibits a successful transformation of an old district heating network and is therefore selected as a case study.

The potential of **geothermal energy** in Germany is estimated to be approximately 550 TWh/a.¹²⁵ However, as many district heating networks are not located close to favourable geological areas for geothermal energy, the technically feasible potential is much smaller. Geothermal energy is continuously available throughout the year, regardless of seasons or climatic conditions. It allows a year-round coverage of base load heat supply and may be supplemented by peak load boilers.¹²⁶

8.1.2 Description of the technology

The Bayernwerk Natur GmbH (former E.ON Bayern-Wärme GmbH) operates a ca. 20 year old district heating network with a connected load of 28 MW_{th} in Poing.

The heating network has an approximate length of 18 km. In winter, the inlet temperature of the heating network is ca. 105 °C while the outlet temperature ranges from 55°C to 60°C.¹²⁷ Yet, new network pumps are expected to optimise the network temperature in future.

In the past heat had been supplied by CHP (two CHP plants supplied by natural gas, and one CHP plant supplied by bio gas and peak load boilers (natural gas and oil). The heat output of the CHP units are around 1 MW_{th}



Figure 62 Location of Poing

¹²¹ AGFW (2013): Transformationsstrategien Fernwärme – TRAFÖ – Ein Gemeinschaftsprojekt von ifeu-Institut, GEF Ingenieur AG und AGFW.

¹²² AGFW (2013).

¹²³ Arbeitsgemeinschaft Energiebilanzen (2013): Auswertungstabellen zur Energiebilanz der Bundesrepublik.

¹²⁴ This text draws extensively from a first analysis of the geothermal plant by AGFW from 2013 as well as further secondary research and telephone interviews with Bayernwerk Natur GmbH.

¹²⁵ Kayser, M. and M. Kaltschmitt (1998): Potenziale hydrothormaler Erdwärme in Deutschland. Institut für Energiewirtschaft und Rationelle Energieanwendungen, University of Stuttgart.

¹²⁶ Kayer and Kaltschmitt (1998).

¹²⁷ AGFW (2013).

each. However from 2008 to 2012, the previously existing producer park was completely remodelled. In addition to the construction of a geothermal heating plant, another peak load boiler was added. As the geothermal plant now covers base load supply in summer and winter, the existing CHP units are currently being dismantled.

INFO-BOX:

District heating network:

Connection rate: 28.06 MW_{th}
 Annual peak load: 14 MW_{th}
 Net heat production: 45 GWh_{th}/a
 Network losses: 11.8%

Geothermal plant:

Geology: Southern German molasses basin
 Drilling depth: 3000 m
 Bulk rate: 100 l/s
 Production temperature: 76 °C
 Re-injection temperature: 50 °C
 Max. heat capacity: 7 MW_{th}
 Net heat production: 31.5 GWh_{th}/a
 Pump current requirement: 3,500 MWh/a

The deployment of the geothermal plant was initiated in 2006, while the official operation began in September 2012. The construction was completed in 2009, after which the testing period of the geothermal plant started. The geothermal plant itself consists of a hydrothermal doublet. The production well and a re-injection well are both approximately 3,000m deep.

All heat generation plants are located in Poing and heat supply is split to one third into the summer half-year and two thirds into the winter half-year. The peak load coverage is taken up by three boilers (natural gas and oil) with installed capacities of 7 MW_{th}, 6 MW_{th} and 17 MW_{th} respectively. These account for ca. 30% of total generation.¹²⁸ In order to compensate for peak loads, a small buffer storage with an effective volume of 20 m³ exists. This is a heating water storage, which was used for the CHP plants, but is now used for heating water for the geothermal heat. It is however not used in the thermal water circuit. The thermal water from the drilling is pumped to three heat exchangers. Depending on heat demand, flow temperature is heated with peak load boilers. The geothermal heat output is up to 7MW_{th} with a bulk rate of approximately 100l/s.¹²⁹ This means that geothermal power can cover up to 50% of the annual peak load. Around 70% of total heat production (see Figure 2) can be covered by the net heat production of the geothermal plant which amounts to 31.5GWh/a, corresponding to approximately 4,500 full load hours.¹³⁰ As the CHP units are being dismantled due to redundancy, electricity required for pumping needs to be purchased.

¹²⁸ A net heat production of 13.5 GWh/a is assumed (AGFW, 2013).

¹²⁹ AGFW (2013).

¹³⁰ AGFW (2013).

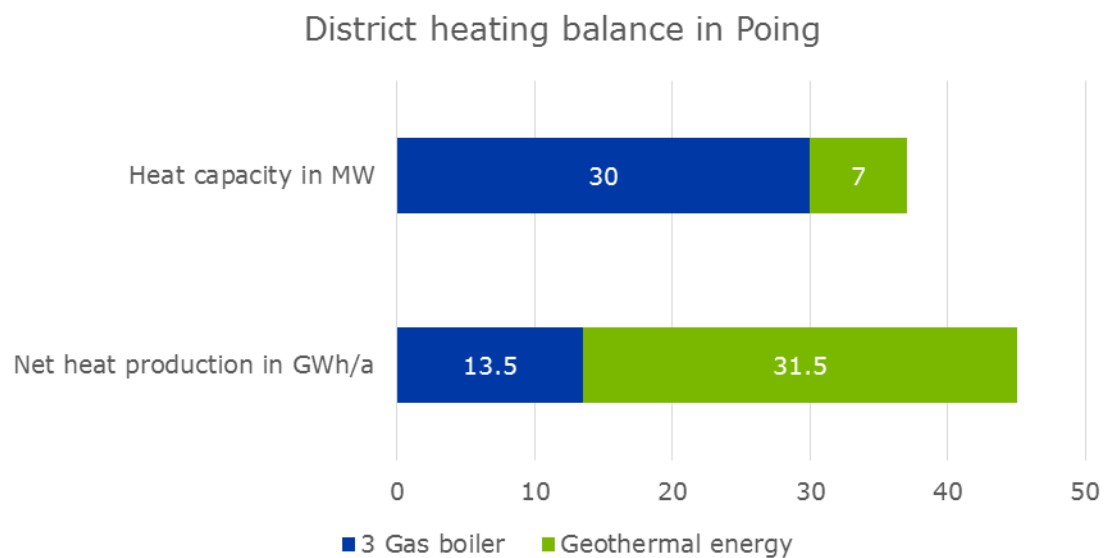


Figure 63 District heating balance in Poing¹³¹

8.1.3 Socio-economic characteristics

Bayernwerk Natur GmbH is a vertically integrated district heating provider, which means heat production and distribution is integrated within the company. The community of Poing was involved in the planning of the geothermal plant from the beginning, however they neither own a part of the geothermal plant, nor do they own parts of the district heating network.

In 2009 ca. 330 users were connected, while the number has risen to ca. 630 in 2014. A total further expansion potential of 36 GWh exists, which would increase the current heat demand to ca. 68 GWh.

Bayernwerk Natur GmbH charges an annual connection/service fee of ca. 500 € in addition to a rate of 64€/MWh_{th} for the heat consumed. This is a high price compared to the conventional district heating provider in the region.

The gas market in Germany has been liberalised since 1998, hence large variations in prices for district heating exist in Germany. At the time of writing this report the gas-fuelled district heating providers in the Munich region were among the cheapest in the country with an average price of ca. 3.12 Ct/kWh¹³² in addition to varied connection charges.

8.1.4 Policy drivers behind the development

Total investment cost for the geothermal plant were 32 Mio. €. Out of this, the cost for the drilling amount to 16.7 Mio € (52%) while materials handling and grouting amount to 3.7 Mio. Costs for the thermal water route were approximately 1.1 Mio €.

Several subsidies exist which support geothermal energy in Germany. The plant itself is subsidised under the Market Incentive Programme – KfW Premium Programme for Renewable Energy. KfW repayment bonuses of 9Mio€ were granted in total for the geothermal plant. This amount comprises a plant repayment bonus of

¹³¹ AGFW (2013).

¹³² http://www.ihk-schleswig-holstein.de/innovation/energie/zahlen_daten_fakten/734180/VEA_Erdgaspreisvergleich.html

2Mio€ (highest amount possible) and drilling support (5Mio€) and further financing of ca. 1Mio€ for each drilling.¹³³¹³⁴¹³⁵ Furthermore, production support exists via feed-in tariffs of 25ct/kWh.¹³⁶

8.1.5 Role of municipality/regional government

The community is neither the owner, not the operator of the plant. The initiation of the project came from Bayernwerk Natur, as they saw great potential for geothermal energy due to the local geological conditions. After a first assessment of the technical and economic potential of geothermal energy in the region, the community of Poing and surrounding communities were involved. Although the degree of support from the community for the development of the plant could not be confirmed, we have found no signs of strong opposition to the project, despite the high prices of geothermal energy in the region. The district heating network in Poing is continuously being expanded. Especially new building sites are being developed and connected to the district heating network. In Poing competition between the district heating network and the natural gas network exists. As there is no obligation to connect, the energy supply of new construction areas is publicly tendered. This means that a new residential area might obtain a gas connection even though district heating exists.

8.1.6 Driving factors and barriers

The main promoter for the development of the geothermal power plant in Poing was the district heating provider and distributor Bayernwerk Natur GmbH. As local conditions are very favourable in the region, a great potential for geothermal energy exists. Additionally, support for the construction of the geothermal power plant was high in the community which made the planning and construction process simple. According to Bayernwerk Natur GmbH no barriers or challenges existed during the planning stages, however several technical issues hindered the construction process. This led to a slower and more expensive development than originally estimated. A major issue that hindered the development were technical problems encountered during the drilling process.

Summarising, the geothermal energy development presents a best practice example as the entire producer park in Poing has been transformed. This means not only was a geothermal plant added so that geothermal energy can be produced locally, but also the previously existing fossil-fuelled CHP units are being dismantled. This makes the heating supply in Poing more environmentally friendly. Additionally, plans for further expansion of the district heating network exist.

¹³³ http://www.bafa.de/bafa/de/energie/erneuerbare_energien/index.html

¹³⁴ The KfW provides low-interest loans and grant repayment support (Tilgungszuschuss) for electricity generation in deep geothermal installations. This programme does not address the geothermal exploration activities. However, the programme's focus is supporting renewable energy sources for heat generation. (see also: <https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/index-2.html>).

¹³⁵ The KfW Programme Geothermal Exploration Risk covers investment costs connected to drilling activities including the required stimulation measures prescribed by KfW as part of project study. The loan amounts to max. 80% of eligible investment costs with different interest rates accounting for the different exploration risks. Only geothermal projects with at least two deep drillings are eligible for support.

¹³⁶ Every kilowatt-hour generated from renewable energy facilities receives a fixed feed-in tariff. Grid operators are required to preferentially feed-in this electricity into the grid over electricity from conventional sources (nuclear power, coal and gas). Renewable energy plant operators receive a 20-year, technology-specific, guaranteed payment for their electricity generation. (see also <http://www.res-legal.eu/search-by-country/germany/single/s/res-e/t/promotion/aid/feed-in-tariff-eeg-feed-in-tariff/lastp/135/>).

8.2 Miskolc Geothermal District Heating Project, Hungary

8.2.1 Introduction

The geothermal project in Miskolc was finished in 2014, and with its commissioning became Central Europe's largest geothermal heating plant came online, supplying some 10 000 households, and a hundred institutions. Besides the geothermal plant, a biomass and a biogas project were also realized in Miskolc, and now more than 40% of the city's heat demand is being supplied from renewable energy sources.

8.2.2 Description of the technology

The geothermal system uses thermal water, through two producing and three reinjection wells. This heat source is practically non-exhaustible, as the reinjection wells continuously guarantee the appropriate amount of water in the system. The installed capacity of the plant is 2x30 MWth but in summer only 5-5 MWth will be utilized. The yearly heat supply, according to the long-term contracts, is around 400 TJ.

The project included expansion of the network to connect the wells with the existing DH system, but no new consumers were connected. This network expansion together with the establishment of the wells was a green-field investment.

8.2.3 Socio-economic characteristics

90% of the Miskolci Geotermia Zrt. (company founded for the project) is owned by Pannergy plc., that leads geothermal projects in other Hungarian cities as well.

The remaining 10% is owned by MIHŐ Kft, the municipality owned district heating supplier, which is one of the 11 utility services companies of Miskolc.

This way the municipality owns the full distribution network and has a minority stake in the geothermal heat production as well. It also plays a key role in the other renewable heat generation projects of the city: it has a 25% share of Bioenergy-Miskolc Kft. – the company founded for the biomass project - and also took part in two biogas projects, one utilising landfill gas and another connected to the municipal wastewater treatment plant.

Before 2011, end user prices were regulated by the local municipalities, and many times heat prices did not reflect the real production costs for heat. In 2011, end user heat prices were frozen at that previous year's level, and later were decreased twice due to the central government's policy of reducing energy prices.

In 2011 the feed-in tariff for the co-generation system ended. From then on not only were the end user prices centrally regulated, but the price that the supplier has to pay for the producer was also regulated. The producer can get two types of fees: capacity fee (HUF/MW/year based on the booked capacity) and heat fee (HUF/GJ based on the produced heat quantity). The Minister in charge for energy policy sets different fees for each producer according to their adjusted cost based on Hungarian Energy and Public Utility Regulatory Authority (HEPURA) calculation. Producer prices are set yearly.¹³⁷

Since both the suppliers' heat procurement prices and end user prices are regulated, from 2011 suppliers are eligible for compensation if their justified costs are not recovered. The support is based on the sold quantity of heat to households, and paid to the supplier companies. The geothermal and fossil based heat fees, capacity fees and support schemes for MIHŐ are summarized in the following table for the last two years.

¹³⁷ The length of the regulatory period is not stated in the legislation, but in the last 2-3 years prices were set yearly

Table 14 Regulated heat and capacity fees and support level for MIHŐ in 2013, 2014

	2013.11.01	2014.10.01
geothermal heat fee	3100 HUF/GJ	2500 HUF/GJ
fossil fueled heat fee	3100 HUF/GJ	2450 HUF/GJ
fossil fueled capacity fee	HUF 2.25 billion/year	HUF 2.55 billion/year
support for household heat supply	3889 HUF/GJ	3670 HUF/GJ

Source: MIHŐ

8.2.4 Policy drivers behind the development

The total cost of the project was EUR 25 million. Around one third of this amount - EUR 9.3 million (HUF 2.79 billion) - came through tenders financed from the European Union European Regional Development Fund (KEOP) and the central budget of Hungary.

The company has already launched long-term contracts with the municipality for the heat supply of public buildings and with two industrial customers. There are also further negotiations with new potential users to facilitate the higher utilization of the plant (as the maximum yearly generated heat could be around 800 TJ). Connection of new customers to the system is important taking into account the possible energy efficiency measures that would lower the average heat consumption of a household.

The geothermal heat producer faces an additional burden as the municipality already had a long term contract (LTC) with a natural gas based heat provider. It has to pay compensation for this contract holder as the heat under this LTC is not fully taken due to the cheaper geothermal capacities. Although remedies were sought to avoid this payment, the attempts have not yet been successful.

In Hungary the regulatory environment changed many times unexpectedly in the last few years, which does not facilitate long term investments required for district heating plants. The geothermal project in Miskolc could only be realized with the help of a committed municipality and a project promoter experienced in previous Hungarian geothermal projects.

8.3 Biomass-based District Heating Development in Pécs, Hungary

8.3.1 Introduction

Pannon Thermal Power Plant, owned by Pannonpower holding, supplies 31,000 households and 450 public institutions with heat in Pécs. The biomass program of the power plant took off in 2001, when the need for fuel-change was recognized due to environmental pressures. As a result of the EU Directive limiting emissions from large combustion plants (2001/80/EC), Hungary introduced strict rules on the emissions of dust, sulfur-dioxide and nitrogen-oxides from power plants as of 2005. Implementation of the Directive (10/2003. (VII. 11.) KvVM) forced Pannon Thermal Power Plant to fundamentally change its heat production technology after it had been burning high-sulfur coal from Mecsek.

In the framework of the first project partly financed by the World Bank, two coal-fired boilers were transformed into gas-fired boilers, with another running on wood chips. The decision to also build a biomass co-generation unit was influenced by the opportunity offered by the Prototype Carbon Fund (PCF) of the World Bank, which was the first global carbon fund set up in 2000 to finance emission-reduction projects in the framework of Joint Implementation (JI) and Clean Development Mechanism (CDM) of the Kyoto Protocol. Six

governments and 17 companies invested in PCF, benefitting from emission-reductions financed by the fund in proportion to their contributions.

Based on the agreement with the World Bank, Pannon Thermal Power Plant was allowed to sell 1.2 million tons of carbon equivalents to the fund between 2008 and 2012 as a result of the development, for a total of 1.3 million USD. This additional and predictable income played a significant role in the success of the power plant to acquire bank credit for 75% of the investment of 36.3 million USD, which was also facilitated by the feed-in-tariff system already in place in Hungary. The biomass power plant has 49.9 MW electricity and 85 MW heat production capacity, and it is operated by a legally separated project company. Its commercial operation started in 2004. The profitability of the project company is in line with expectations, the investment is expected to be recovered by the end of 2018.

8.3.2 Technology description

Pannonpower started a new brownfield investment in 2010 with the purpose of building a straw-fired power plant with 35 MW of electricity and 72 MW of heat production capacity. The development of 84 million EUR was financed by the parent company (Dalkia Energia Zrt. with French ownership) without any investment subsidy. The plant, however, has been granted participation in the feed-in-tariff system for a ten-year period, beginning with the start of operations. It is entitled to sell an annual 225,000 MWh of electricity under FIT (whereas the wood-fired block can sell 335,000 MWh/year until 31st May, 2018). The development was completed by the end of 2013. The new block is capable of supplying almost 80% of heat demand of the Pécs district heating system; the remaining 20% is provided by the woodchip-fired power plant (85 MW_{th}, 50 MW_e capacity), while the two natural gas-fired boilers serve only as back-ups.

Table 15 Transition to biomass: change of generation capacities (MW)

	2001-2003		2004-2012		2013-	
	heat (MWth)	electricity (MWe)	heat (MWth)	electricity (MWe)	heat (MWth)	electricity (MWe)
coal	570	190	-	-	-	-
natural gas	-	-	155	70	155	-
wood	-	-	85	49,9	85	49,9
straw	-	-	-	-	72	35

With the realization of the two biomass co-generation units Pannonpower operates Europe's biggest district heating system based fully on renewable energy and cogeneration, and Pécs is the first city in Hungary that provides for its district heating exclusively from renewable energy sources. The straw-fired power plant based on Danish technology features a number of innovations.¹³⁸

8.3.3 Role of Municipality

The district heating provider of Pécs (PÉTÁV Kft.) is 49% owned by Pannon Thermal Power Plant, and 51% owned by the municipality of Pécs. Pannon Thermal Power Plant and PÉTÁV signed a long-term contract to provide heat energy (Heat LTC) in 2008 for the period until the end of 2030. The contract reserves 194.5 MW of heat capacity until the end of 2011, and 188 MW from the beginning of 2012, and provides for the annual sale of 1650 TJ of heat energy. From the second quarter of 2011, the Heat LTC applies a price indexation that is in

¹³⁸ The project was selected in March 2014 by COGEN Europe, the European association for the promotion of cogeneration, as the best of the continent in 2013 in the category of market development, while the city of Pécs – largely due to the power plant development – won a special award in the European competition RES Champions League. The city thus stands a good chance to be awarded with the title of European Green Capital in 2017.

line with the biomass procurement contracts: heat tariffs are 40% tied to the change of gasoline prices, and 60% to the average of producer and consumer inflation. Pannon Thermal Power Plant – partly with regards to the expected reduction of costs as a result of 100% renewable-based heat production – implemented a one-time, 12.6% reduction of heat tariff in the middle of 2010.

The municipality of Pécs signed an agreement with Pannonpower in 2008 pledging itself to further develop the district heating market. As a result of this commitment many new institutions were connected to the district heating system since 2008. The company and the city also cooperate in bringing new industrial establishments to Pécs: new investments mean new jobs for the city and new consumers for the power plant. This is of great importance for Pannonpower as it seeks to counterbalance a 9% drop in household consumption in the last 5 years by gaining new industrial clients.

The good cooperation between the city and the DH company has been maintained in spite of the fact that even the minimum heat quantities agreed to in the LTC were not taken. In fact, new consumers partly compensate for the unsold heat under the LTC. The 2014 energy strategy approved by the municipality reinforced the central role assigned to district heating, which is mainly explained by environmental considerations on the part of the city: high concentration levels of nitrogen-oxides continue to be a problem, and the municipality tries to prevent households from switching to individual heating modes.

8.3.4 Policy drivers

Two regulatory changes brought uncertainties for the straw-firing investment aimed to take off in 2009. The first was the decision of the European Commission in 2008 ruling long-term power purchase contracts inherited from the era of privatization to be illegal state subsidies. The 2010 decision of the Hungarian Government about the recognition of stranded costs made it clear that state subsidies given in the form of LTCs should not be paid back, so the DH plant remained solvent. The second uncertainty was brought by the governmental plans to review the feed-in-tariff (FIT) system, which is still under consideration.

The power plant, however, remained committed to the straw-firing block, mainly due to the long term strategy of Dalkia to increase the share of renewables in its portfolio and the political backing from the municipality. Construction was already underway when the government regulated prices for district heating in October 2010; the Heat LTC was not renegotiated by the power plant and PÉTÁV, only the application of the price formula of the LTC was suspended.

The operation of the straw-firing plant finally began in July 2013, in spite of the fact that the Danish technology supplier had gone bankrupt and that there were problems with the biomass suppliers as well. The plant procures the annual 220,000 tons of biomass needed for its operation within the 100 km radius from Pécs (around 20% from Croatia), in the framework of long-term contracts (of 10–15 years). This gives permanent work for 170 people, and seasonal work for additional 470. The power plant saves an annual 80 million cubic meters of natural gas, and carbon emissions are reduced by 150,000 tons.

Although air pollutant emissions of straw-firing exceeds those of natural gas, the concentration of substances in Pécs has not changed significantly (by more than 1%) compared to its basic air-pollution levels with the exception of HCl, but even this concentration has not exceeded 10–30% of the permitted levels. Due to increased traffic, a 20–40% increase in pollutant emissions was measured along the critical supply routes.

From a business perspective, the possibility of cogeneration has been paramount in making the investment succeed: both the volume of power sales and the existence of a heat market are essential. However, as both volumes and prices of sales have remained below what was anticipated and straw prices increased significantly (mainly due to increased road charges and oil indexation), the economic performance of the plant is worse than expected.

8.4 DH system of Greater Copenhagen

8.4.1 Short description of the initiative

This case study takes a closer look at the DH system of Greater Copenhagen. This well-established heat grid was greatly expanded in the 1980s and is now Denmark's largest DH grid. It covers Greater Copenhagen and supplies around 570 000 people with heat. The Greater Copenhagen DH system connects three large waste incineration plants, four CHP plants, as well as a larger number of peak load plants. The grid covers five municipalities and is operated by the two large transmission grid companies CTR and VECS as well as smaller distribution grid companies.

The distribution grid in Copenhagen municipality itself is owned and operated by HOFOR, a municipally owned company which also supplies services in the areas of water, sewage, gas, and energy production. Heat can be supplied to consumers either by the plants owned by HOFOR EnergiProduktion, by heat from the distribution grids operated by CTR and VECS, or from independent producers.

HOFOR, VECS, and CTR have set up a heat dispatch centre (Varmelast.dk) which ensures that at any time, the heat offered at the lowest prices is dispatched into the grid. The three grid operators prepare daily demand forecasts based on meteorological data, upon which the participating heat producers issue cost graphs indicating the hourly prices at which they can supply heat over the next 24 hours. The dispatch centre then determines the least-cost combination of heat sources for each hour and sends out the relevant orders to the producers. Adjustments are made three times within the 24 hour period to account for deviations from the load forecast or for other changes.

Total heat production stands at roughly 33 000 TJ/a. Heat density varies greatly within the covered area, as it includes the centre of Copenhagen as well as suburbs characterised by single family houses.

The DH grid is still being expanded slightly as customers in the area are converted from individual gas heating to grid-connected heating. However, Greater Copenhagen is mainly interesting as a case study because it is taking considerable efforts to decrease its use of fossil fuels in favour of RES. In 2008, 35% of the heat supplied through the grid was of renewable origin. The majority of renewable heat is produced by CHP plants which have been equipped for burning solid biomass. Another large contribution comes from the renewable portion of the waste burnt in the incinerator plants. Geothermal heat accounts for a very small proportion of heat production, with one pilot well currently in operation. The following table provides more detailed information on the energy mix in Copenhagen municipality in 2010, resulting in a RES share of 55%.

Table 16 Fuel sources for district heating in Copenhagen municipality, 2010

Fuel type	GWh	Share
Wood pellets	477	11%
Straw	217	5%
Waste (renewable share)	1,693	39%
Waste (fossil share – plastic)	434	10%
Coal	998	23%
Oil and diesel	260	6%
Natural gas	304	7%

Source: http://ec.europa.eu/environment/europeangreencapital/wp-content/uploads/2012/07/Section-12-Energy-performance_Copenhagen.pdf

8.4.2 Main policy and regulatory driving factors

In Greater Copenhagen, especially the municipality of Copenhagen has ambitious climate protection plans, aiming for full decarbonisation by 2025. HOFOR as a publicly owned company supports this strategic objective. HOFOR is therefore investing in its wind energy business and making efforts to decarbonise its DH supply, in cooperation with CTR and VEKS. In an effort to achieve the decarbonisation policy objective at least cost, the companies have initiated a series of studies as part of the Heat Plan Greater Copenhagen (Varmeplan Hovedstaden). A first study concluded that 70% RES could be achievable by 2015. A second phase of the study found that a 100% renewable heat supply by 2025, in accordance with Copenhagen's strategic objective, was possible. A third stage analysed a variety of investment scenarios for heat generation in the long run.

While local climate policy has been an important driver for the shift from fossil to RES, the DH grid, Danish national policy is one reason why the Heat Plan scenario calculations look favourable for RES: The CHP plants benefit from a national support scheme which provides a feed-in premium to renewable electricity. In addition, a considerable tax burden is levied on fossil heating fuels such as mineral oil products, coal, lignite, or coke in Denmark, making renewable fuels relatively attractive financially. In 2011, an average household with a consumption of 18.1 MWh/year would spend an estimated 1523 € (11,342 DKK) on district heating, compared to 2,955 € (22,000 DKK) on oil heating¹³⁹. Table x provides more details on the DH prices in Copenhagen municipality in 2015:

Table 17 HOFOR consumer prices for district heat in 2015, including VAT, Exchange rate of 02.06.2015.

	Consumer price € (DKK)
Hot water	
fixed price per MW per year	26.83 (199.78)
energy price (per MWh)	88.90 (661.81)
Steam	
fixed price per MW per year	26.83 (199.78)
energy price (per MWh)	62.22 (463.28)

Source: <http://www.hofor.dk/fjernvarme/prisen-paa-fjernvarme-2015/>

The 1979 heat supply act allows municipalities to require mandatory DH connection from consumers in designated DH areas. However, not all municipalities in the Greater Copenhagen area are making use of this legal right. In municipalities where connection is voluntary, DH has nevertheless been a cost-competitive and thus attractive option for consumers in recent years.

¹³⁹ source: C40CITIES, http://www.c40.org/case_studies/98-of-copenhagen-city-heating-supplied-by-waste-heat. Exchange rate of 02.06.2015

8.4.3 Impacts of the initiative/solution

As the pricing of heat is heavily regulated, the shift from fossil to RES fuels in the DH grid has not had an effect on consumer prices in Greater Copenhagen. Offering renewable heat at competitive prices is of course only possible due to the direct and indirect support provided to RES on national level, which in turn is financed by Danish taxpayers and electricity consumers.

The shift from fossil to RES fuels has no direct effect on energy efficiency in the connected households and commercial buildings. However, Danish energy efficiency regulation requires HOFOR to take measures to save 1% of energy demand every year. The company therefore provides advice and financial support for customers who want to insulate their houses.

HOFOR is strategically exploring ways to increase its RES share in district heating without relying too much on biomass, in case sustainability concerns or supply bottlenecks might arise in the future. Improved regulatory conditions may be necessary to apply excess wind electricity in heat production and to conduct economically risky geothermal explorations.

8.4.4 Applicability of the initiative to other regions

The case of Greater Copenhagen shows that an ambitious local climate strategy, in combination with existing national support schemes for RES, can be very effective in motivating heat suppliers to increase their use of RES, resulting in no or little extra costs for the municipality. This can serve as an example for municipalities in other Member States.

8.4.5 Barriers to the application of initiatives in other regions

Third party access to the grid is relatively easier in Greater Copenhagen, as ownership unbundling is rather far progressed and the dispatch centre regulates access on the basis of prices. The process of ownership unbundling has been much slower in some other Member States and may constitute a barrier in this respect.

9 A District Heating Model of Hungary

9.1 Introduction

The amount of renewable based district heating generation depends on a lot of factors, including: the present share of district heating and the relative cost of RES DH generation considering different support regimes for both RES-based power and/or heat generation and also non-RES based support schemes such as fossil-based CHP generation. The following figure summarizes those factors, which could influence the share and utilization of RES DH.

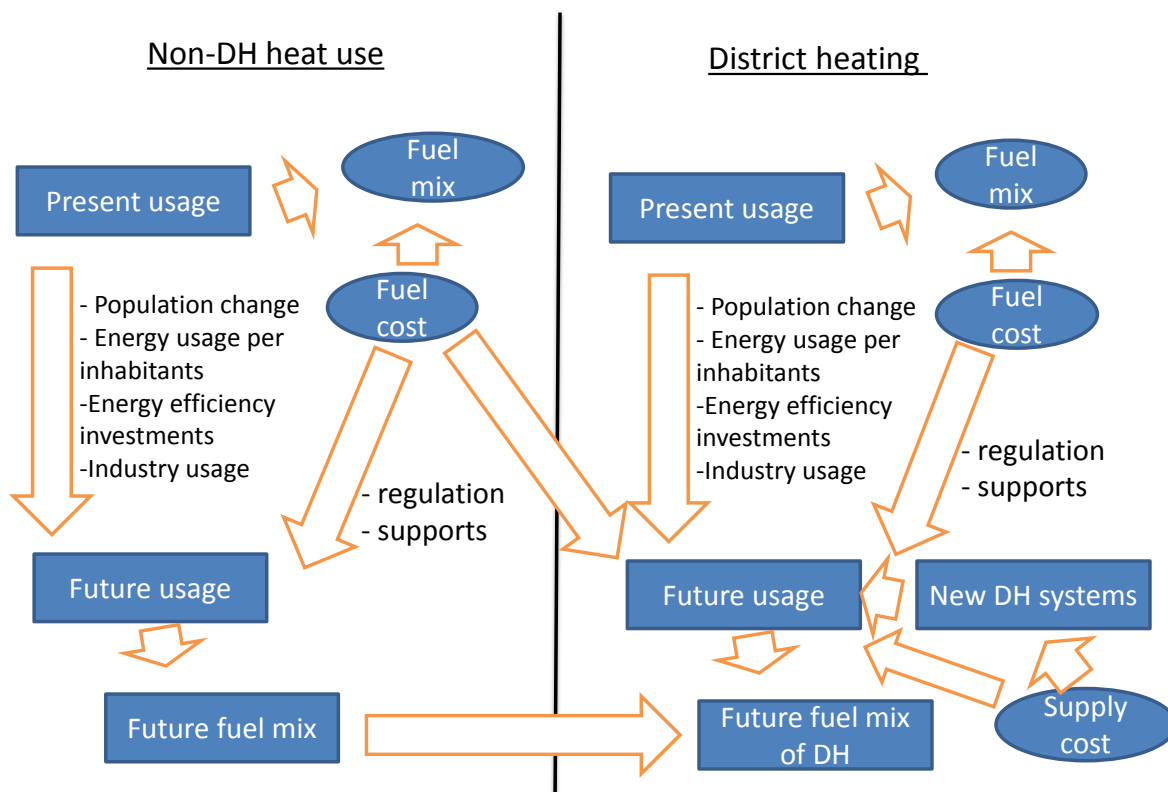


Figure 64 Factors determining the RES DH usage

We have to note that for most heat consumers the price of the service is the most important factor while the source is inconsequential. If we would like to forecast the deployment of RES based DH generation in the future, first we must evaluate the present situation according to the share of DH in total heat supply and the fuel and other cost of heat generation for various sources. Both for the DH and non-DH sector the future usage depends on population change, per capita energy usage, energy efficiency investments and the industrial heat demand. These factors determine the total future heat demand, but many additional factors influence the composition of the energy mix. This depends on the future fuel cost of the different types of heat generation technologies, the cost of district heat supply and also the types of regulation and supports schemes available. Support schemes for renewable based heat generation or non-fossil based CHP generation significantly influences the relative prices of the various fuel types, e.g. a support for direct renewable based heat generation could worsen the competitiveness of district heating generation. Similar effects can be observed if electricity from cogeneration is supported. The price regulation and other regulatory decisions affect the competitiveness

of the various types of heat generation, e.g. legal obligations including the prohibition of switching away from district heating, which is a very powerful tool in the sector.

In the end many exogenous factors can influence RES-based DH generation which can be accounted for in an inclusive modelling approach. In this section we introduce the Hungarian District Heating Model, developed by REKK, to analyse the effect of the various policy instruments listed above. The model can forecast the share of Hungarian RES-based district heating generation under different scenarios and identify the most important factors determining the future shares of renewable-based DH generation. First we summarize the main inputs and assumptions for the model, then introduce a likely reference scenario for the Hungarian district heating sector, and finally carry out several scenario analyses in order to identify the most important driving factors of the Hungarian RES DH generation. Although this model is only used for the Hungarian DH sector, the main findings are also applicable for other European countries.

9.2 The structure of the Hungarian District Heating Model

We develop a bottom-up district heating model based on the present DH situation in Hungary. The model covers 97 district heating supply areas in Hungary and 175 heat generators. In each supply area the present heat consumption is divided into three consumption categories: i) households; ii) service sector and iii) industry. We forecast the total heat consumption for the DH sector. It is important to note that this model only covers that heat demand, which is presently served by DH, so the model neither take into account the new DH zones nor the connection of new consumers to the present DH systems.

The generation module includes the main features of the district heating generators, including the fuel type, the year of commissioning, the type of the generator, the heat and electricity efficiency and also the maximum thermal capacity. From this data – using price forecasts for the various fuel costs and assuming different OM cost - we can calculate the marginal cost of heat production. We calculate not only the cost of heat generation for the DH system, but also determine the cost of heat generation for individual heating modes (mainly the individual gas heating which is most prevalent in Hungary). It is important to distinguish the present producers from the new ones in the DH sector. While old units can produce heat at marginal cost, new generators have to take into account the investment costs also when calculating the average cost of heat generation. In the reference scenario we do not take into account the different taxes (e.g. reduced VAT), subsidies (e.g. CHP support) nor regulated prices. In the model we assume that the cheapest technology will always satisfy the heat consumption of the given supply area. Finally, we can draw the merit order curve for every supply area, and calculate the heat demand which determines the heat energy mix, including DH and non-DH technologies, and the average cost of the heat supply. The functioning of the Model is illustrated in the following figure.

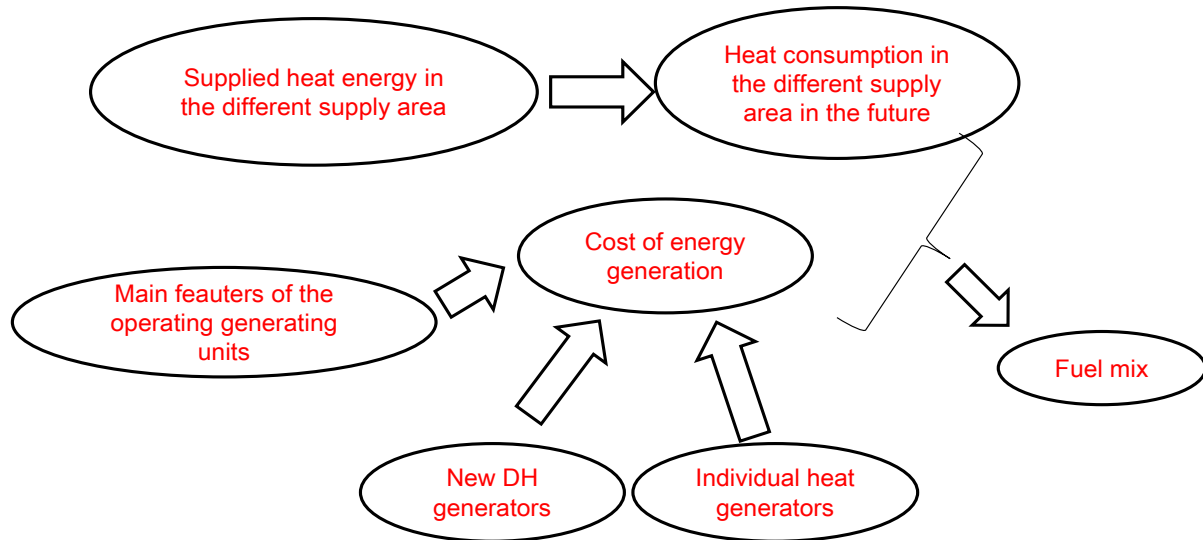


Figure 65 Functioning of the Hungarian DH Model

9.2.1 DH supply

The model consists of 97 DH supply areas. We have collected the heat consumption figures in every DH supply area (HEPURA, 2014; MATASSZ (2003), and we also compared it to the national statistics. The total consumption of the covered supply area in 2014 is 42 PJ, which is almost equal with the 2012 data published by Eurostat (41 PJ). According to the data used in the model, 46.2 % is household consumption, 16.1 % is from the service sector and the rest (37.7 %) is industrial consumption. The largest supply area is Budapest, with consumption exceeding 13 PJ, representing one third of the total DH in Hungary.

In the reference scenario we assume that the consumption of households and service sector decreases by 1.5 % per year due to the energy efficiency investments, which is equivalent to the proposed energy efficiency target set in the draft version of the Hungarian Strategy on the Energy Use of Buildings. However in the industrial sector the drop in consumption is greater. Based on the last ten years of Eurostat data, the average consumption decrease for the DH sector in the industrial segment was 3.5 %, and the trend is very robust. We assume that this trend will continue in the analysed period.

In order to calculate the total cost of heat supply from the DH system, we have to calculate the cost of supplying heat to the final consumers as well. This refers to the distribution cost, including heat loss, and while this is highly dependent on the length and age of the DH system such data is not publicly available. Based on the literature (Ericsson, 2009) we assume that the cost of DH supply is 2500 HUF/GJ in 2014. This includes the fuel cost (due to distribution losses) and O&M cost. After the first modelling year the total cost of DH supply is distributed to the actual DH consumption. For example if in a given supply area the DH consumption is 1000 GJ but in the next year it drops to 900 GJ, it means that the cost of supply for district heat increases to 1111 HUF/GJ (e.g. $1000 \text{ HUF/GJ} \cdot 1000 \text{ GJ} / 900 \text{ GJ} = 1111 \text{ HUF/GJ}$). It means that the average cost of supply increases when consumption decrease, because less users of the system have to pay the total cost of supply.

9.2.2 Generation side of the model

In the generation side of the model we distinguish three groups of heat generators: i) existing DH producers, ii) future DH producers and iii) future individual heat producers. In the next section we demonstrate how to calculate the marginal and average cost of the different producers.

9.2.3 Existing DH producers

The total thermal capacity of the 175 district heat producers in Hungary is 9081 MW_{th}, 93.4 % of them are gas-based thermal production and the rest are from biomass (5.2%), geothermal (1.0 %) and nuclear (0.5 %). Two thirds of the thermal generation capacities are cogeneration. We determine plant-by-plant the marginal cost of production. The following figure depicts the elements of marginal cost pricing.

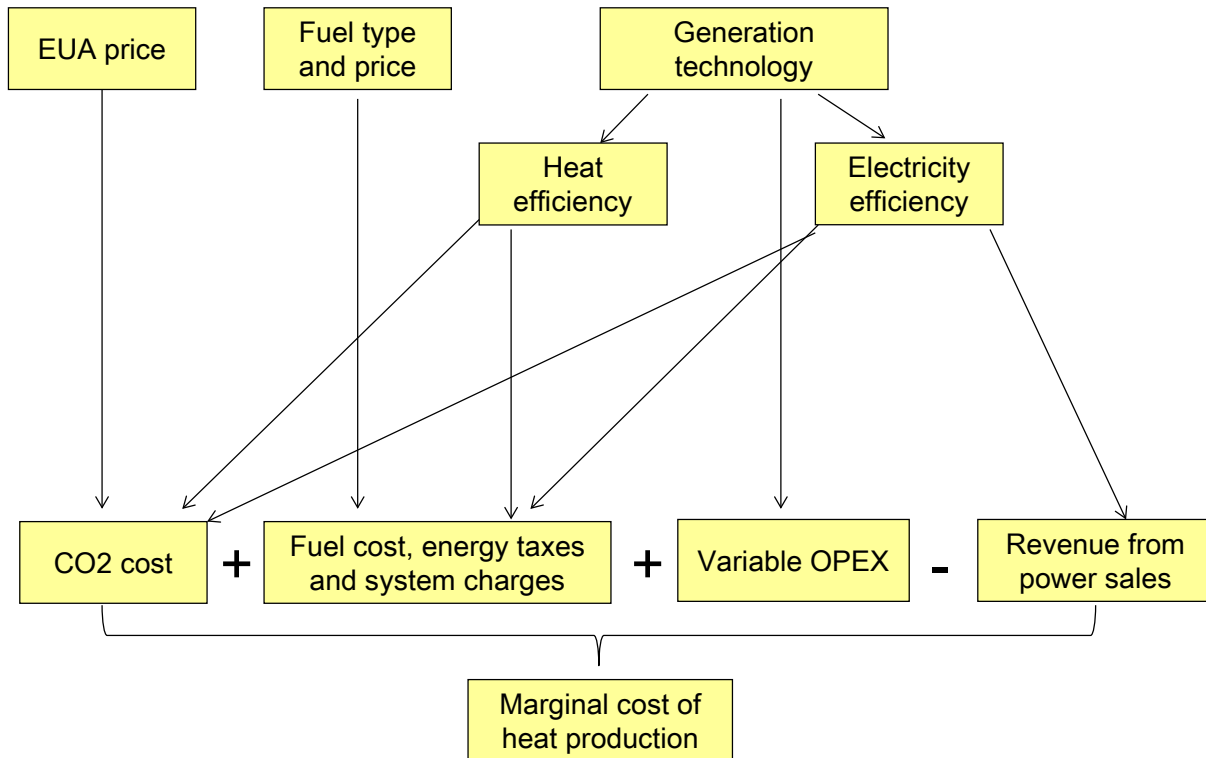


Figure 66 Elements of the marginal cost in the existing DH producers

9.2.3.1 CO₂ costs

CO₂ cost is dependent on two factors: the efficiency of the DH producers and the CO₂ price. Only producers over 20 MW_{th} are obliged to pay CO₂ costs, so for smaller power plants this cost element is set to zero. In the model only natural gas boilers and natural gas-based CHPs emitted CO₂, where the emission factor is 55.82 kg/GJ. This amount is emitted for each GJ of fuel burned, therefore the marginal emission cost in HUF/GJ is calculated as:

$$MC_{CO_2} = P_{CO_2} \times Q_{CO_2} = P_{CO_2} \left(\frac{EUR}{t} \right) \times \frac{\text{emission factor} \left(\frac{kg}{GJ} \right)}{\text{plant heat efficiency} (\%)} \times \text{Exchange rate} \left(\frac{HUF}{EUR} \right)$$

We assume for the whole modelled period – 2014 to 2030 – a CO₂ price of 6 €/t in the reference scenario.

9.2.3.2 Fuel cost

To calculate fuel costs, we simply determine the fuel needed to produce 1 GJ of heat, considering the power plant efficiency, and the appropriate fuel cost according to the following expression:

$$MC_{fuel} = \frac{P_{fuel}}{\text{heat efficiency}}$$

We have four types of DH producers in the model: gas-based, biomass-based, nuclear-based and geothermal-based heat generation. We assume the following costs: 1100 HUF/GJ (REKK, 2014a) for biomass, 500 HUF/GJ for nuclear and zero cost for geothermal. In the case of natural gas we calculate with 2345 HUF/GJ (REKK, 2014b) in 2014, which decreases to 2100 HUF/GJ by the end of this decade and will remain at this level in the 2020s (REKK, 2014c).

9.2.3.3 Energy taxes

The cost of energy taxes is equal with level of excise tax of the given fuel divided by the net efficiency. Only natural gas-fired plants have to pay excise taxes (because no coal-fired DH plants are in the model), the amount of it is 88.5 HUF/GJ.

$$MC_{excise\ tax} = \frac{P_{excise\ tax}}{heat\ efficiency}$$

In Hungary cogeneration plants also have to pay a special sectoral tax, equalling 1.1 % of the total revenue of the generator.

9.2.3.4 System charges

Natural gas-fired DH generators have to pay system charges including transmission and distribution fee, odorization fee and security storage fee. The average cost of them in Hungary is 129 HUF/GJ¹⁴⁰, and we assume that this value would not change in the modelled period. Similar to the energy taxes and fuel cost, we calculate the marginal cost of system charges in the heat generation, if we divide the system charges by the net efficiency of the DH generator.

$$MC_{system\ charge} = \frac{P_{system\ charges}}{heat\ efficiency}$$

9.2.3.5 Variable OPEX

Finally the last cost element is the variable part of OPEX. We assume that the marginal cost of OPEX is equal to 100 HUF/GJ for non-CHP producers, and 200 HUF/GJ for CHP¹⁴¹ producers.

9.2.3.6 Revenue from power sales

As we have already mentioned, two thirds of the thermal capacities are cogeneration. For these producers we assume that power sales decrease the marginal cost of heat generation, but it has to be noted that CHP generators have lower heat efficiency. It means that the MC_{fuel} is much higher for them compared to a non-CHP natural gas fired generator.

$$MR_{power\ sales} = \frac{P_{electricity\ prices}}{electricity\ efficiency}$$

We forecast the Hungarian electricity prices using the REKK developed European Electricity Market Model (EEMM)¹⁴² in order to calculate the marginal revenue. In 2014 that price is 44.6 €/MWh, and it falls to 43 €/MWh by 2020 where it remains for the decade.

¹⁴⁰ Source: Calculation based on an average-sized industrial gas consumer

¹⁴¹ Based on interviews with plant operators

¹⁴² The detailed description of the model can be found at András Mezősi (2014): In the jungle of Regulatory Instruments, PhD thesis, Corvinus University of Budapest

9.2.3.7 Total cost of DH generation

The following equation summarizes how to calculate the marginal cost of heat production in existing DH generators.

$$MC_{heat} = MC_{CO2} + MC_{fuel} + MC_{excise\ tax} + MC_{system\ charges} + OPEX - MR_{power\ sales}$$

Calculating plant-by-plant the marginal cost of heat generation we can determine the merit order curve for 2014, indicated in the following figure. The cheapest option is to produce by geothermal, biomass and nuclear plants. It is followed by the gas-based cogeneration capacities, while the most expensive is producing heat with gas boilers. It is important to note that the merit order curve is just an illustration, because the heat producers are not competitors if situated in other DH zones.

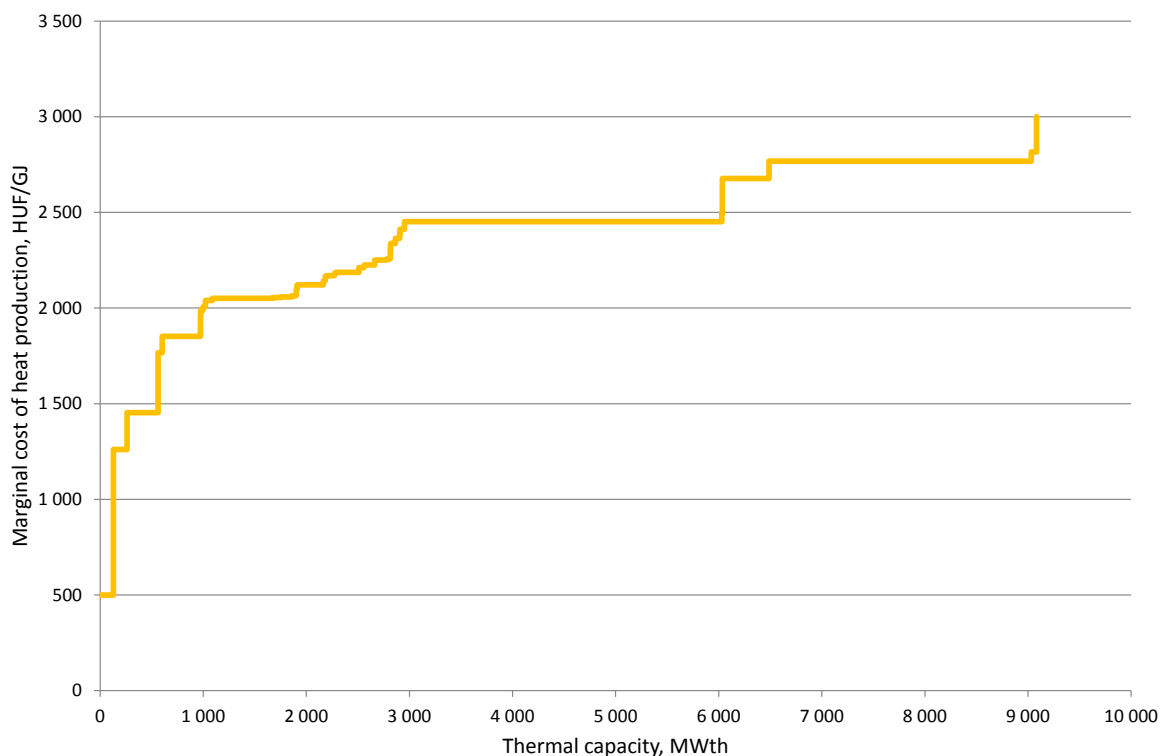


Figure 67 Merit order curve of heat production in 2014
Source: REKK calculation

9.2.4 Decommissioning of existing DH generators

In order to forecast the future DH fuel mix, we have to incorporate the expected decommissioning of the existing heat producers. To do that first we collect/determine the commissioning year for all DH producers (assuming the lifetime of CHP plants to be 20 years and all other technologies 50 years) which allows us to predict the decommissioning rate of the existing capacities as illustrated in Figure 68. Until 2019 the generation capacity will be quite stable with only a small number of generators decommissioned, but in 2020 a large drop is observable marking the point at which nearly 4000 MWth capacity will be retired. By the end of the modelled period the remaining total capacity falls below 3000 MWth, which is one third of the present capacity level.

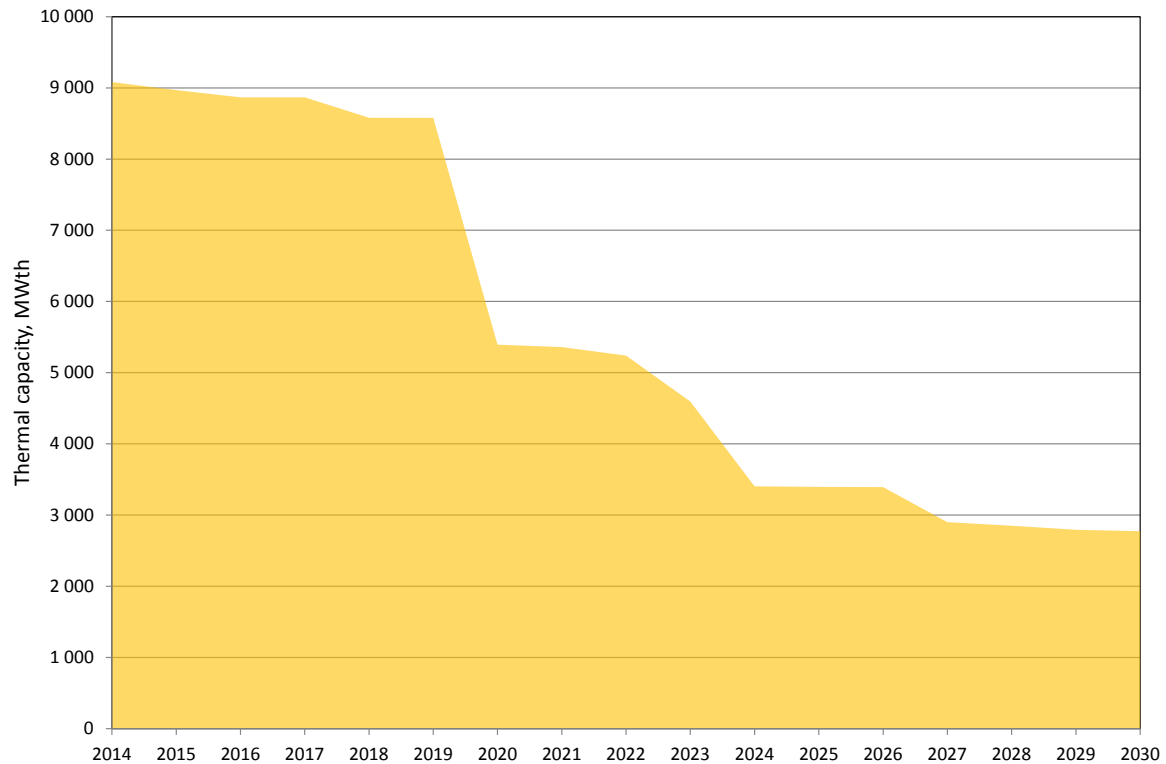


Figure 68 Expected capacities of the existing thermal capacities between 2014-2030, MWth
Source: REKK collection

9.2.5 New DH generators

As the previous figure shows, new capacity is needed to satisfy future heat demand. There are two basic options to substitute the decommissioning capacity: new DH producers or individual heat generators. In this section we calculate the cost of new DH producers. In the model we define four types of new DH producers: geothermal; biomass; gas-based CHP and gas-based non-CHP generators. When a decision is made on a new DH generator, investors calculate not only the marginal cost of heat production, but they also take into account the investment costs and the yearly fixed OM costs also. In each technology we calculate the average cost of heat production, which shows what the average heat revenue requirement is needed to repay the investment. We use a discounted cash-flow (DCF) modelling approach to calculate the average cost of heat production with the following assumptions that are indicated in Table 1: 8 % real discount rate, 10 % corporate tax for all technology, linear amortization with the corresponding investment cost, variable and fix cost for the four technology. In the last column we also indicated the assumed yearly learning rate showing the yearly cost reduction of investment cost resulting from technological advancements.

Table 18 Main features of the four analysed DH technology

	Heat efficiency, %	Electricity efficiency, %	Yearly utilization rate	Investment cost, mHUF/MW	Yearly OM cost, mHUF/MWth	Lifetime	Learning rate, %/year
Geothermal - high efficiency	90%	0%	70%	420	31.1	25	1.5%
Geothermal - average efficiency	90%	0%	70%	600	31.1	25	1.5%
Geothermal - low efficiency	90%	0%	70%	780	31.1	25	1.5%
Biomass	87%	0%	35%	150	3.7	15	1.5%
Gas-non CHP	85%	0%	35%	60	1.86	20	0%
Gas CHP	38%	42%	40%	262.8	19.2	15	0%

Source: Pöyry (2009), DEA(2012), EC (2008)

Using the data we can calculate the average cost of heat production for the various technologies across future investment years and the corresponding average cost figures are included in the following table. Also note that the figures do not include the additional costs of heat distribution.

Table 19 Cost of DH production in different investment year

	District heating system					
	Geothermal - high efficiency	Geothermal - average efficiency	Geothermal - low efficiency	Biomass	Gas-non CHP	Gas CHP
2014	3 457	4 235	5 013	3 300	3 657	6 970
2015	3 486	4 276	5 066	3 325	3 681	6 810
2016	3 314	4 116	4 918	3 350	3 694	6 839
2017	3 341	4 155	4 969	3 374	3 692	6 852
2018	3 368	4 194	4 819	3 398	3 687	6 869
2019	3 395	4 032	4 869	3 221	3 680	6 880
2020	3 221	4 069	4 718	3 244	3 677	6 891
2021	3 247	3 906	4 766	3 267	3 677	6 891
2022	3 273	3 943	4 613	3 289	3 677	6 891
2023	3 298	3 979	4 660	3 111	3 677	6 891
2024	3 123	3 814	4 506	3 133	3 677	6 891
2025	3 147	3 849	4 551	3 155	3 677	6 891
2026	3 171	3 884	4 596	3 176	3 677	6 891
2027	3 195	3 717	4 440	3 197	3 677	6 891
2028	3 018	3 751	4 483	3 017	3 677	6 891
2029	3 041	3 784	4 326	3 037	3 677	6 891
2030	3 064	3 616	4 368	3 057	3 677	6 891

The investment cost of geothermal DH generators depends on the location. The higher the geothermal potential is in a given region, the lower the investment cost. All of the DH zones are grouped into three categories taking into account the heat characteristics of the given site using a simplified ranking system where a single point is tallied for each of the following characteristics: i) the temperature at 2000 meters is above 90 °C, ii) the temperature at 1000 meters is above 50 °C, and iii) the heatwave is higher than 90 mW/m². Satisfying all measurements with 3 points we assume that DH zones are situated in a high efficiency geothermal location, a

score of 2 points represents an average geothermal location, and 0 or 1 marks a low efficiency geothermal location for DH.

9.2.6 New individual heat generators

We distinguish three types of individual heat production: i) gas boiler, ii) solar thermal and iii) heat-pump. Individual biomass is not taken into account, because in high-density populated cities it is not a viable option for heat generation. Table 3 lists the main features of these individual heat producers similarly to the DH generator characterization.

Table 20 Main features of the three analysed individual technology

	Heat efficiency, %	Electricity efficiency, %	Yearly utilization rate	Investment cost, mHUF/MW	Yearly OM cost, mHUF/MWth	Lifetime	Learning rate, %/year
Gas boiler	91%	0%	10%	29.2	1.7	15	0.0%
Solar	100%	0%	10%	166.7	2.0	15	1.5%
Heat pump	100%	0%	36%	333.3	38.6	20	2.5%

Source: DEA (2012b)

Like we did for the DH technologies, we can also calculate the average cost of heat production for the various investment years. The respective average cost values are shown in the following table.

Table 21 Cost of heat generation by individual technologies between 2014-2030

	Gas boiler	Solar	Heat pump
2014	5 224	6 991	6 413
2015	5 250	6 883	6 486
2016	5 264	6 773	6 357
2017	5 262	6 661	6 226
2018	5 256	6 548	6 294
2019	5 249	6 434	6 160
2020	5 246	6 319	6 024
2021	5 246	6 203	6 087
2022	5 246	6 285	5 949
2023	5 246	6 166	5 809
2024	5 246	6 046	5 867
2025	5 246	5 924	5 724
2026	5 246	5 802	5 779
2027	5 246	5 878	5 634
2028	5 246	5 753	5 687
2029	5 246	5 627	5 538
2030	5 246	5 500	5 589

It can be seen that until 2025 the cheapest individual heat generation mode is the gas boiler, but after 2025 - due to the technology learning rate - solar thermal becomes a more economic form of individual heating.

9.2.7 Capacity limit of new generators

Regarding both the DH production and also the individual heat production the model uses yearly and overall capacity limits for each technology. With some technologies, like geothermal, it is not economically feasible to satisfy the total demand. The cost of supply during peak demand periods using geothermal would be very costly because capacities would be idle for most hours of the year, resulting in extremely high average costs. We apply an overall limit in the case of individual solar thermals and heat pump technologies, recognizing that each can only satisfy part of aggregate heat demand. These limits also vary between sectors. We assume that in industry heat-pumps cannot be used in large scale while solar thermal only has a minor role.. We also apply yearly deployment limits, especially for individual heat production, to achieve more realistic results. The following table summarizes the yearly and overall limits of the different technologies.

Table 22 Overall and yearly capacity limits of the various technologies

	Per year		Overall	
	Household+service	Industry	Household+service	Industry
GEO	70%	70%	70%	70%
Biomass	100%	100%	100%	100%
Gas-non CHP	100%	100%	100%	100%
Gas CHP	100%	100%	100%	100%
Gas boiler	5%	5%	100%	100%
Solar	3%	3%	30%	10%
Heat pump	2%	0%	20%	0%

Source: REKK assumptions

9.3 Modelling results

In the previous sections we have introduced how the Hungarian District Heating model works, including the central assumptions and data sources, while in this section we summarize the results and the main findings of the model runs. We analyse the portfolio mix of the district heating consumption between 2014 and 2030, the price development in the examined period in different scenarios and the total system cost. The last is calculated as the total cost – including investment, OM and variable costs – to satisfy the total heat demand of the modelled heating areas. First we introduce the reference scenario in detail, when no new support schemes exist in the analysed sector. After that we assess the model results under various support regimes, like RES production support, feed-in tariff for CHP tied to electricity generation and support for district heat consumption, such as reduced VAT for DH consumption.

9.3.1 Reference case

In the reference scenario no support regimes exist at all, including reduced VAT or support of RES cogeneration, although presently applicable in Hungary. Presently district heat consumption is near 42 PJ. Due to the decreasing heat consumption driven by energy efficiency investments, the heat consumption will fall below 32 PJ by the end of 2030 in the reference demand scenario.

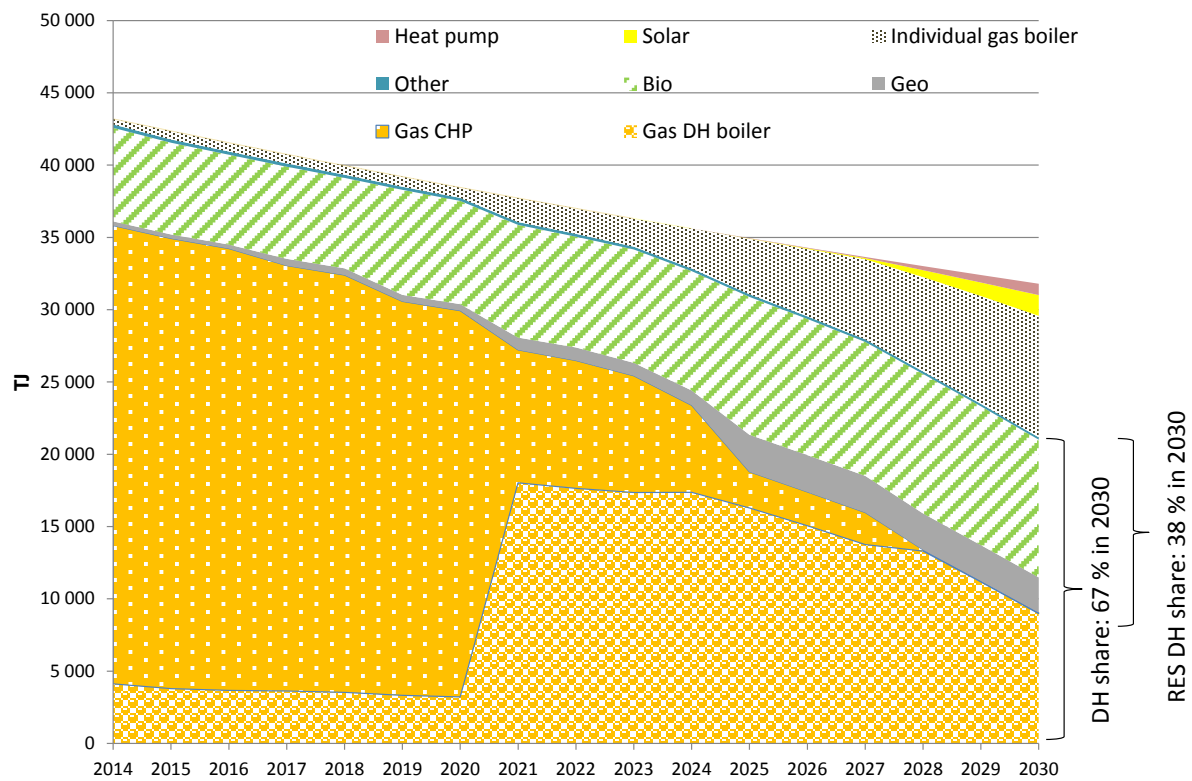


Figure 69 Heat production mix of DH production in the reference scenario, TJ, 2014-2030¹⁴³

The results show that until the end of this decade no dramatic change occurs. Some consumers switch from district heat generation to individual gas boiler, but the change is not very significant. But in 2020 several significant transformations will take place according to the model results. First, some large CHP producers will be decommissioned, which is partly replaced by the existing gas boiler heat generation in the DH network. Second, geothermal DH generation would become economically viable from the beginning of 2020s due to the decreasing investment cost, and its deployment will start to increase. By 2030 the DH share is still significant, 67 % of the total modelled consumption will be still served by DH, but the trend as a percentage of overall consumption is declining. The RES DH share in 2030 is around 38 %.

It is very important to see that DH generation varies between locations: in some DH areas DH share will be still 100 % in 2030, while in some towns DH disappears and all heat consumption is satisfied by individual heat producers. In the following we depict a small sized town with a 147 TJ heat consumption level in 2014, which is presently satisfied by gas-based DH production.

¹⁴³ It has to be noted that the 2014 year is also a modelled year not based on precise data.

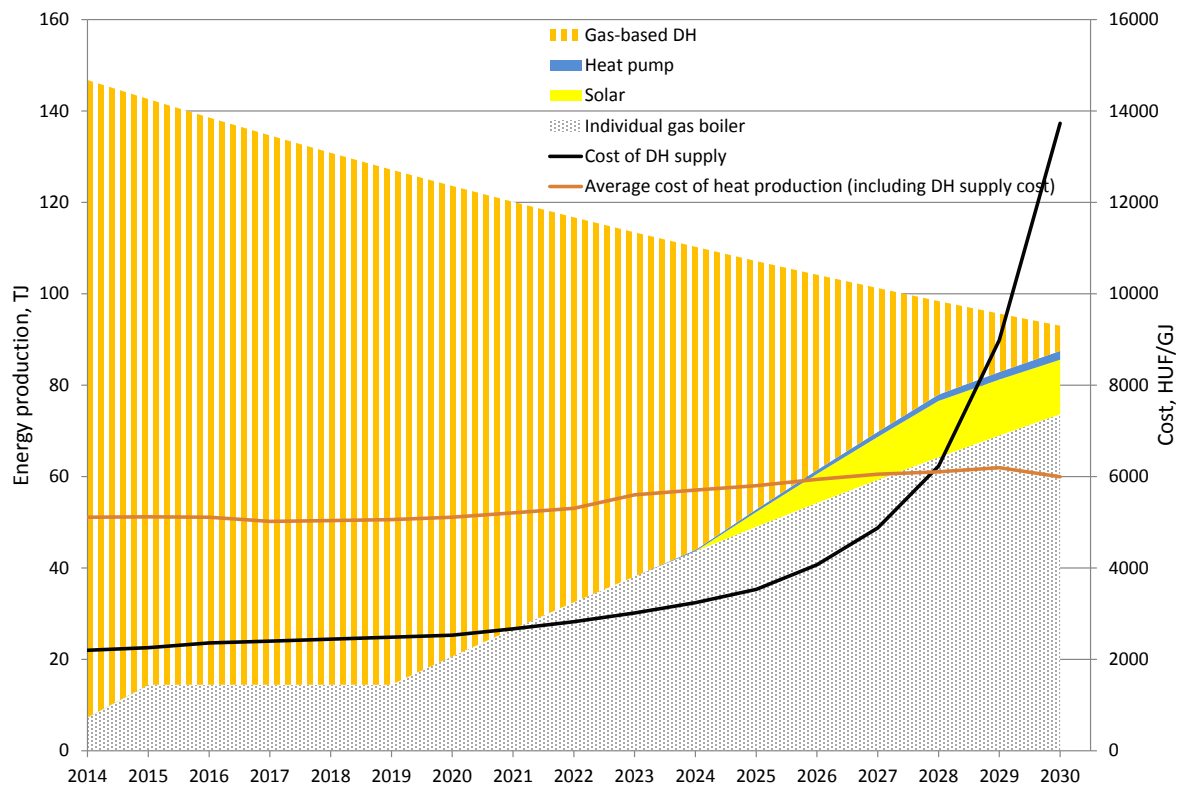


Figure 70 Heat energy mix development in a smaller sized town, the cost of heat consumption and DH supply cost, 2014-2030

DH supply cost will increase in the analysed period due to two factors. First, many consumers switch to individual gas boiler which is a cheaper option to generate heat. Second, due to the energy efficiency investments overall heat consumption decreases, causing a steep increase in cost of DH supply. In the beginning of the 2020s the cost of DH supply increases to 3000 HUF/GJ from the presently assumed 2200 HUF/GJ, because the cost of DH supply is endogenous in the model; less consumers share the fixed cost of DH supply. In the middle of 2020s these two factors cause a dramatic change. The cost of DH supply becomes so large that nearly all the consumers switch to individual heat generation, and DH nearly disappears, replaced mainly by individual gas boilers with a smaller portion of the consumption satisfied by solar thermal and heat pumps. This switch takes place over a six year period, where movement away from DH is a self-generating process, and after a certain rate the process cannot be reserved due to the exorbitant fixed charge element. At the same time, if we observe average cost of heat generation including the supply cost of DH, it will not show such sharp escalation. This example is a reminder that the decreasing DH production can cause a near total and sudden switch from DH to individual heat generation if no legal obligation (e.g. the prohibition of disconnection) or other barrier prevents it.

9.3.2 Supporting DH consumption

In some countries, like in Hungary, DH consumption is subsidized by something like a reduced VAT, which gives DH generation a competitive advantage compared to individual heat generation technologies. In the following we show a model run assuming that DH consumption is subsidized by 20 %.

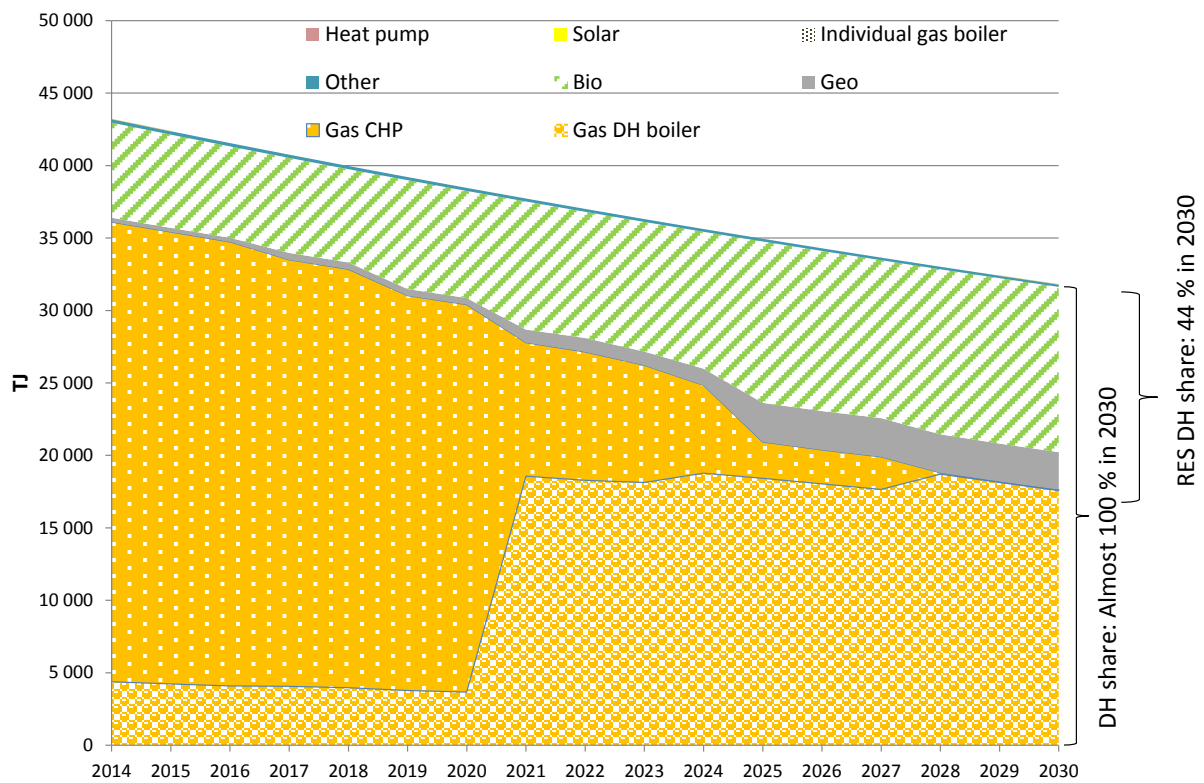


Figure 71 The effects of a 20 % subsidization of DH consumption on the heat energy mix

It can be seen that due to this subsidy level DH production crowds out the individual heat generation, even in the long run. While RES DH share is 38 % in 2030 in the reference case, this increased to 44 %.

It is important to analyse the total cost of heat production, which includes the DH cost and also the support. We calculate the total system cost both in the reference scenario and in the case when a DH support scheme exists.

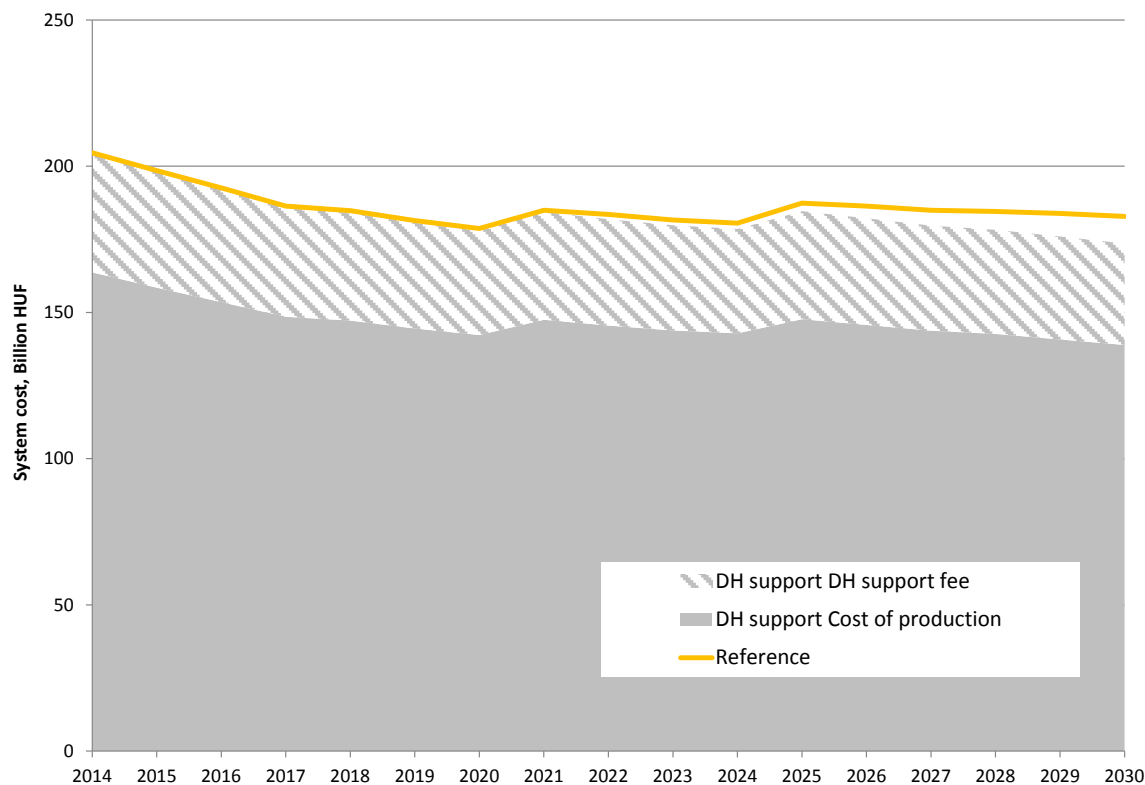


Figure 72 System cost in the reference scenario, and the components of the system cost in a DH support regime, 2014-2030

Figure 72 reveals a surprising result, that the system cost in the reference scenario is more expensive than the case when a DH support regime exists. It seems counterintuitive, but the following example shows how it could happen.

Table 23 Example of the effect of a DH consumption support regime

	Capacity, GJ	Production cost excluding DH distribution cost, HUF/GJ	Production cost including DH distribution cost, if the DH generation is 1000 GJ, HUF/GJ	Cost without subsidy	Cost with 20 % subsidy on DH consumption
CHP	500	1 000	2 000	3 000	1 600
DH gas boiler	500	1 500	2 500	-	2 000
Individual gas boiler	500	2 400	2 400	2 400	-
Total generation cost including DH supply cost, mHUF	-	-	-	2.7	1.8
Subsidy cost, mHUF	-	-	-	0	0.45
Total system cost, mHUF	-	-	-	2.7	2.25

Assume three technologies - CHP, DH gas boiler and individual gas boilers - with a capacity limit of 500 GJ. We assume that the total consumption of this area is 1000 GJ. The heat production cost of the three technologies is 1000, 1500 and 2400 HUF/GJ excluding the cost of DH distribution. We assume that the total cost of DH distributions as 1 million HUF. If the heat consumption is satisfied by DH production then the cost of CHP production is 2000 HUF/GJ, while the cost of DH gas boiler is 2500 HUF/GJ. We can see that in this case the production of heat with an individual gas boiler is the cheaper option, so consumers will switch to this technology until the capacity limit is reached. As a result, the cost of the CHP production increases by 1000 HUF/GJ (to 3000

HUF/GJ), due to the reduction of DH-based heat consumption. This increase is necessary to cover the 1 million HUF of the DH distribution costs. In this scenario the total system cost of heat generation is 2.7 million HUF (3000 HUF/GJ*500+2400 HUF/GJ*500).

In the other case when the DH consumption is subsidized by 20%, the cost of CHP production decreases to 1600 HUF/GJ and the DH gas boiler cost decreases to 2000 HUF/GJ. In this circumstance both technologies are cheaper than the individual gas boiler and the total cost of heat production including the cost of heat supply is 1.8 million HUF. But we have to account for the subsidy cost also, which is calculated by taking the difference of the production costs multiplied by the generated heat: (2000 HUF/GJ-1600 HUF/GJ)*500 GJ+(2500 HUF/GJ-2000 HUF/GJ)*500 GJ. This equals 0.45 million HUF, making the total system cost 2.25 million HUF which is 0.45 million HUF cheaper. This example shows that subsidizing the DH consumption could reduce the total system cost, although it depends on many factors: the total cost of DH supply, the cost of production of the different technologies, etc.

9.3.3 The effect of a RES production support scheme

With the model we can investigate the effect of a RES production support scheme on the heating energy mix. We assume that all the renewable technologies get a 250 HUF/GJ premium. Not only the DH based RES producers are eligible for the support, but also the non-DH RES technologies (individual), like solar thermal and heat-pumps, but we assume that only new technologies get this support. The assumed premium is quite low compared to the average price of heat production (2000-5000 HUF/GJ), but even this amount has a huge effect on the energy mix, as the following figure depicts.

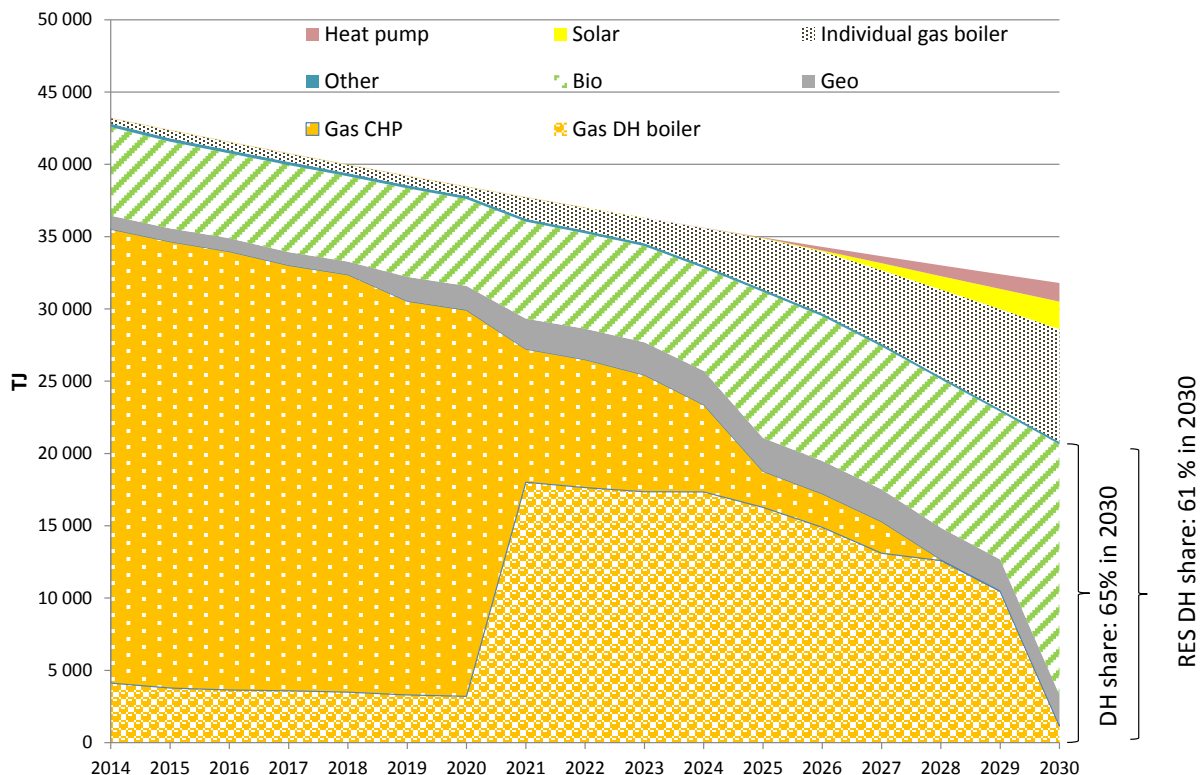


Figure 73 The effect of a 250 HUF/GJ RES production support on the heat energy mix, 2014-2030

In this scenario DH share in 2030 is equal to the value of the reference scenario. However in the reference scenario 30 % of heat production is still gas-based, and in this case the gas share is below 5 % with the rest of DH production coming from geothermal and biomass based heat generation. The total subsidy before 2020 is below 1 billion HUF per year, and at the end of the analysed period it will increase to 5.1 billion HUF per year. Based on the total system cost of this scenario, the difference between the reference scenario and the RES

production support regime scenario is below 1 %. This figure is quite small, thanks to the learning effect of the renewable technologies. Without the learning effect the situation would completely different. Although the yearly learning rate is small (1.5-2.5 %/year), the accumulated effect is over 25-45% in a 15 year period. The result of the modelling is shown in the following figure.

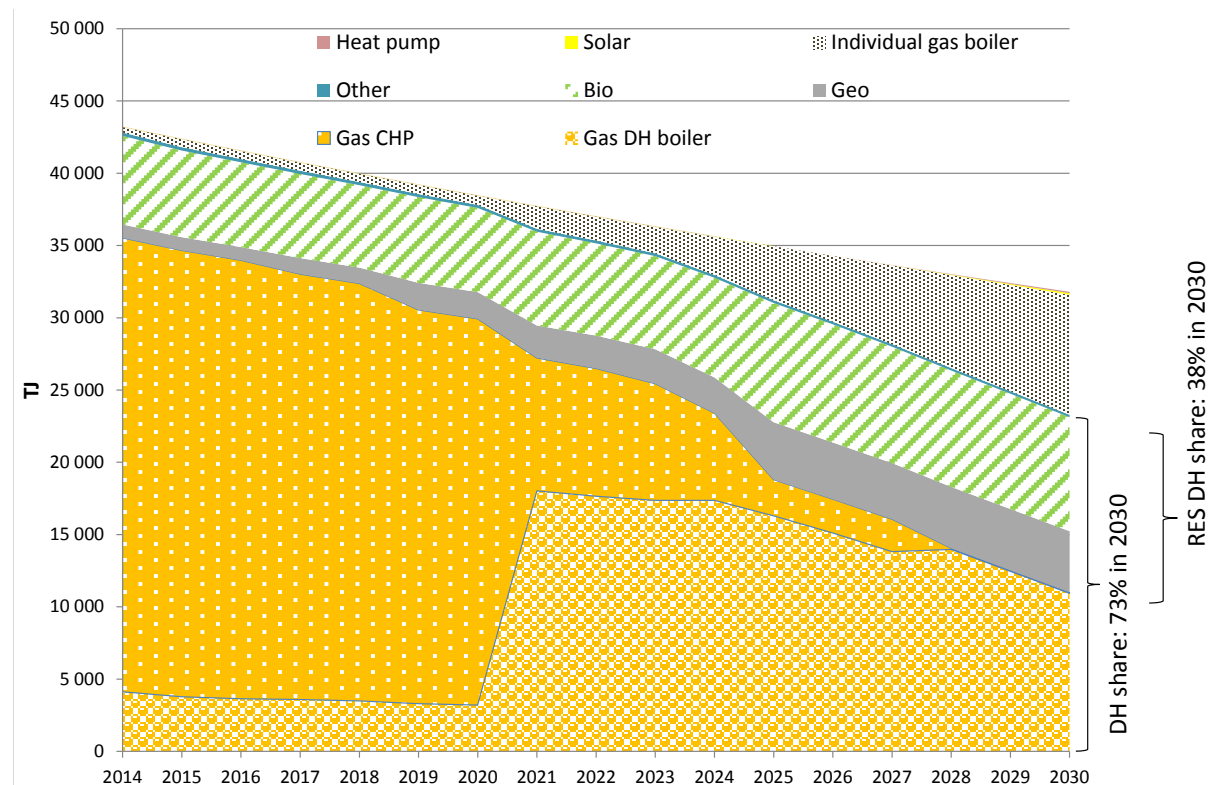


Figure 74 The effect of a 250 HUF/GJ RES production support on the heat energy mix without learning effect, 2014-2030

In this case we can see two major changes. First the DH production increases to 73 % in 2030, because solar thermal and heat pump remain very expensive and cannot enter the market. These sources do not ‘crowd out’ DH heating modes. The other important result is that RES based DH production reaches “only” 38 % by 2030, where the majority of RES based DH is biomass-based and geothermal heat generation. One important message of the modelling is that the assumed learning rate has an important impact on the share of the RES based DH. As it is a small effect, the learning curve could be easily overwhelmed by other factors, such as a non-competitive supplier market that drives prices upward. So it is imperative to design support schemes in a way that allows gradual market growth (not too sharp causing supply bottlenecks), and real competition amongst more suppliers.

9.3.4 The effect of a CHP production support scheme

As we have already pointed out in the introduction, subsidizing cogeneration even only for electricity would lower the marginal cost of heat production of these technologies. As a result CHP producers would get competitive advantages compared to other types of DH generators and individual heat producers. In the following we assess a scenario where both the presently operated and also new technologies would receive a feed-in tariff for generated electricity from CHP plants at the level of 90 €/MWh. This means that the average premium on electricity is around 45 €/MWh.

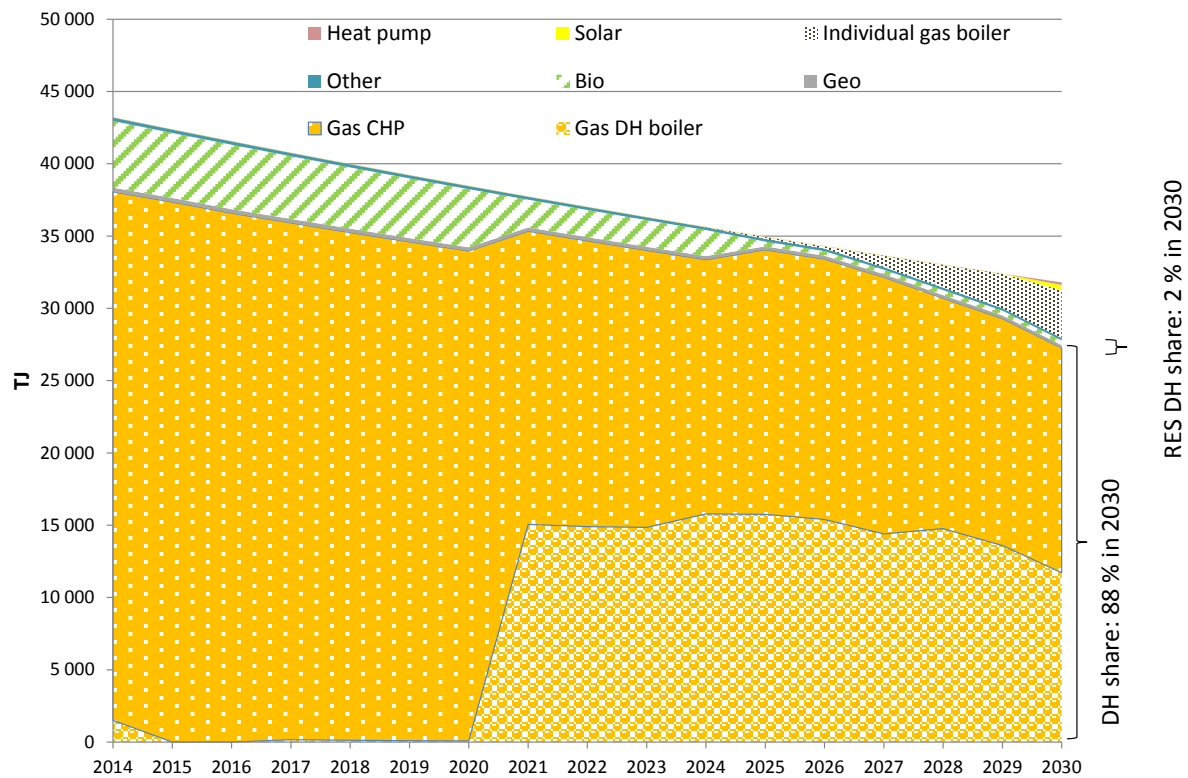


Figure 75 The effect of 90 €/MWh CHP electricity generation production support on heat energy mix, 2014-2030

In the beginning of the assessment period, the majority of the heat production is based on the presently operated CHPs, crowding out the gas boilers. While in the reference scenario in 2014 the Gas DH boiler production is 4.1 PJ, in the case of a CHP support regime it decreases to 1.5 PJ. In 2020 large CHP producers will be decommissioned causing a large drop in CHP heat production. However by the end of 2020s the largest share of heat will be still be satisfied by CHPs thanks to the relatively high feed-in tariff in the electricity sector. What we can see from the modelling results is that the total DH supply will increase to 88 % (in the reference scenario the DH supply covered 67 % of the total heat consumption), but due to the support of CHPs, biomass based DH generators cannot enter to the market. It pushes the RES DH share in 2030 to only 2 %, compared to the reference case when this figure is 37 %, so the support has a significant crowding out effect on RES based DH.

It is worth examining the system cost of this scenario. Although the heat price is lower compared to the reference case, the assumed subsidy completely changes the picture, causing the average system cost of this regime is higher by 30 % towards the end of the 2020s.

9.3.5 Summary of the main results

Using the Hungarian District Heating Model we can analyse how the different policy tools may change the energy mix in the heat sector, and can also calculate how the total system cost of heat generation would change if these policies are introduced. The following table summarizes the main modelling results.

Table 24 Summary of the modelling

	REF	DH support	RES support	CHP support
Average system cost, million HUF	186 321	183 636	186 330	227 704
Overall DH share in 2030	66.6%	100.0%	65.4%	87.9%
Geothermal DH share in 2030	7.7%	8.1%	6.6%	0.7%
Biomass DH share in 2030	29.9%	35.9%	54.5%	1.0%
Total RES DH share in 2030	37.6%	44.0%	61.1%	1.7%

We can conclude the followings:

- RES DH share is very high already in the reference scenario, almost 40 % by 2030. 80 % of the RES heat production comes from biomass, while 20 % is geothermal-based.
- Subsidizing the DH consumption (e.g. reduced VAT) may crowd out the individual heat production and also help the RES DH, which increases by 6.4 % points in 2030. In the study we have showed that the total system cost reduced compared to the reference case.
- RES support would drive RES DH production to the highest level amongst the scenarios without increasing the total system cost significantly.
- Subsidizing CHP electricity production increases the overall DH share, but RES DH technologies are crowded out by gas-based CHP heat producers and the RES DH share is reduced to 2 % by 2030.

Overall we can conclude that the CHP subsidy may decrease very dramatically the competitiveness of RES DH, while both the DH and RES support can increase it. So in this sense, the policies should be very carefully designed in order to avoid inadvertently building constraints for RES based DH. Also the mix of policy tools should be examined in order to determine if mixing various policy tools would lead to inefficiencies (cancelling out positive effects of support schemes) and increase system costs. These results should be further checked if the model is further elaborated, e.g. if the biomass based CHP production is also introduced to the capacity mix.